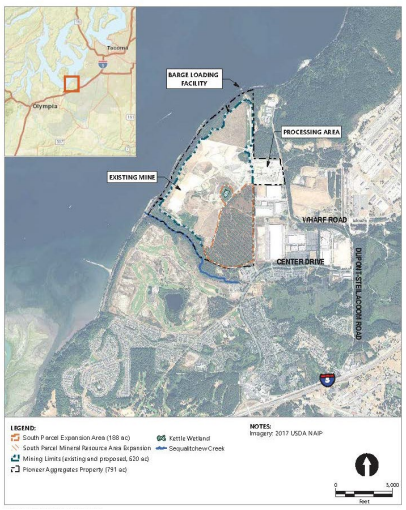
DRAFT ENVIRONMENTAL IMPACT STATEMENT

for the proposed

PIONEER AGGREGATES SOUTH PARCEL PROJECT



prepared by

City of DuPont

June 14 2024

CITY OF DUPONT
1700 Civic Drive, DuPont, WA 98327
Telephone: 253.964.8121
www.dupontwa.gov

June 14, 2024

Dear Affected Agencies, Tribes, Organizations and Interested Parties:

Enclosed is the Draft Environmental Impact Statement (DEIS) for the proposed ***Pioneer Aggregates South Parcel Project, City File No. SEPA2021-002***. This DEIS analyzes the probable adverse environmental impacts associated with the Proposed Action Alternative and the No Action Alternative.

The public comment period associated with this DEIS is: **June 14, 2024 through July 15, 2024**

Agencies, affected tribes, organizations and members of the public are invited to comment on the DEIS. Methods for presenting your comments are described below.

All comments are due no later than July 15, 2024 and may be submitted via the following:

City of DuPont website at: https://www.dupontwa.gov/719/Pioneer-Aggregates-South-Parcel-Project-

Or by providing hard copies via US mail or hand delivery to The City of DuPont at 1700 Civic Drive, DuPont, WA 98327 care of Barb Kincaid.

Following the DEIS comment period, City of DuPont will prepare a Final EIS (FEIS) that addresses comments received during the DEIS public comment period.

Copies of this DEIS have been distributed to agencies noted on the Distribution List of this DEIS (**Appendix A**). The DEIS can be reviewed at the City of DuPont at 1700 Civic Drive, DuPont, WA 98327, and online at https://www.dupontwa.gov/719/Pioneer-Aggregates-South-Parcel-Project-

Thank you for your interest in the ***Pioneer Aggregates South Parcel Project*** DEIS.

Sincerely,

Barbara Kincaid, City of DuPont SEPA Official

DRAFT
ENVIRONMENTAL IMPACT STATEMENT

for the

PIONEER AGGREGATES SOUTH PARCEL PROJECT

This Draft Environmental Impact Statement (DEIS) for the proposed *Pioneer Aggregates South Parcel Project* has been prepared in compliance with the State Environmental Policy Act (SEPA) of 1971 (Chapter 43.21C, Revised Code of Washington); the SEPA Rules (Chapter 197-11, Washington Administrative Code); and rules adopted by the City of DuPont implementing SEPA (DuPont Municipal Code Chapter 23.01). Preparation of this EIS is the responsibility of the City of DuPont, and based on a scoping process has directed the areas of research and analysis that were undertaken in preparation of this EIS. This document is not an authorization for an action, nor does it constitute a decision or a recommendation for an action. In its final form – as a Final EIS – it will accompany the Proposed Action and will be considered in making final decisions concerning mining operation of the proposed *Pioneer Aggregates South Parcel Project*.

Date of Draft EIS Issuance..... **June 14, 2024**

Date Comments are due on the Draft EIS ..... **July 15, 2024**

PREFACE

The purpose of this Draft Environmental Impact Statement (DEIS) is to:

- identify and evaluate probable significant adverse environmental impacts that could result from development associated with the *Proposed Action* and development alternatives, and the *No Action Alternative;* and
- identify measures to mitigate those impacts.

This DEIS does not authorize a specific action or alternative nor does it recommend for or against a particular course of action; it is one of several key documents that will be considered in the decision-making process for this project. A list of expected regulatory actions, including: licenses, permits and approvals is contained in the **Fact Sheet** to this Draft EIS (pgs. ii-iii); the Final Environmental Impact Statement (FEIS) associated with this project will accompany the applications specifically associated with the permit processes and will be considered as the final environmental (SEPA) document relative to those applications.

The environmental elements that are analyzed in this DEIS were determined as a result of the formal, public EIS scoping process, which occurred from September 20, 2021 through October 20, 2021. The SEPA Determination of Significance/Scoping Notice was mailed to numerous governmental agencies, organizations, and owners and current occupants of parcels located within approximately 500 feet of the site. Following review of the written comments received, the City of DuPont determined the issues and alternatives to be analyzed in this DEIS. They include broad areas of environmental review consisting of: Earth, Air Quality, Surface Water & Groundwater, Fisheries, Plants & Animals, Noise, Land & Shoreline, Aesthetics, Cultural Resources, Transportation, and Economic & Fiscal Conditions.

The Table of Contents for this DEIS is contained on pgs. v-ix of the **Fact Sheet**. In general, the DEIS is organized into four major chapters:

- **Fact Sheet** (immediately following this Preface) provides an overview of the proposed action and development alternatives, permits and major approvals needed, contact information and the Table of Contents;
- **Chapter 1** (beginning on page 1-1) summarizes the description of the proposed project, the Proposed Action, and the No Action Alternative, as well as provides a summary of environmental impacts, mitigation measures, and significant unavoidable adverse impacts (if any);
- **Chapter 2** (beginning on page 2-1) provides a detailed description of the Proposed Action and alternatives and the No Action Alternative; and,
- **Chapter 3** (beginning on page 3-1) is an analysis of potential impacts in the subject areas mentioned above for the Proposed Action and development alternatives. This chapter also identifies relevant mitigation measures and potential significant unavoidable adverse environmental impacts.

FACT SHEET

Name of Project

Pioneer Aggregates South Parcel Project

Proponent

CalPortland

Location

The proposed *Pioneer Aggregates South Parcel Project* would occur on an approximately 313-acre site located on and to the southeast of the existing Pioneer Aggregates Mine in the City of DuPont, southwestern Pierce County, sections 22, 23, and 26, Township 19 North, Range 1 East of the Willamette Meridian. The site includes areas previously undisturbed by mining (termed the "Expansion Area") and mining deeper within a portion of existing mine (referred to as the "Re- Mine Area"). The Expansion Area is approximately 188 acres and is comprised of three subareas as follows: The *Kettle Area* is a 10.8-acre previously undisturbed area; the 9.2-acre *Buffer Strip* is a strip of vegetation that was retained along the inside of the originally permitted mine bordering the undeveloped South Parcel; and, the *South Parcel Area* is 168 acres located southeast of the original mine. The Re-Mine Area consists of 125 acres in the southeastern portion of the existing mine where current mining activities are permitted above current groundwater levels.

EIS Required

The City of DuPont issued a Determination of Significance (DS) on September 20, 2021 indicating that an Environmental Impact Statement must be prepared for the *Pioneer Aggregates South Parcel Project*.

EIS Alternatives

The EIS evaluates the Proposed Action (Alternative 1) and the No Action Alternative (Alternative 2) as described below:

Alternative 1 – Proposed Action

The Proposed Action is to allow horizontal expansion of mining into approximately 188 acres previously undisturbed by mining (Expansion Area), and vertical deepening of approximately 125 acres where mining would deepen a portion of the Existing Mine (Re-Mine Area). In advance of proposed mining, the Proposed

Action includes installation of wells to intercept and pump groundwater to dry out gravels for mining. The intercepted groundwater would be conveyed by surface channels and infiltrated in ponds on the floor of the Existing Mine. The Proposed Action is anticipated to extend mining at the current average rate for approximately 14 years. The method of mining and materials processing, and transport of materials would not change from current conditions at the Existing Mine.

Alternative 2 – No Action Alternative

This alternative is typically defined as what would most likely happen if the proposal does not move forward. According to the SEPA Rules, "no action" does not necessarily mean that nothing (no development in this case) would occur. The No Action Alternative that will be studied in this EIS will include two scenarios: Scenario A – Continuation of Existing Conditions (i.e. continuation of mining at the Existing Mine which has an estimated remaining life of 6 to 10 years with mining currently limited to an elevation of 10 feet above groundwater level); and, Scenario B – Site Development Under Existing Zoning (i.e. development under the existing Manufacturing and Research, Residential-4, Residential Reserve, and Open Space/Sensitive Area zoning designations). While it is unlikely that the Sequalitchew Creek Restoration Plan would be implemented if the proposal does not occur, it is possible that other funding (e.g., grants) could be obtained to carry out the Restoration Plan. Therefore, the No Action Alternative will reference the potential for the Sequalitchew Creek Restoration Plan to be implemented without the Proposed Action.

Lead Agency

City of DuPont

SEPA Responsible Official

Barbara Kincaid
Community Development Director
City of DuPont
DuPont, WA 98327

EIS Contact Person

Barbara Kincaid
Telephone: (253) 912-5393
Email: bkincaid@dupontwa.com

Required Approvals and/or Permits

Preliminary analysis indicates that the following approvals and/or permits may be required from agencies with jurisdiction[1] for continued mining. Additional permits/approvals may be required. Note that mining permits will not be legally effective unless and until permits for the Restoration Plan are issued.

State of Washington

- Dept. of Natural Resources - Reclamation Permit, Forest Practices Permit.
- Dept. of Ecology - NPDES, Administrative Order for Wetland Impacts.

City of DuPont

- Community Development – Site Plan Review, Tree Modification, Critical Areas Permit, Site Development Permit (including Grading Permit), Building Permit, Determination of Transportation Concurrency.
- Public Works – Site Work (Civil Work) Review and Storm Drainage Facilities Review.

EIS Authors and Principal Contributors

EA Engineering, Science and Technology, Inc., PBC

- EIS Project Manager, Primary Author: Project Description, Land Use, Peer Review Aesthetics and Air Quality.

DE Sherrard & Associates

- Surface Water & Groundwater Lead.

Aspect Consulting

- Surface Water, Groundwater, Earth.

Anchor QEA

- Trees, Critical Areas, Wetlands, Floodplain, Parking.

[1] An agency with jurisdiction is "an agency with authority to approve, veto or finance all or part of a nonexempt proposal (or part of a proposal)" (WAC 197-11-714(3)). Typically, this refers to a local, state or federal agency with licensing or permitting approval responsibility concerning a project.

Landau Associates

- Air Quality, Noise, and peer review for Earth and Surface Water.

Heffron Transportation

- Transportation

Historical Research Associates

- Cultural Resources

Mott MacDonald

- Peer Review - Groundwater

Raedeke Associates

- Peer Review - Trees, Critical Areas, Wetlands, Floodplain

BRC | Coffman Engineers

- Peer Review – Noise

Transpo Group

- Peer Review – Transportation, Parking

Cultural Resource Consultants

- Peer Review – Cultural Resources

ECONorthwest

- Economics & Fiscal

Location of Background Information

Background material and supporting documents are available at the offices of:

EA Engineering, Science and Technology, Inc., PBC
2200 Sixth Avenue, Suite 707
Seattle, WA 98121

City of DuPont
1700 Civic Drive
DuPont, WA 98327

Date of DEIS Issuance

June 14, 2024

Date DEIS Comments Are Due

July 15, 2024

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https://www.dupontwa.gov/719/Pioneer-Aggregates-South-Parcel-Project-

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Availability of this DEIS

Copies of this DEIS have been distributed to agencies, organizations and individuals noted on the Distribution List. This DEIS can be reviewed at:

DuPont City Hall
1700 Civic Drive
DuPont, WA 98327

The DEIS can be reviewed and downloaded by following the link below:
https://www.dupontwa.gov/719/Pioneer-Aggregates-South-Parcel-Project-

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4. ACRONYMS

5. REFERENCES

APPENDICES

A. Distribution List
B. Earth and Water Resources Report, Aspect Consulting, May 2023
C. Air Quality Assessment, Ramboll Corporation, September 2022
D. Stormwater Management Report, Aspect Consulting, February 2021
E. Groundwater Model Update, Aspect Consulting, June 2017
F. South Parcel Monitoring Plan, Aspect Consulting, November 2017
G. Fisheries Technical Report, Anchor QEA, June 2023
H. Plants & Animals Technical Report, Anchor QEA, June 2023
I. Landmarks Tree Inventory, Anchor QEA, August 2021
J. Floodplain Habitat Assessment & Mitigation Report, Anchor QEA, November 2020
K. Noise Study, Ramboll Corporation, September 2022
L. Visual Impact Analysis, ESA, December 2022
M. Cultural Resources Desktop Analysis, November 2022
N. Traffic Impact Assessment, Heffron Transportation, July 2022
O. Parking Narrative, Anchor QEA, November 2020
P. Fiscal Condition Assessment, ECONorthwest, February 2024

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Chapter 1
SUMMARY

CHAPTER 1
SUMMARY

1.1 INTRODUCTION

This chapter provides a summary of the Draft Environmental Impact Statement (Draft EIS) for the *Pioneer Aggregates South Parcel Project*. **Chapter 1** briefly describes the Proposed Action (Alternative 1) and the No Action Alternative (Alternative 2) and contains a comprehensive overview of environmental impacts identified for the Proposed Action and alternatives. Please see **Chapter 2** of this Draft EIS for a more detailed description of the Proposed Action and alternative and **Chapter 3** for a detailed description of the affected environment, environmental impacts, mitigation measures, and significant unavoidable adverse impacts.

The proposed *Pioneer Aggregates South Parcel Project* would occur on an approximately 313-acre site located on and to the southeast of the existing Pioneer Aggregates Mine in the City of DuPont, southwestern Pierce County, Sections 22, 23, and 26, Township 19 North, Range 1 East of the Willamette Meridian. The site includes areas previously undisturbed by mining (termed the "Expansion Area") and mining deeper within a portion of existing mine (referred to as the "Re- Mine Area"). The Expansion Area is approximately 188 acres and is comprised of three subareas as follows: The *Kettle Area* is a 10.8-acre previously undisturbed area; the 9.2-acre *Buffer Strip* is a strip of vegetation that was retained along the inside of the originally permitted mine bordering the undeveloped South Parcel; and the *South Parcel Area* is 168 acres located southeast of the original mine. The Re-Mine Area consists of 125 acres in the southeastern portion of the existing mine where current mining activities are permitted above current groundwater levels.

Alternative 1 – Proposed Action

The Proposed Action is to allow horizontal expansion of mining into approximately 188 acres previously undisturbed by mining (Expansion Area), and vertical deepening of approximately 125 acres where mining would deepen a portion of the Existing Mine (Re-Mine Area). In advance of proposed mining, the Proposed Action includes installation of wells to intercept and pump groundwater to dry out gravels for mining. The intercepted groundwater would be conveyed by surface channels and infiltrated in ponds on the floor of the Existing Mine. The Proposed Action is anticipated to extend mining at the current average rate for approximately 14 years. The method of mining and materials processing, and transport of materials would not change from current conditions at the Existing Mine.

Alternative 2 – No Action Alternative

This alternative is typically defined as what would most likely happen if the proposal does not move forward. According to the SEPA Rules, "no action" does not necessarily mean that nothing (no development in this case) would occur. The No Action Alternative that will be studied in this EIS will include two scenarios: Scenario A – Continuation of Existing Conditions (i.e. continuation of mining at the Existing Mine which has an estimated remaining life of 6 to 10 years with mining currently limited to an elevation of 10 feet above groundwater level); and, Scenario B – Site Development Under Existing Zoning (i.e. development under the existing Manufacturing and Research, Residential-4, Residential Reserve, and Open Space/Sensitive Area zoning designations). While it is unlikely that the Sequalitchew Creek Restoration Plan would be implemented if the proposal does not occur, it is possible that other funding (e.g., grants) could be obtained to carry out the Restoration Plan. Therefore, the No Action Alternative will reference the potential for the Sequalitchew Creek Restoration Plan to be implemented without the Proposed Action.

1.2 IMPACTS, MITIGATION MEASURES AND SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

The following highlights the impacts, mitigation measures, and significant unavoidable adverse impacts that would potentially result from the alternatives analyzed in this Draft EIS. **Table 1-1** summarizes the potential impacts that would be anticipated under the EIS Alternatives. This summary is not intended to be a substitute for the complete discussion of each element that is contained in **Chapter 3**.

For the Draft EIS analysis, the Sequalitchew Creek Restoration Plan is considered a separate project. As such, the summary of impacts of the Proposed Action only addresses the impacts of proposed mining/reclamation and does not include implementation of the Restoration Plan. The combined impacts of mining under the Proposed Action together with implementation of the Sequalitchew Creek Restoration Plan are discussed as cumulative impacts.

Table 1-1
IMPACT SUMMARY MATRIX

Alternative 1 Proposed Action	Alternative 2 No Action Alternative
3.1 – EARTH	
• Natural deposits of sand and gravel would be removed, altering the topography and leaving an irregular-shaped bowl. Following mining, slopes would be re-contoured consistent with the reclamation plan.	• Under Scenario A mining activities at the Re-Mine Area would continue as permitted, with the Expansion Area remaining in forest. The Expansion Area would be redeveloped under existing zoning and would likely remain relatively flat under Scenario B.
• Stability of the slopes would be acceptable and exceed static and seismic safety values.	• Under Scenario A the mine slopes within the Re-Mine Area would be consistent with approved permits, with the Expansion Area remaining undeveloped. Development under existing zoning in the Expansion Area under Scenario B would not be expected to result in substantial slopes.
• Considering the course-grained nature and good infiltration characteristics and the proposed stormwater control system, erosion impacts are not anticipated.	• Under Scenario A stormwater in the Re-Mine Area would be controlled as under current conditions. Under Scenario B clearing and development under existing zoning would result in the potential for erosion; stormwater control during construction and operations would be required to be consistent with applicable regulations.
• The proposed mining and reclamation are intended to serve as a final remedy for any lead and arsenic impacted soils, and impacts associated with past industrial activities on the site and deposits associated with the Tacoma Smelter Plume are not anticipated.	• Under Scenario A the Re-Mine Area would be reclaimed consistent with the current approved Reclamation Plan, and the Expansion Area would remain forest land. Development under existing zoning under Scenario B would require measures for final remedy of contaminants on the site.
• Impacts to Landslide, Steep Slope, and Erosion Hazard Areas associated with Sequalitchew Creek ravine are not anticipated.	• As under Alternative 1, impacts to Landslide, Steep Slope, and Erosion Hazard areas associated with Sequalitchew Creek would not be anticipated under Scenario A or Scenario B.

Alternative 1 Proposed Action	Alternative 2 No Action Alternative
3.2 – AIR QUALITY	
• Site preparation activities (logging and clearing, topsoil removal, and construction of perimeter berms) may temporarily cause localized increases in particulate matter (dust) and engine exhaust pollutants. Emissions would be temporary and localized and is expected to be minimal compared to regional emissions.	• Under Scenario A mining activity on the Re-Mine Area would continue until permitted mining is complete (6 to 10 years estimate). Under Scenario B development of the Expansion Area under existing zoning would result in fugitive dust, equipment emissions, and GHG emissions from construction, Operations of uses under existing zoning would also generate emissions.
• Fugitive dust emissions associated with mining and transport of materials would occur, primarily during the drier summer months. With operations conducted consistent with applicable air quality regulations, significant impacts are not anticipated.	• Fugitive dust emissions under Scenario A and Scenario B would generally be as described above.
• Greenhouse gas emissions (GHG emissions) associated with direct emissions (proposed mining, processing, and transport) and indirect emissions (production of electricity utilized and transport) would occur. The annual generation of GHG emissions would not change, although the timeframe for mining on the site would be extended. The direct/indirect GHG emissions associated with the Proposed Action would represent a very small percentage of the total state-wide inventory.	• GHG emissions on the Re-Mine Area under Scenario A would be as under current conditions with the Expansion Area remaining undeveloped. Under Scenario B development of the Expansion Area with construction and operation of uses under existing zoning would be anticipated to generate GHG emissions at a similar magnitude as Alternative 1.
3.3 – GROUNDWATER	
Impacts of the Proposed Action • Vashon Aquifer water levels would decrease due to dewatering activities needed for mining. Ultimately, the gravel deposits of which the Vashon Aquifer is comprised would be removed from the Re-Mine Area and part of the South Parcel. Drawdown of the Vashon Aquifer is anticipated to affect groundwater within a one to two-mile radius from the proposed mine site, with aquifer drawdown projected to generally decrease with increasing distance from the dewatering area. The extracted groundwater would be conveyed to a constructed wetland system and ultimately infiltration galleries located at the bottom of the current mine, where the Vashon Aquifer and the Sea Level Aquifer are comingled and permeable Steilacoom Gravels are present.	• Under Scenario A, mining activities at the Re-Mine Area would continue as permitted and would occur above the groundwater level. No active dewatering wells or passive dewatering trough would be installed and the associated decrease in Vashon Aquifer levels would not occur. Under Scenario B, the increase in impervious surfaces on the site with development consistent with existing zoning would increase surface water runoff and decrease area available for groundwater recharge to underlying aquifers; however, with adherence to applicable regulations related to stormwater quantity, significant impacts are not anticipated.

Alternative 1 Proposed Action	Alternative 2 No Action Alternative
• Potential impacts on aquifer water levels are expected to build slowly over time as wells are added and mining progresses southward. At the end of mining, a passive dewatering trough would be constructed at the toe of the eastern mine slope to collect groundwater and replace the dewatering wells.	• No potential impacts on aquifer levels would occur because no active dewatering wells or passive dewatering trough would be installed under Scenario A or Scenario B.
• With active dewatering during mining, the ("worst case scenario") maximum predicted aquifer drawdown is 69.56 feet beneath the South Parcel and is up to 9.29 feet beneath the western edge of the off-site marsh complex. Maximum performance threshold drawdowns farther east in the marsh complex are approximately one foot or less. With passive dewatering at the end of mining, the maximum predicted aquifer drawdown is 64.43 feet beneath the South Parcel and is up to 8.73 feet beneath the marsh complex. Maximum performance threshold drawdowns farther east in the marsh complex are approximately one foot or less.	• No aquifer drawdown would occur because no active dewatering wells or passive dewatering trough would be installed under Scenario A or Scenario B.
• With the Proposed Action, the general groundwater flow direction in the Vashon Aquifer is expected to remain to the northwest. However, in the immediate vicinity of the project site, local groundwater flow paths are expected to change and flow toward the dewatering wells (or the groundwater collection trough in the last step of groundwater dewatering) rather than flowing toward their existing natural discharge points (i.e., the Olympia Beds Truncation or seeps in the Sequalitchew Creek ravine). Up to 79% of the groundwater flows to Sequalitchew Creek would be lost. Predicted water level changes in the Sea Level Aquifer are expected to be negligible beneath the Olympia Beds. Lower groundwater levels in the Vashon Aquifer near the site are expected to result in less groundwater discharge to surface water bodies and more aquifer recharge due to surface water losses.	• No changes in groundwater flow direction are expected under Scenario A or Scenario B.

Alternative 1 Proposed Action	Alternative 2 No Action Alternative
• Groundwater quality beneath and in the area of the South Parcel would largely be unaffected by the Proposed Action. Mining permits require best management practices for groundwater and stormwater pollution prevention, defined spill control and cleanup procedures, and operations management to minimize the use of potential pollutants within the mine.	• No significant impacts on groundwater quality are expected with continuing mining activities at the Re-Mine Area under Scenario A as mining permits requiring BMPs would be required, similar to for the Proposed Action. Clearing and grading associated with construction activities for Scenario B would increase potential for erosion impacts to surface and groundwater resources. With adherence to applicable regulations during construction, significant impacts to groundwater quality are not anticipated
• Drinking water supplies near the South Parcel (Sequalitchew Springs, DuPont's Bell Hill and Hoffman Hill wellfields) are not expected to be impacted by the Proposed Action since they are either significantly up gradient of the project site (Sequalitchew Springs) or completed in deeper aquifers that are separated from the Vashon Aquifer by confining units.	• No significant impacts on water supplies are expected under Scenario A or Scenario B, similar to under the Proposed Action.
Cumulative Conditions • The combined impacts of mining under the Proposed Action together with implementation of the Sequalitchew Creek Restoration Plan (the "cumulative condition") on groundwater would include: ○ East Edmond Marsh is predicted to become a groundwater discharge feature; groundwater recharge is expected to increase beneath West Edmond Marsh; significant changes in the groundwater recharge/discharge relationships are not expected at Bell, McKay, and Hamer Marshes. ○ Greater surface water flow through West Edmond Marsh and the Sequalitchew Creek "dry reach" is likely to increase groundwater recharge in its vicinity. Increased recharge in this area would potentially cause spring discharge in the upper Sequalitchew Creek ravine to increase. ○ Streamflow loss from Lower Sequalitchew Creek to the combined Vashon-Sea Level Aquifer should increase (as well as nearby aquifer water level). ○ During dry summers (when Sequalitchew Springs discharge to Sequalitchew Lake is fully consumed by	• There is a potential that the Sequalitchew Creek Restoration Plan could be implemented without the Proposed Action (alternative funding sources would be necessary). If so, cumulative conditions would be generally similar to Alternative 1.

Alternative 1 Proposed Action	Alternative 2 No Action Alternative
JBLM), no surface water outflow from Sequalitchew Lake to East Edmond Marsh and Sequalitchew Creek would occur. Lower reaches of Sequalitchew Creek would be dry. ○ Intertidal spring water quality and discharge rates from the combined Vashon-Sea Level Aquifer are not expected to change. ○ Recharge near the Diversion Canal (if any) would likely decrease; however, the canal is not a significant source of recharge to the aquifer.	
3.4 – SURFACE WATER	
Impacts of the Proposed Action • Under the Proposed Action, there would likely be impacts to surface water features both onsite and within the larger Sequalitchew Creek watershed, primarily due to the permanently lowered groundwater levels in the vicinity of the site due to long-term pumping and groundwater drainage at the site.	• Under Scenario A, mining activities at the Re-Mine Area would continue as permitted. No active dewatering wells or passive dewatering trough would be installed and the associated impacts from these activities on surface water features would not occur. Under Scenario B, the increase in impervious surfaces on the site with development consistent with existing zoning would increase surface water runoff; however, with adherence to applicable regulations related to stormwater quantity, significant impacts on surface water are not anticipated.
• On an overall basis, on-site grading would affect stormwater flows, but not the overall stormwater balance, within the site. Primarily, changes in groundwater levels beneath the site resulting from proposed groundwater lowering are expected to affect flow in Sequalitchew Creek and surface water levels in the marsh system.	• On-site grading would occur under Scenario A in the Re-Mine Area. On-site grading would also occur under Scenario B, but much less than under the Proposed Action. Similar to the Proposed Action, grading for these Scenarios would affect stormwater flows but not the overall stormwater balance.
• *Sequalitchew Lake* - Water levels in the lake are not anticipated to be significantly impacted by the Proposed Action because the primary water source to the lake is groundwater (spring) discharge at the far eastern end. This source is far from appreciable groundwater drawdown area from the project. Also, the lake level is controlled by the Diversion Weir.	• Water levels in the lake are not anticipated to be significantly impacted under Scenario A or Scenario B because groundwater drawdown would not occur.
• *Marsh System* - Water levels in the off-site marshes]are expected to be lowered, due to the proposed groundwater lowering. The effect on marsh water levels is anticipated to vary seasonally as	• Water levels in the marsh system are not anticipated to be lowered under Scenario A or Scenario B , because groundwater drawdown would not occur.

Alternative 1 Proposed Action	Alternative 2 No Action Alternative
well. In West Edmond Marsh, there could be an average decline of 1.9 ft., in East Edmond Marsh an average decline of 0.1 ft., and in Bell-McKay-Hamer Marshes and average decline of 0.3 ft.	
• *Sequalitchew Creek* - The Proposed Action and associated groundwater-level lowering would decrease the number and flow rate of groundwater seeps and springs feeding Sequalitchew Creek within the ravine section. With passive dewatering at the end of mining, reductions in spring flows leading to the creek are anticipated to occur throughout the entire year and to range from 76% (in January) to 86% (in summer). Base flow and peak flow in the creek are accordingly expected to be reduced. The annual average flow in Sequalitchew Creek is anticipated to be reduced from approximately 1.6 cfs to approximately 0.34 cfs.	• Decreases in the number and flow rate of groundwater seeps and springs feeding Sequalitchew Creek are not expected under Scenario A or Scenario B because groundwater drawdown would not occur.
• *Other Surface Water Features* - Wetland 1-D; Pond Lake, Strickland, Grant, and Old Fort Lakes; and Wetlands #8, #9, #10, and #11 may be impacted by the proposed groundwater lowering. The magnitude of the impact would depend on proximity to the proposed groundwater lowering activities at the site. Impacts to Wetland 1-D water levels would be the greatest (reduced by approximately 3 ft). Water levels at the other off-site water features would be reduced from 0.5 ft (Old Fort Lakes) to 2 ft (Pond Lake). The on-site Kettle Wetland and its buffer would be cleared under the Proposed Action, and the entire wetland would be eliminated. The proposal includes creation of a new wetland onsite.	• Other off-site water features are not expected to be impacted under Scenario A or Scenario B because groundwater drawdown would not occur. The on-site Kettle Wetland would not be eliminated under either Scenario.
Cumulative Conditions • The combined impacts of mining under the Proposed Action together with implementation of the Sequalitchew Creek Restoration Plan (the "cumulative condition") on surface water would include: ○ *Marsh System* - Target water levels in the East and West Edmond Marshes could generally be achieved, resulting in continuous surface water flow from Sequalitchew Lake through to Sequalitchew Creek. In general, the water quality within East and West Edmond Marshes is expected to be	• There is a potential that the Sequalitchew Creek Restoration Plan could be implemented without the Proposed Action (alternative funding sources would be necessary). If so, cumulative conditions would be generally similar to Alternative 1.

Alternative 1 Proposed Action	Alternative 2 No Action Alternative
improved under the Proposed Action and the Restoration Plan, due to increased and consistent surface water inflows from Sequalitchew Lake and flushing out through Sequalitchew Creek. ○ *Sequalitchew Creek* - Flow rates and volumes delivered to and flowing through the dry reach segment of Sequalitchew Creek between West Edmond Marsh and the ravine section of the creek are generally expected to increase. However, even with the Restoration Plan, there may still be periods of dry, no-flow conditions in the dry reach of the creek. The number of no-flow days at the mid-ravine would be expected to increase under the Proposed Action and Restoration Plan scenario because of reduced or eliminated groundwater seepage to the ravine section of the creek that would no longer be present to add flows to the creek. These lower predicted flows in the creek are anticipated to occur typically in the period from July through October. However, no flow days are rare under existing conditions and would remain rare with the Proposed Action and Restoration Plan. The water quality effects in the ravine section of Sequalitchew Creek from the combined Proposed Project and Restoration Plan scenario would be primarily related to temperature. Temperatures in the creek in the winter are expected to fall to 5 or 6°C (41°F to 43°F). Creek temperatures in the summer—particularly June through August—are expected to rise to 21°C. ○ *Other Surface Water Features* – other nearby surface water bodies would not benefit directly from the Restoration Plan implementation and would be expected to be impacted by the proposed groundwater lowering in a similar manner to described under the Proposed Action. ○ *Stormwater Management* – stormwater management would be implemented similar to under the Proposed Action.	

Alternative 1 Proposed Action	Alternative 2 No Action Alternative
3.5 – FISHERIES	
Impacts of the Proposed Action • Potential fisheries impacts to the marine shoreline include effects from the spillage of sand and gravel from the conveyor, potential for overturning of barges during loading, accidental spills of pollutants, shading, and lighting. Extending the life of the conveyor and barge loading dock by about 14 years would extend any impacts to areas directly beneath the dock by shading the shallow water, as well as impacts associated with dock lighting.	• Under Scenario A the current conditions associated with the marine shoreline associated with potential spillage of sand and gravel from the conveyer and potential barge spills would continue, although for a shorter mine life. Under Scenario B clearing and grading associated with construction of residential and manufacturing/research park use would increase potential for erosion impacts to area fisheries resources; with adherence to applicable regulations during construction, significant impacts to these resources are not anticipated. The increase in impervious surfaces on the Expansion Area portion of the site with development consistent with existing zoning would increase surface water runoff; with adherence to applicable regulations related to stormwater quantity and quality, significant impacts are not anticipated.
Cumulative Conditions • The combined impacts of mining under the Proposed Action together with implementation of the Sequalitchew Creek Restoration Plan (the 'cumulative condition') on stream habitat would include a re-establishment of flow from Sequalitchew Lake to flow through the marshes and into Sequalitchew Creek ravine, and re-establishing ecosystem processes. The increase in hydrology and stream energy would increase aquatic ecosystem productivity and create and maintain habitat diversity, particularly for target species such as chum salmon and cutthroat trout in the system.	• Under Scenario A, the condition of Sequalitchew Creek fish habitat would remain as under existing conditions. There is a potential that the Sequalitchew Creek Restoration Plan could be implemented without the Proposed Action (alternative funding sources would be necessary) and cumulative conditions would be generally similar to Alternative 1. Under Scenario B, an increased potential for fisheries impacts from stormwater runoff during construction and operation uses consistent with existing zoning on the Expansion Area would occur. Cumulative conditions under Scenario B would be similar to Scenario A.
• The cumulative condition would affect stream temperature in the Sequalitchew Creek ravine by restoring the flow of surface water in the system at a different temperature. The effects would vary seasonally as the volume of water from Sequalitchew Lake and temperature vary. In summer, the outflow from Sequalitchew Lake is warmer than Sequalitchew Creek; groundwater input to the creek would also be reduced due to groundwater diversion. This temperature increase could alter habitat for juvenile fish.	• Water temperature conditions associated with the Sequalitchew Creek Restoration Plan may not occur under Scenario A or Scenario B. There is a potential that the Sequalitchew Creek Restoration Plan could be implemented without the Proposed Action (alternative funding sources would be necessary); if implemented, temperature conditions under either alternative would be similar to Alternative 1, although the temperature increase in creek water could be less than under Alternative 1 given retention of groundwater input to the creek.
• Flows in the dry reach area upstream of Sequalitchew Creek ravine (an area that currently receives inconsistent flow, with periods of no flow) would increase in the cumulative condition and improve fisheries habitat conditions. However, there could be periods	• Flows in the dry reach area upstream or the Sequalitchew Creek ravine would not increase under Scenario A or Scenario B without implementation of the Sequalitchew Creek Restoration Plan. There is a potential that the Sequalitchew Creek Restoration Plan could be implemented without the Proposed Action

Alternative 1 Proposed Action	Alternative 2 No Action Alternative
where there would continue to be no flow which would temporarily disrupt the enhanced habitat and fish migratory functions of the stream reach.	(alternative funding sources would be necessary); if implemented, flow conditions in the dry reach area would be similar to Alternative 1.
• The vast majority of flow at mid-ravine would originate from Sequalitchew Lake. Springs within the ravine currently contribute to mid-ravine flows, and groundwater input to springs would be reduced or eliminated. The contribution from springs with the Proposed Action and Sequalitchew Creek Restoration Plan would be lower than under existing conditions.	• Flow to the mid-ravine under Scenario A and Scenario B would be similar to current conditions without implementation of the Sequalitchew Creek Restoration Plan. There is a potential that the Sequalitchew Creek Restoration Plan could be implemented without the Proposed Action (alternative funding sources would be necessary); if implemented, flow conditions in the mid-ravine would be similar to Alternative 1 although contribution from springs to mid-ravine flows would likely be higher than under Alternative 1.
3.6 – PLANTS & ANIMALS	
Impacts of the Proposed Action - Plants • Direct plant and habitat impacts would include clearing of remaining forest within the Re-Mine Area and majority of forest and shrubland/grassland within the Expansion Area.	• Under Scenario A the remaining forest within the Re-Mine Area, and forest and shrubland/grassland within the Expansion Area would remain. Under Scenario B the majority of the forest and shrubland/grassland in the Expansion Area would be cleared to accommodate development under existing zoning.
• Approximately 90 landmark trees would be removed. Replacement of landmark trees would be provided consistent with City of DuPont replacement ratio guidance.	• The existing landmark trees on the site would remain as under existing conditions under Scenario A. Under Scenario B, the majority of the Expansion Area would likely be cleared in association with development under existing zoning, with landmark trees retained or replaced in accordance with DMC requirements.
• The 1.8-acre Kettle Wetland and buffer would be cleared and eliminated. Proposed mitigation includes creation of new wetland.	• The Kettle Wetland and wetland would be retained under both Scenario A and Scenario B. The Kettle Wetland buffer width could be reduced to the DMC minimum under Scenario B.
Cumulative Conditions - Plants • No cumulative impacts to forest, landmark trees, shrublands, or grasslands habitat anticipated.	• No cumulative impacts to forest, landmark trees, shrublands and grasslands habitat anticipated under Scenario A or Scenario B.
• Sequalitchew Creek Restoration would include re-establishment of flow from Sequalitchew Lake through marshes and to Sequalitchew Creek. Cumulative conditions at specific aquatic resources most applicable to the proposal are as follows: • *West Edmond Marsh* – seasonal fluctuations in water levels would decrease which would help stabilize vegetation communities;	• Under Scenario A and Scenario B the Sequalitchew Creek Restoration Plan would not receive funding from the Applicant, although it is possible that funding for the plan could be provided from another source(s). If funding for the Sequalitchew Creek Restoration Plan were to be obtained and the plan in implemented, conditions at the West Edmond Marsh, East Edmond March, and Brackish March would be similar to the cumulative condition under Alternative 1. The changes to groundwater flow that would disrupt ravine (seep) wetlands under Alternative 1 would likely not occur under Scenario A and Scenario B.

Alternative 1 Proposed Action	Alternative 2 No Action Alternative
• *East Edmond Marsh* – restored gradient between Lake Sequalitchew to Sequalitchew Creek ravine would allow for re-establishment forested wetland and wetland buffer. • *Sequalitchew Creek Ravine Wetlands* – Changes to groundwater flow would disrupt ravine (seep) wetland habitat. Increased creek flow would also change creek width and increase sediment load which would affect riparian and floodplain wetland communities. • *Brackish Marsh* – Increased flows in Sequalitchew Creek would increase sediment input and decrease salinity at the creek mouth; these conditions are not expected to impact existing marsh vegetation or functions.	
Impacts of the Proposed Action - Animals • Foraging and breeding habitat for birds and mammals would be reduced and degraded. Clearing of vegetation would increase the fragmentation and isolation of remaining habitat.	• Under Scenario A the remaining forest habitat within the Re-Mine Area, and forest and shrubland/grassland habitat within the Expansion Area would remain. Under Scenario B the majority of the vegetation habitat in the Expansion Area would be cleared and/or fragmented to accommodate development under existing zoning.
• Removal of mature trees in the coniferous forest could reduce habitat for big brown bat, little brown bat, and Yuma myotis bat priority species. Clearing of forested areas within the site would reduce habitat that is thought to have once been within the historical range of gray squirrels but is unlikely to be occupied by the current population.	• Under Scenario A the remaining forest within the Re-Mine Area, and forest within the Expansion Area would remain as would associated animal habitat. Under Scenario B the majority of the forest and associated animal habitat in the Expansion Area would be cleared to accommodate development under existing zoning
• Within the Kettle Wetland any existing amphibians would perish or be displaced during the clearing of the surface vegetation and soils. New habitat with similar hydrology would be provided in the mitigation wetland.	• The Kettle Wetland and wetland would be retained under both Scenario A and Scenario B. The Kettle Wetland buffer width could be reduced to the DMC minimum under Scenario B.
Cumulative Conditions - Animals • For birds the cumulative condition (specifically the Restoration Plan) would reverse the changes in bird habitat in East and West Edmond Marsh that have occurred over the last three decades. This would include a reorganization of some specific habitats to include scrub-shrub wetlands and forested wetlands. It would increase the area of forested wetland buffer as water levels in	• Under Scenario A, the condition of bird would remain as under existing conditions. There is a potential that the Sequalitchew Creek Restoration Plan could be implemented without the Proposed Action (alternative funding sources would be necessary) and cumulative conditions would be generally similar to Alternative 1. Under Scenario B, an increased potential for South Parcel clearing during

Alternative 1 Proposed Action	Alternative 2 No Action Alternative
some areas of East Edmond Marsh drop and increase the amount of and persistence of emergent wetland habitat in the west end of West Edmond Marsh.	construction and activity associated with uses consistent with existing zoning on the Expansion Area would occur. Cumulative conditions under Scenario B would be similar to Scenario A.
• Beaver in the Edmond Marsh complex would be actively managed under the cumulative condition (specifically the Sequalitchew Creek Restoration Plan). The intent is to maintain the beaver population while managing water levels to restore flow. Other mammal species are expected to see increases in available habitat, particularly where water levels drop providing additional denning opportunities in the wetland banks and increasing the size of upland islands within the wetland complex.	• Beaver management in the Edmond Marsh complex would not occur under Scenario A or Scenario B without implementation of the Sequalitchew Creek Restoration Plan. There is a potential that the Sequalitchew Creek Restoration Plan could be implemented without the Proposed Action (alternative funding sources would be necessary); if implemented, beaver management would be similar to Alternative 1.
• Amphibian reproduction can be adversely affected by sudden, non-seasonal changes in water levels. This occurs in West Edmond Marsh when the large beaver dam above the dry reach is breached. Amphibian eggs attached to the stalks of emergent vegetation would suddenly be above water, causing complete mortality. Areas of reduced wetland area under the cumulative condition in the Edmond Marsh complex could reduce the area of habitat for some amphibian species, while others would benefit from the re-establishment of the forested riparian buffer.	• Amphibian conditions would remain as under current conditions under Scenario A or Scenario B without implementation of the Sequalitchew Creek Restoration Plan. There is a potential that the Sequalitchew Creek Restoration Plan could be implemented without the Proposed Action (alternative funding sources would be necessary); if implemented, amphibian conditions would be similar to Alternative 1.
3.7 – NOISE	
• Site preparation activity (logging, top soil removal, extension of conveyors, etc.) would entail heavy equipment similar to that used in current mining, and noise levels associated with site preparation would be similar to that under current and proposed mining. Site preparation activities could result in temporary and short-term increases in noise levels.	• Under Scenario A noise associated with continued mining in the Re-Mine Area would continue to generate noise similar to existing conditions for the duration of remaining mining (6 to 10 years estimated). The Expansion Area would remain undeveloped. Under Scenario B construction associated with development under existing zoning would generate temporary increases in noise.
• Operational noise from equipment used for mining (front-end loaders, bulldozer, and electric conveyor) would increase compared to existing conditions.	• Under Scenario A noise associated with continued mining in the Re-Mine Area would continue to generate noise similar to existing conditions for the duration of remaining mining (6 to 10 years estimated). Operation of residential and manufacturing/research uses under Scenario B would generate noise associated with traffic and on-site activity.

Alternative 1 Proposed Action	Alternative 2 No Action Alternative
• Noise associated with proposed mining was modeled (CadnaA noise model), and modeled noise levels generally complied with applicable noise limits. Some exceedance at the upper floors of the Creekside Apartment units facing the site may exceed limits if Phase 2C mining occurred during early morning hours (between 5 and 7 AM); limiting bulldozer use during these morning hours results in modeled noise levels below the noise limit.	• Noise associated with continued mining on the Re-Mine Area under Scenario A would be as under current conditions. Under Scenario B construction and operation of uses under existing zoning on the Expansion Area would generate noise; noise levels would be required to be in compliance with applicable noise limits.
3.8 – LAND USE	
• The Proposed Action would continue mining use on the Re-mine Area and would change the land use of the Expansion Area from undeveloped forest area to mining use.	• Under Scenario A the use of the Re-Mine Area would continue in mining use and the Expansion Area would remain as undeveloped forest. The Expansion Area would be converted to manufacturing/research and residential use under Scenario B.
• No existing uses would be displaced under the Proposed Action.	• No existing uses would be displaced under Scenario A or Scenario B, although the Expansion Area would be developed consistent with existing zoning under Scenario B.
• Portions of the Expansion Area are proximate to surrounding sensitive uses off-site and mining activity (noise, dust) has the potential to be perceived at surrounding uses, including recreational and residential land uses.	• Under Scenario A the use of the Re-Mine Area would continue in mining use and the Expansion Area would remain as undeveloped forest. Under Scenario B the Expansion Area would be redeveloped with manufacturing/research and residential uses under existing zoning, and activity associated with these uses (noise, traffic, etc.) has the potential to be perceived at surrounding land uses.
• The proposed minimum 100-foot wide vegetated setback from the top of the Sequalitchew Creek ravine slope, coupled with a 20-foot high berm where the trail is not in the ravine, would limit the potential for impacts to users of the trail.	• Under Scenario A the Expansion Area would remain in undeveloped forest use. Redevelopment of the Expansion Area with manufacturing/research and residential uses consistent with existing zoning under Scenario B would be required to provide 25-foot front setbacks and 15-foot side and rear setbacks; providing a 20-foot high berm where the trail is not in a ravine is not a zoning requirement.
• The southeast corner of the Expansion Area is proximate to the Creekside Village apartment complex and phased clearing and mining (Phase 2C) would occur in proximity to this residential use. The vegetated perimeter buffer and 20-foot high berm would limit the potential for impacts.	• The Expansion Area would remain in undeveloped forest use under Scenario A. Under Scenario B the southeast corner of the Expansion Area would be developed with uses consistent with the Manufacturing/Research Park zoning. A 20-foot high berm is not required under existing zoning.
• On an overall basis, proposed mining is not expected to indirectly affect uses in the vicinity. Proposed mining activities are considered a transitional use and would not prevent future uses of	• As under Alternative 1, land use under Scenario A would not be anticipated to result in indirect land use impacts or generate spin-of uses. Residential and manufacturing/research uses under Scenario B would provide new site residents and employees that would increase the potential for spin-off uses in the area

Alternative 1 Proposed Action	Alternative 2 No Action Alternative
the area. It is not anticipated that the Proposed Action would generate any spin-off uses in the area.	
3.9 - AESTHETICS	
• Under the Proposed Action site preparation and extraction of mined material would result in a permanent change in the visual character of the Expansion Area portion of the site.	• Under Scenario A the Expansion Area would remain in undeveloped forest visual character. Manufacturing/research park and residential development under Scenario B would permanently change the visual character of the Expansion Area.
• The change of visual character of the Expansion Area would occur incrementally over an approximately 14-year period.	• Under Scenario A the Expansion Area would remain in undeveloped forest visual character. Manufacturing/research park and residential development under Scenario B would permanently change the visual character of the Expansion Area.
• Six viewpoints representative of viewpoints where public views toward the site are simulated to illustrate to illustrate the potential for visual impacts. ○ Changes to the existing view from the identified viewpoints primarily relate to the removal of mature trees on the site from viewpoints along Powerline Road and at Powerline Road Community Garden. ○ Views to the site would not be affected from viewpoints at Sequalitchew Drive, Sequalitchew Trail, or the Home Course.	• Visual conditions would be as under existing conditions under Scenario A with a similar potential for visual change under Scenario B as under Alternative 1. ○ Depending on the level of development on the Expansion Area under Scenario B some removal of mature trees could be visible. Depending on the location and height of buildings some buildings could be visible. ○ Given the intervening topography, development under Scenario B would likely not be visible from the Sequalitchew Drive, Sequalitchew Trail or Home Course viewpoints.
3.10 – CULTURAL RESOURCES	
• A review of archaeological sites in or near the Area of Impacts (ADI) was completed for this EIS.	• Same as Alternative 1 for Scenario A and Scenario B.
• Three known archaeological are located within the ADI and one known site is located south of the ADI. ○ Site 45P162 – Railroad Dump #2 (*within the ADI*) ○ Site 45P163 – Railroad Dump #3 (*within the ADI*) ○ Site 45P166 – Methodist Episcopal Mission (*outside ADI*) ○ Site 45P170 – DuPont Company (*within ADI*)	• Same as Alternative 1 for Scenario A and Scenario B.
• Sites 45P162, 45P163 and 45P170 within the ADI have been deemed not eligible for listing in the National Register of Historic	• Same as Alternative 1 for Scenario A and Scenario B.

Alternative 1 Proposed Action	Alternative 2 No Action Alternative
Places (NRHP) and Site 45P166 is located outside of the ADI and would not be impacted.	
3.11 – TRANSPORTATION	
• Trip generation would continue at current levels and would remain below the peak day estimates evaluated in the 2013 North Parcel FEIS.	• Under Scenario A current traffic conditions associated with the Re-Mine Area would continue and there would be no traffic associated with the Expansion Area. Construction and operational traffic typical of manufacturing/research and residential uses would be generated on the Expansion Area under Scenario B.
• As indicated in the 2013 North Parcel FEIS, "*because the project generated trips would represent a small portion of traffic volumes at study intersections and would have negligible effect on the levels of service at the I-5 ramps and city intersections, no adverse level of service impacts are projected to result from the South Parcel proposal.*" This conclusion is applicable to the Proposed Action.	• The conclusion from the 2013 North Parcel FEIS is not applicable to either Scenario A or Scenario B.
3.12 – FISCAL	
• Fiscal conditions are primarily a function of tax revenues to the City of DuPont generated by the Proposed Action and City of DuPont service costs associated with the proposal.	• Similar to Alternative 1 for Scenario A and Scenario B.
• The most relevant tax revenue sources to the City of DuPont associated with the Proposed Action include property taxes, sales & use taxes, business & occupation taxes, and utility taxes.	• Similar to Alternative 1 for Scenario A and Scenario B.
• Public service costs to the City of DuPont associated with the Proposed Action include costs associated with: Police and Fire Departments; Parks/Facilities/Greenways; General City Administration; Community Development; and Public Works (street maintenance).	• Similar to Alternative 1 for Scenario A and Scenario B.
• The cost/revenue balance to the City of DuPont associated with the Proposed Action is analyzed under two approaches (cost allocation approach and average value approach). The fiscal analysis indicates a surplus to the City of DuPont under either approach, ranging from an estimated annual surplus of $18,400 under the cost allocation	• For Scenario A the current cost/revenue condition associated with the Re-Mine Area would continue, with minimal revenue and cost associated with the Expansion Area. For Scenario B the current cost/revenue condition associated with the Re-Mine Area would continue. For the Expansion Area, both manufacturing/research and residential uses represent a more intense use of the land that would lead to more property, sales, and utility, and other taxes on a per

Alternative 1 Proposed Action	Alternative 2 No Action Alternative
approach to an estimated annual surplus of $125,700 under the average value approach.	square foot basis. However, on the cost side these uses also generate more needs for public services such as public safety services for residential uses and public works needs to support manufacturing uses.

SUMMARY OF MITIGATION MEASURES AND SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

3.1 Earth

Mitigation Measures

The following mitigation measures have been included in the Proposed Action to reduce impacts on slope stability and erosion (see to Section 3.3, **Surface Water**, and Section 3.4, **Groundwater** for additional discussion and mitigation measures related to surface water and groundwater):

- A reclamation plan would be prepared and implemented in accordance with the Surface Mining Act (RCW 78.44). The reclamation plan would be submitted to DNR for review and approval prior to mining. Prior review by the City is also required as part of that process.

- Mining would occur in segments; no mass clearing of the Expansion Area portion of the site would occur.

- An erosion and sediment control plan would be prepared and implemented in accordance with the requirements of the City of DuPont Municipal Code (DMC 22.01.180) and the NPDES Sand and Gravel General Permit. Erosion control features would include stormwater drainage into the interior of the mine and onsite stormwater disposal.

- A vegetated buffer would be maintained between the proposed mine area and the top of steep slopes in accordance with the City of DuPont's Sensitive Areas Code [DMC 25.105.070(2)].

- A 100-foot setback would be maintained from the top of slopes greater than 40% within the Sequalitchew Creek ravine, consistent with the conditions for the existing mine and the 1994 and 2012 Settlement Agreements.

- Earthwork for excavation and reclamation would be in accordance with the federal and state statutes of the Mine Safety and Health Act and the Surface Mining Act.

- Topsoil would be stockpiled and used for reclamation of mined areas. Consistent with the approved Reclamation Plan, Cleanup Action Plan developed for the South Parcel Project and published Ecology guidance, samples would be collected from stockpiled topsoil to confirm arsenic concentrations meet Ecology standards.

- After application of the topsoil, slopes would be re-vegetated by planting with trees and grass. When reclamation is complete, heavy equipment would generally not operate on the reclaimed slopes except for construction or maintenance of pedestrian paths, access roads, utilities, or other permitted facilities.

- The Expansion Area would be cleared in segments corresponding to the mining plan.

- Internal drainage would be maintained during mining.

- Mine slopes would be track-walked to tamp soils and create surface roughness to encourage infiltration of stormwater on the slope.

- Mine slopes would be reclaimed with soil amendments and vegetation according to a DNR-approved Reclamation Plan.

- The existing wheel wash, or equivalent equipment, would continue to be used and maintained for vehicles exiting the mine.

- Settling ponds would be constructed upstream of the infiltration ponds.

- Mine slopes would be periodically inspected and repaired or revegetated to reduce erosion or improve surface stability.

Significant Unavoidable Adverse Impacts

The Proposed Action would result in the unavoidable alteration of topography and creation of new slopes. With implementation of proposed mitigation measures, however, no significant unavoidable adverse earth-related impacts are anticipated from the Proposed Action.

3.2 Air Quality

Mitigation Measures

The following mitigation measures have been included in the Proposed Action to reduce air quality impacts.

Proposed Mitigation Measures

- The use of control equipment, enclosures, and wet (or chemical) suppression techniques, as practical, and curtailment during high winds.
- Surfacing roadways and parking areas with asphalt, concrete, or gravel.
- Treating temporary, low-traffic areas (e.g., construction sites) with water or chemical stabilizers, reducing vehicle speeds, constructing pavement or rip rap exit aprons, and use of the existing wheel wash system or equivalent equipment by vehicles before they exit to prevent the track-out of mud or dirt onto paved public roadways.
- Covering or wetting truck loads or allowing adequate freeboard to prevent the escape of dust-bearing materials.

Other Possible Mitigation Measures

- Converting incandescent lighting systems to LED and implementing motion-activated lighting.
- Regenerating electricity from the conveyor belt leading downhill to the barge load-out facility.
- Participating in PSE's Schedule 258 electricity energy efficiency program.

Significant Unavoidable Adverse Impacts

With the application of some or all the mitigation measures described above and consistent use of best management practices, no significant air quality impacts are expected from the proposed project.

3.3 Groundwater

Mitigation Measures

Proposed Mitigation Measures

The following mitigation measures have been included in the Proposed Action to reduce surface water and groundwater impacts.

- Groundwater and surface water level monitoring for features in the site area that could potentially be affected would be implemented. Monitoring data would be reviewed throughout the active dewatering period and used in support of the Proposed Action mitigation measures bulleted below. City review of monitoring data should include retention of a qualified hydrogeologist to provide qualified review of both data and projected impacts.

- Steps 1 and 2 of the aquifer pumping tests would be completely reversible and would allow for confirmation testing of groundwater model predictions. If observed impacts differ significantly from predicted impacts, updates to the groundwater model would be pursued to improve its predictive accuracy for subsequent dewatering steps and/or adjustments to the dewatering and mining activity plans would be made.

- The dewatering plan would be phased so that dewatering would start at locations farthest from Sequalitchew Creek and the wetland complex, and gradually would proceed closer to the waterbodies only if observed aquifer water levels do not exceed performance threshold values.

- If performance threshold water levels are exceeded, adaptive management responses (such as adjusting the dewatering operations and/or the boundaries and depth of mining so that performance threshold exceedances do not occur) would be required before additional mining could occur.

- Since dewatering Step 3 would be irreversible, increased monitoring vigilance at different phases of Step 3 as dewatering and mining progress southward could be warranted to ensure that performance threshold water levels are not exceeded.

- Erosion and sediment controls and stormwater treatment, which are intended to protect groundwater quality and the long-term performance of the proposed infiltration facilities, would be implemented (see ***Section 3.1, Earth***, for details).

Other Possible Contingency Mitigation Measures

As an element of the approval conditions for the Proposed Action, the City of DuPont could require a Monitoring and Response Plan. The Monitoring and Response Plan could include, among other things, definition of monitoring methodology, establishment of performance thresholds, and identification of contingency response measures to the considered for implementation if monitoring indicates exceedance of a performance threshold. The Monitoring and Response Plan could incorporate elements of the adaptive management processes proposed to be established for the Proposed Action and the Sequalitchew Creek Restoration Plan.

The Sequalitchew Creek Restoration Plan is a separate but related action that is intended to

be implemented in parallel with the Proposed Action. The mine and the stream restoration project each have their own adaptive management process tailored to achieving the goals and objectives of each specific project. The interaction between the two adaptive management processes could include: 1) project schedules that encourage restoration in advance of the potential impacts from mining; 2) development of performance thresholds for mining that support restoration and 3) coordinated monitoring and open sharing of information. The City, as the permitting authority for both projects would have a key role in assuring consistency between the two adaptive management plans. The adaptive management process included in the Monitoring Plan (Aspect Consulting, 2017) includes, but is not limited to, the following potential mitigation actions if the impacts of dewatering on groundwater levels are greater than anticipated including: Installing additional monitoring locations; modifying the dewatering system or approach; revising the mining plan; and providing additional mitigation to impacted surface waters.

The Sequalitchew Creek Restoration Plan's adaptive management process similarly identifies examples of potential response actions to be implemented if restored flows do not meet the plans objectives that include, but are not limited to: removing beaver obstructions; installing additional beaver exclusion devices; escalating beaver management; installing additional flow paths through the former railroad grade that divides Edmond Marsh; sealing the losing reach; creating connections to Bell and/or McKay marshes; and expediting later elements of the Restoration Plan.

Other groundwater contingency mitigation measures that could be implemented as part of the adaptive management process include:

- Groundwater captured from the mine could be conveyed to the Sequalitchew Creek ravine (either by open channel or micro-tunneling). This approach could provide mitigation for decreased seep discharge within the ravine if the conveyance outfall (or confluence) is located in the vicinity where groundwater discharge currently occurs. However, this mitigation measure could require revisiting conflicting provisions in the 2011 Settlement Agreement and would not augment streamflow between Sequalitchew Lake and the ravine.

- Groundwater captured from the mine could be pumped into Edmond Marsh rather than into the Sequalitchew Creek ravine. Benefits of this mitigation approach would be that cool groundwater (which has a low summer water temperature relative to surface water) would enter the marsh and could enhance Sequalitchew Creek surface water flow and fish habitat. A potential drawback of this mitigation action is that groundwater discharge/infiltration to the comingled Vashon-Sea Level Aquifer would substantially decrease. In addition, it likely would over-mitigate expected dewatering impacts to Sequalitchew Creek if active year-round (as opposed to only during certain dry or low-flow conditions).

- Water could be actively conveyed to Edmond Marsh during dry periods, while during

all other periods captured groundwater from the South Parcel could be conveyed to the lower mine area for infiltration (as is planned in the Proposed Action). This could serve as a contingent measure for consideration and/or further study to supplement Sequalitchew Creek flows during dry periods when no outflow from Sequalitchew Lake occurs or if the Restoration Plan provides less environmental benefit than currently expected.

Significant Unavoidable Adverse Impacts

- The Vashon Aquifer water table would significantly decrease in the vicinity of the South Parcel. Groundwater levels beneath Edmond Marsh, the closest marsh to the site, are predicted to decrease by up to 0.87 feet near its center (at MW-EM-2S) and remain up to 0.84 feet lower following completion of the Proposed Action. At the west end of the marsh (MW-EM-1S), long-term groundwater level declines of up to 8.73 feet could occur.

- Groundwater discharge in the Sequalitchew Creek ravine is expected to significantly decrease (by an annual average of up to 83%) during the Proposed Action and is expected to provide on average 79% less baseflow to Sequalitchew Creek following the Proposed Action. Greater percentage decreases in baseflow are expected during the dry season. Impacts to baseflow quantity could be mitigated by the Sequalitchew Creek Restoration Plan, except during periods when surface water outflow from Sequalitchew Lake does not occur.

3.4 Surface Water

Mitigation Measures

Proposed Mitigation Measures

- Mitigation for the elimination of the Kettle Wetland will be accomplished by the creation of a new 3.4-acre constructed wetland in the southwest portion of the existing mine's bottom. The constructed wetland will be designed, constructed, maintained, and monitored in accordance with a detailed wetland mitigation plan (Anchor QEA, 2021). This is discussed in further detail in Section 3.5, **Plants and Animals**.

- On-site stormwater flow and groundwater seepage and the associated potential for increased erosion will be managed in accordance with a series of Mine Best Management Practices, as described in the Preliminary Stormwater Management Report (2021) and the Earth and Water Resources Report (Aspect 2022, Revised 2023).

Proposed Mitigation Measures for Off-Site Resources

As described in **Chapter 2** of this DEIS, the 2011 Settlement Agreement states that permits for the Pioneer Aggregates South Parcel Project (Proposed Action) shall not be effective until permits for the Sequalitchew Creek Restoration Plan (Restoration Plan) are in place. The Restoration Plan will be evaluated as a separate but related action. The Restoration Plan seeks to restore and enhance streamflow and ecological functions from Sequalitchew Lake through Edmond Marsh into Sequalitchew Creek ravine by sequentially restoring diverted flows back to the creek, improving the sustainability of flows through the system, and restoring aquatic habitat.

The impacts of this mitigation measure are the same as described above in the subsection Cumulative Impacts with Proposed Action and Sequalitchew Creek Restoration Plan.

Other Possible Contingency Mitigation Measures

As an element of the approval conditions for the Proposed Action, the City of DuPont could require a Monitoring and Response Plan. The Monitoring and Response Plan could include, among other things, definition of monitoring methodology, establishment of performance thresholds, and identification of contingency response measures to the considered for implementation if monitoring indicates exceedance of a performance threshold. The Monitoring and Response Plan could incorporate elements of the adaptive management processes proposed to be established for the Proposed Action and the Sequalitchew Creek Restoration Plan.

The Sequalitchew Creek Restoration Plan is a separate but related action that is intended to be implemented in parallel with the Proposed Action. The mine and the stream restoration project each have their own adaptive management process tailored to achieving the goals and objectives of each specific project. The interaction between the two adaptive management processes could include: 1) project schedules that encourage restoration in advance of the potential impacts from mining; 2) development of performance thresholds for mining that support restoration and 3) coordinated monitoring and open sharing of information. The City, as the permitting authority for both projects would have a key role in assuring consistency between the two adaptive management plans.

The adaptive management process included in the Monitoring Plan (Aspect Consulting, 2017) includes, but is not limited to, the following potential mitigation actions if the impacts of dewatering on groundwater levels are greater than anticipated including: Installing additional monitoring locations; modifying the dewatering system or approach; revising the mining plan; and providing additional mitigation to impacted surface waters.

The Sequalitchew Creek Restoration Plan's adaptive management process similarly identifies examples of potential response actions to be implemented if restored flows do

not meet the plans objectives that include, but are not limited to: removing beaver obstructions; installing additional beaver exclusion devices; escalating beaver management; installing additional flow paths through the former railroad grade that divides Edmond Marsh; sealing the losing reach; creating connections to Bell and/or McKay marshes; and expediting later elements of the Restoration Plan.

Other surface water contingency mitigation measures that could be implemented as part of the adaptive management process include:

- As described in Section 3.3, **Groundwater**, a possible contingency mitigation measure not considered in recent CalPortland documents – but discussed in the 2010 Final Feasibility Study (Anchor QEA 2010) – is to convey at least some of the intercepted groundwater seepage from the eastern slopes of the proposed mine expansion area to discharge to the ravine section of Sequalitchew Creek or West Edmond Marsh. Such mitigation has the potential to provide surface water flows in Sequalitchew Creek to offset the reduced groundwater seepage to the creek due to the Proposed Action and/or to make up for low- or no-flow periods in the creek and marsh system due to low or no flow discharges from Sequalitchew Lake under implementation of the Restoration Plan. If coupled with the Restoration Plan (including lining the dry reach section of the creek), the diversion of the groundwater seepage from the proposed expansion area to West Edmond Marsh would provide flows to the dry reach as well as the ravine section of Sequalitchew Creek, while diversion to the ravine section of the creek would only provide flows to the ravine section (not the dry reach). Such mitigation could be adaptively managed, based on flow and temperature conditions in Sequalitchew Creek, and in such a way as to allow for some groundwater seepage from the proposed expansion area to be retained on-site and infiltrated to the Vashon-Sea Level Aquifer via the planned infiltration facilities in order to reduce negative impacts to the intertidal springs. Conveying groundwater from the mine expansion area to the ravine may require revisiting conflicting provisions in the 2011 Settlement Agreement.

- Another possible additional mitigation measure that was considered in the 2010 Final Feasibility Study (Anchor QEA 2010) is raising the level of Sequalitchew Lake to increase the hydraulic gradient of Sequalitchew Creek through the East and West Edmond Marshes in order to better facilitate flows through the marsh system. With Restoration Plan implementation, the anticipated hydraulic gradient across the marsh system is approximately 0.0006 ft/ft According to the 2010 Final Feasibility Study, the primary limitation to raising the lake level to induce a higher gradient is the protection of the Sequalitchew Springs located on the east end of Sequalitchew Lake. The Sequalitchew Springs are the drinking water source for JBLM and are protected behind a back-flow prevention weir. Reportedly, the lake level could potentially be raised (by modifying the outlet structure at the west end of the lake) by 0.56 ft with a moderate level of effort for modifications to the back-flow

prevention weir at the springs. Raising the lake level higher than that is possible but would reportedly require a significant reconstruction of the facilities at the springs.

Significant Unavoidable Adverse Impacts

Under the Proposed Action with the Sequalitchew Creek Restoration Plan, unavoidable adverse impacts to the surface water system of the Sequalitchew Creek watershed would likely include:

- Increasing the surface water gradient between Sequalitchew Lake and the top of the ravine to restore the natural flow regime to the Sequalitchew Creek watershed, in combination with lower groundwater levels resulting from mining, would result in water levels in East and West Edmond Marshes being lowered by up to approximately 3 ft compared to existing conditions.

- Water levels in isolated lakes and kettle wetlands not directly connected by surface water to the Sequalitchew Creek system would be lowered due to lowered groundwater levels from the Proposed Action. The anticipated decrease in water levels would be approximately 3 ft for Wetland 1D; 2 ft for Pond Lake; 1 ft for Wetlands, #8, #9, #10, and #11; and 0.5 ft for Old Fort Lake. Implementation of the Restoration Plan would likely not mitigate these impacts. These isolated wetlands have significant seasonal variability in water levels and are often dry during the summer. For these reasons, changes that result from changes in groundwater level may be difficult to observe.

- Flows in the ravine section of Sequalitchew Creek would likely be lower than under existing conditions an estimated 10% of the time due to a reduction in groundwater seeps and spring discharges to the creek following groundwater lowering.

- Water temperatures in Sequalitchew Creek from April through September would likely be warmer than under existing conditions and could be expected to exceed 16°C (the 7--day average of daily maximum temperatures water quality criterion provided in WAC 173-201A-200) from May to September.

- If the contingency mitigation measure of conveying the intercepted groundwater from the eastern slopes of the proposed expansion area to Sequalitchew Creek and/or West Edmond Marsh is feasible and implemented as part of the adaptive management process for the Proposed Action and Restoration Plan Alternative, the flow and temperature impacts to Sequalitchew Creek would likely be at least partially reduced, if not eliminated, and may result in greater overall improvement of conditions within the creek.

- Flows in the JBLM Diversion Canal would be reduced with the redirection of Sequalitchew Lake outlet flows to the historically natural drainage course through

Sequalitchew Creek. Because the Diversion Canal was originally constructed to convey stormwater flows from JBLM and provide a watercourse for Sequalitchew Lake outlet flows, the reduced flows in the Diversion Canal are not considered an adverse impact.

- Because on-site stormwater flows will be managed in a similar manner as existing conditions (i.e., on-site collection, conveyance, and infiltration) and because the removal of the Kettle Wetland will be mitigated by a new constructed wetland, no significant unavoidable adverse impacts to on-site surface waters are anticipated under the Proposed Action and Restoration Plan scenario.

3.5 Fisheries

Mitigation Measures

Proposed On-Site Mitigation

- Existing mitigation measures at the barge loading facility at Tatsolo Point that minimize the potential for impacts on fisheries resources would continue. These include:
    - The facility is designed in accordance with adopted federal, state, and local regulations and guidelines to reduce the likelihood of spills of lubricants, fuels, and chemicals employed in the processing and manufacturing proposed for the site;
    - The overwater portion of the conveyor is enclosed to prevent spillage of gravel; and
    - The dock is not used for the delivery of supplies, or chemical or other materials by water; a spill plan has been prepared for all elements and operations of the facility (marine and upland). Appropriate oil spill containment equipment is available at the dock site.

- Mining operations would continue to manage fugitive dust, and forested buffers around Sequalitchew Creek would remain to protect water quality and its support of healthy fisheries resources.

- Site water and stormwater would continue to be recycled and/or infiltrated in the mine, eliminating turbid runoff and its potential to impact fisheries resources.

- During construction of the mitigation wetland and other excavation of soils, construction best management practices would be used to prevent erosion of soils and sedimentation of water resources that support fisheries resources.

Proposed Mitigation for Off-Site Resources

- Implementation of the Sequalitchew Creek Restoration Plan would mitigate for potential impacts to aquatic resources and vegetation resulting from changes to groundwater levels. The Sequalitchew Restoration Plan will be permitted and implemented contemporaneously with mining of the South Parcel. Among other things, the Restoration Plan would mitigate for the impacts of the mine. Monitoring and mitigation measures, including specific timeframes for monitoring and mitigation efforts, are defined in the Restoration Plan. The goal of the Restoration Plan is to offset potential impacts to aquatic resources within the area subject to changes in groundwater level.

- The Sequalitchew Creek Restoration Plan and proposed mining both include monitoring and adaptive management programs aimed at ensuring the projects achieve their objectives (e.g., to maintain and enhance fisheries resources). A main purpose of ongoing monitoring and adaptive management is to look for detrimental cumulative effects and, if identified, adaptively respond to minimize them.

Other Possible Contingency Mitigation Measure

- As an element of the approval conditions for the Proposed Action, the City of DuPont could require a Monitoring and Response Plan. The Monitoring and Response Plan could include, among other things, definition of monitoring methodology, establishment of performance thresholds, and identification of contingency response measures to the considered for implementation if monitoring indicates exceedance of a performance threshold. The Monitoring and Response Plan could incorporate elements of the adaptive management processes proposed to be established for the Proposed Action and the Sequalitchew Creek Restoration Plan.

- The Sequalitchew Creek Restoration Plan is a separate but related action that is intended to be implemented in parallel with the Proposed Action. The mine and the stream restoration project each have their own adaptive management process tailored to achieving the goals and objectives of each specific project. The interaction between the two adaptive management processes could include: 1) project schedules that encourage restoration in advance of the potential impacts from mining; 2) development of performance thresholds for mining that support restoration and 3) coordinated monitoring and open sharing of information. The City, as the permitting authority for both projects would have a key role in assuring consistency between the two adaptive management plans. The adaptive management process included in the Monitoring Plan (Aspect Consulting, 2017) includes, but is not limited to, the following potential mitigation actions if the impacts of dewatering on groundwater levels are greater than anticipated including: Installing additional monitoring locations; modifying the

dewatering system or approach; revising the mining plan; and providing additional mitigation to impacted surface waters.

- Other groundwater contingency mitigation measures that could be implemented as part of the adaptive management process include:

    - Groundwater captured from the mine could be conveyed to the Sequalitchew Creek ravine (either by open channel or micro-tunneling). This approach could provide mitigation for decreased seep discharge within the ravine if the conveyance outfall (or confluence) is located in the vicinity where groundwater discharge currently occurs. However, this previously considered mitigation measure would require revisiting conflicting provisions in the 2011 Settlement Agreement and would not augment streamflow between Sequalitchew Lake and the ravine.

    - Groundwater captured from the mine could be pumped into Edmond Marsh rather than into the Sequalitchew Creek ravine. Benefits of this mitigation approach would be that cool groundwater (which has a low summer water temperature relative to surface water) would enter the marsh and could enhance Sequalitchew Creek surface water flow and fish habitat. A potential drawback of this mitigation action is that it is, at best, a temporary action because pumping in perpetuity is not feasible, and groundwater discharge/infiltration to the comingled Vashon-Sea Level Aquifer would substantially decrease. In addition, it likely would over-mitigate expected dewatering impacts to Sequalitchew Creek if active year-round (as opposed to only during certain dry or low-flow conditions).

    - Water could be actively conveyed to Edmond Marsh during dry periods, while during all other periods captured groundwater from the South Parcel could be conveyed to the lower mine area for infiltration (as is planned in the Proposed Action). This could serve as a contingent measure for consideration and/or further study to supplement Sequalitchew Creek flows during dry periods when no outflow from Sequalitchew Lake occurs or if the Restoration Plan provides less environmental benefit than currently expected. However, this mitigation measure is also likely at best, a temporary action because pumping in perpetuity is not feasible.

Significant Unavoidable Adverse Impacts

The cumulative impacts of the Proposed Action and Sequalitchew Creek Restoration Plan (the cumulative condition) would generally improve all aspects of the freshwater fish habitat in the Sequalitchew Creek watershed compared to current conditions.

The existing low flows do not currently support a fish population. The flows in the ravine section of Sequalitchew Creek under the Proposed Action would likely be lower than under existing conditions an estimated 10% of the time (during drought years) with the reduction in groundwater discharge to the creek.

Increased water temperature in the Sequalitchew Creek system is anticipated to occur in late summer when only resident fish are present. Fish movement and growth could be limited during the period when water temperature peaks in late summer until temperatures reduce in fall.

Considering the overall increase in freshwater fish habitat conditions in the cumulative condition, in combination with the proposed and potential measures identified in Sub-section 3.5.3, significant unavoidable adverse impacts are not anticipated.

3.6 Plants & Animals

Mitigation Measures

Proposed On-Site Mitigation

- Revegetation of cleared and mined area on the site would occur as part of segmental reclamation under the Reclamation Plan reviewed and approved by the Washington State Department of Natural Resources.

- Mitigation for impacts for the removal of the Kettle Wetland are identified in the Project *Wetland Mitigation Plan*. The design of the mitigation wetland complex is intended to create aquatic, wetland, riparian, and upland forest habitat by using groundwater intercepted within the mine. Specific Kettle Wetland mitigation goals include the following:
    - Create a constructed palustrine depressional wetland complex consisting of forested, scrub-shrub, emergent, and aquatic bed wetland areas at least 3.4 acres in size.
    - Provide adequate wetland acreage, functions, and values to mitigate all Project-related wetland impacts to the Kettle Wetland.
    - Construct a vegetated buffer at least 100 feet around the boundary of the wetland.
    - Create a larger complex of seep wetlands and springs within the mine.

- Springs and seeps will generally emanate on the eastern and southeastern slopes of the proposed mine in the South Parcel. Generally, seeps and springs will form within the lower one-third of the mine slope, approximately 20 to 30 vertical feet above the Olympia Beds. These areas will be colonized or planted with pioneer wetland species, such as horsetail *(Equisetum* sp.), buttercup (*Ranunculus* sp.), and miner's lettuce (*Montia fontana*). Additional species would be introduced later, once the soils have developed sufficiently to support seral grasses such as foxtails, rushes, sedges etc.

The buffers around these new seeps will be subject to the City of DuPont's Critical Areas Ordinance (DMC 25.105.050) and protected. The minimum buffer size is 50 feet. These buffers would be planted in accordance with the mine reclamation plan and monitored in accordance with the Wetland Mitigation Plan. Control of Scot's broom, reed canarygrass, Himalayan blackberry (*Rubus armeniacus*), and other noxious weeds within areas affected by the proposed Project would also be included as part of the Project mitigation activities.

- The Applicant (CalPortland) has provided a tree replacement proposal as part of its application and will coordinate with the City of DuPont regarding the appropriate strategy for replacement of removed landmark trees through proposed mine reclamation plans.

Proposed Mitigation for Off-Site Resources

- Implementation and monitoring of the Sequalitchew Creek Restoration Plan would provide mitigation to minimize potential impacts to aquatic resources and vegetation resulting from changes to groundwater levels. As described in **Chapter 2** of this DEIS, the Sequalitchew Creek Restoration Plan will be permitted and implemented contemporaneously with mining of the South Parcel.

- Conditions associated with this mitigation measure are the same as described above in the subsection Cumulative impacts with Proposed Action and Sequalitchew Creek Restoration Plan.

Other Possible Contingency Mitigation Measure

- As an element of the approval conditions for the Proposed Action, the City of DuPont could require a Monitoring and Response Plan. The Monitoring and Response Plan could include, among other things, definition of monitoring methodology, establishment of performance thresholds, and identification of contingency response measures to the considered for implementation if monitoring indicates exceedance of a performance threshold. The Monitoring and Response Plan could incorporate elements of the adaptive management processes proposed to be established for the Proposed Action and the Sequalitchew Creek Restoration Plan.

- The Sequalitchew Creek Restoration Plan is a separate but related action that is intended to be implemented in parallel with the Proposed Action. The mine and the stream restoration project each have their own adaptive management process tailored to achieving the goals and objectives of each specific project. The interaction between the two adaptive management processes could include: 1) project schedules that encourage restoration in advance of the potential impacts from mining; 2) development of performance thresholds for mining that support restoration and 3) coordinated

monitoring and open sharing of information. The City, as the permitting authority for both projects would have a key role in assuring consistency between the two adaptive management plans.

Significant Unavoidable Adverse Impacts

Development of the Proposed Action would result in the loss of existing conifer forest/shrublands, the existing kettle wetland, and associated animal habitat on the site. The proposed site reclamation plan and wetland mitigation plan would mitigate loss of on-site resources. These impacts would be unavoidable but not considered significant with mitigation described above in Section 3.6.3.

The Proposed Action would indirectly impact the off-site Seep Wetlands associated with the Sequalitchew Creek Ravine by disrupting the hydrology of these wetlands. This impact would be unavoidable and mitigated by creation a larger complex of seep wetlands on the eastern slope of the reclaimed mine, resulting in a net impact that is considered insignificant.

Cumulatively, implementation of the Sequalitchew Creek Restoration Plan would further mitigate for the loss of wetland acreage associated with reduction in groundwater levels. The intent of the proposed mitigation measures described in 3.6.3 with the Sequalitchew Creek Restoration Plan, is to reduce these unavoidable adverse impacts to a non-significant status. If implementation of the proposed mitigation measures fails to mitigate these unavoidable adverse impacts, the City will consider implementing other possible contingency mitigation measures listed in Section 3.6.3 as part of the adaptive management process.

3.7 Noise

Mitigation Measures

The following mitigation measures have been included in the Proposed Action to reduce noise impacts.

Proposed Construction Measure

- Construction activities (i.e., logging and construction of the southern berm) would be conducted during daytime hours only (7 AM to 10 PM) to minimize noise impacts.

Proposed Operation Measures

- The plans for the site include construction of a 20-foot high berm on the south side of Phase 2C to reduce noise at off-site locations, especially at the Creekside Apartments. With such a berm, modeled sound levels of worst-case mining activities are well below the applicable daytime noise limits at all receptor locations.

- Excavation in Phase 2C during early morning hours (i.e., between 5 and 7 AM) may exceed the stricter nighttime limit of 50 dBA applicable at the Creekside Apartments. Restriction of the bulldozer to daytime hours only within Phase 2C reduces the modeled sound levels at the Creekside Apartments to 48 dBA or less, which would comply with DuPont's nighttime noise limit.

Significant Unavoidable Adverse Impacts

With construction of the proposed berm as noted above and with restriction of hours of bulldozer operation in Phase 2C to daytime hours only, the project is expected to comply with City of DuPont noise limits. Furthermore, potential noise impacts at the Creekside Apartments (R1) can be mitigated by the proposed mitigation measures, although short-term unavoidable noise impacts may be expected. Due to the short-term nature of the impacts at R1, any such impacts would not be considered significant.

3.8 Land Use

Mitigation Measures

No significant adverse land use impacts have been identified. However, the following mitigation measures have been identified to further reduce the potential for land use impacts associated with the proposed South Parcel Project.

Proposed Mitigation Measures

- Maintain a vegetated buffer along Powerline Road. Trees will be planted densely to establish screening during mining operations. After mining is completed, selective thinning may be necessary to facility a healthy future forest within the buffer.

- Mitigation measures identified throughout the EIS would minimize impacts to land use from mining activities, consistent with City regulations (see Section 3.1, **Earth**, Section 3.2, **Air Quality/GHG Emissions**, Section 3.6, **Noise**, and Section 3.10, **Transportation**).

Significant Unavoidable Adverse Impacts

The proposed Pioneer Aggregates South Parcel Project would result in an unavoidable change to the land use character of the existing landscape within the Expansion Area portion of the site. The extraction of mined material would result in a permeant change in the land use character of the site. However, the Proposed Action is not expected to result in a significant adverse impact to land uses of the surrounding community. Mining is a transitional use of the site; although mining would alter the site for a number of years, after mining is complete, the site would likely be developed to another permitted use.

3.9 Aesthetics

Mitigation Measures

The following mitigation measure have been included in the Proposed Action to reduce aesthetics impacts.

Proposed Mitigation Measures

- A vegetated buffer would be maintained along Powerline Road. Trees would be planted densely to establish screening during mining operations. After mining is completed, selective thinning may be necessary to facility a healthy future forest within the buffer.

- As mining progresses, completed mine segments would be reclaimed to a vegetated condition. The reclamation plan would be reviewed by the Washington State Department of Natural Resources ("DNR") for consistency with the Surface Mining Act (RCW 78.44). In general, reclamation would consist of regrading, replacement of topsoil, and revegetation.

Significant Unavoidable Adverse Impacts

The Proposed Action would result in an unavoidable change to the visual character of the Expansion Area portion of the site. The extraction of mined material would result in a permeant change in the visual character of the site. However, the Proposed Action is not expected to result in a significant adverse impact to the visual environment of the surrounding community. The mining operation is expected to be only minimally visible to the general public from outside of the property boundary. In addition, mining is a transitional use of the site; although mining would alter the site for a number of years, after mining is complete, the site would be reclaimed and ultimately it would be available for development to another permitted use.

3.10 Cultural Resources

Mitigation Measures

The following mitigation measures have been included in the Proposed Action, or in a prior decision applicable to the property, to reduce cultural resources impacts.

Proposed Mitigation Measures

- Based on the additional evaluation and assessment of cultural resources for the project that was completed and included in **Appendix M**, it is recommended that additional shovel probing be conducted in the two areas shown in **Appendix M**, with a high probability for containing archaeological resources prior to clearing, mining and/or construction of the proposed noise berm. A study plan should be developed in consultation with DAHP and the affected Indian Tribes. Alternatively, archaeological monitoring of any ground disturbing activities in these areas should be conducted.

- Mitigation requirements that address archaeological monitoring and inadvertent discovery of cultural resources or human remains prior to ground disturbance or during mining as required as a result of the 2004 Settlement Agreement between Quadrant Corporation, Weyerhaeuser real Estate Company, the City of DuPont and the Nisqually Tribe. These mitigation requirements apply to all Weyerhaeuser properties in the City of DuPont, and have been recommended, applied as conditions of approval, and implemented as ongoing management practices in all Glacier NW/CalPortland mining projects in the City. These mitigation measures should continue to be implemented as applicable to the South Parcel Project. These measures include the following (paraphrased from North Parcel conditions No. 28-30):

    - Notification of Nisqually Indian Tribe resource representative in advance of any clearing or topsoil stripping for each mine segment; and employment of the tribal Archaeologist to write a closing report to DAHP documenting coordination with the Nisqually Indian Tribe and observed conditions.
    - Notification of DAHP and the Nisqually Indian Tribe if any Native American remains are unearthed.
    - Monitoring of clearing activities by the Nisqually Indian Tribe to identify any historic resources and appropriate notice and treatment of any resources discovered.

- If any archaeological sites are identified under the Proposed Action, and they are determined to be eligible for the NRHP, and that proposed mining activities would constitute a significant adverse impact to them, then DAHP and the affected Tribes should be consulted for guidance regarding appropriate mitigation measures. Mitigation

measures may include, but not be limited to data recovery and/or interpretation (e.g., displays, exhibits).

Significant Unavoidable Adverse Impacts

No historically significant cultural resources have been previously identified within the site to date; therefore, no significant adverse impacts would occur to known resources. However, if a previously unidentified cultural resource is discovered with in the ADI, there is potential for a significant adverse impact to occur if the resource is determined to be eligible for the NRHP.

3.11 Transportation

Mitigation Measures

No transportation-related mitigation measures are necessary, and no additional transportation-related measures are provided.

Significant Unavoidable Adverse Impacts

The proposed Pioneer Aggregates South Parcel Project is not expected to result in significant transportation impacts in the study area. Trip generation is expected to continue at current levels and would remain below the peak day estimates that had been evaluated in the 2013 FEIS.

3.12 Fiscal

Mitigation Measures

No significant adverse fiscal impacts have been identified. Beyond the payment of required payment of applicable property tax, sales & use tax, business & occupation tax, and utility taxes, no additional mitigation is identified.

Significant Unavoidable Adverse Impacts

The fiscal analysis conducted for this EIS indicates that expected revenues to the City of DuPont would exceed expected costs. Therefore, no significant unavoidable adverse are anticipated. .

Chapter 2

DESCRIPTION OF PROPOSED ACTION(S) & ALTERNATIVES

CHAPTER 2

DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

This chapter of the *Pioneer Aggregates South Parcel Project* Draft Environmental Impact Statement (DEIS) provides discussion on the following: Overviews of the *Pioneer Aggregates South Parcel Project*, the Environmental Review Process, and Previous Planning, Environmental Review and Settlement Agreement; Description of the Proposed Action; Overview of Major Elements of the EIS and Alternatives; and Discussion of Benefits and Disadvantages of Deferring the Proposed Action. A detailed description of the affected environment, environmental impacts, mitigation measures, and significant unavoidable adverse impacts is provided in **Chapter 3** of this DEIS.

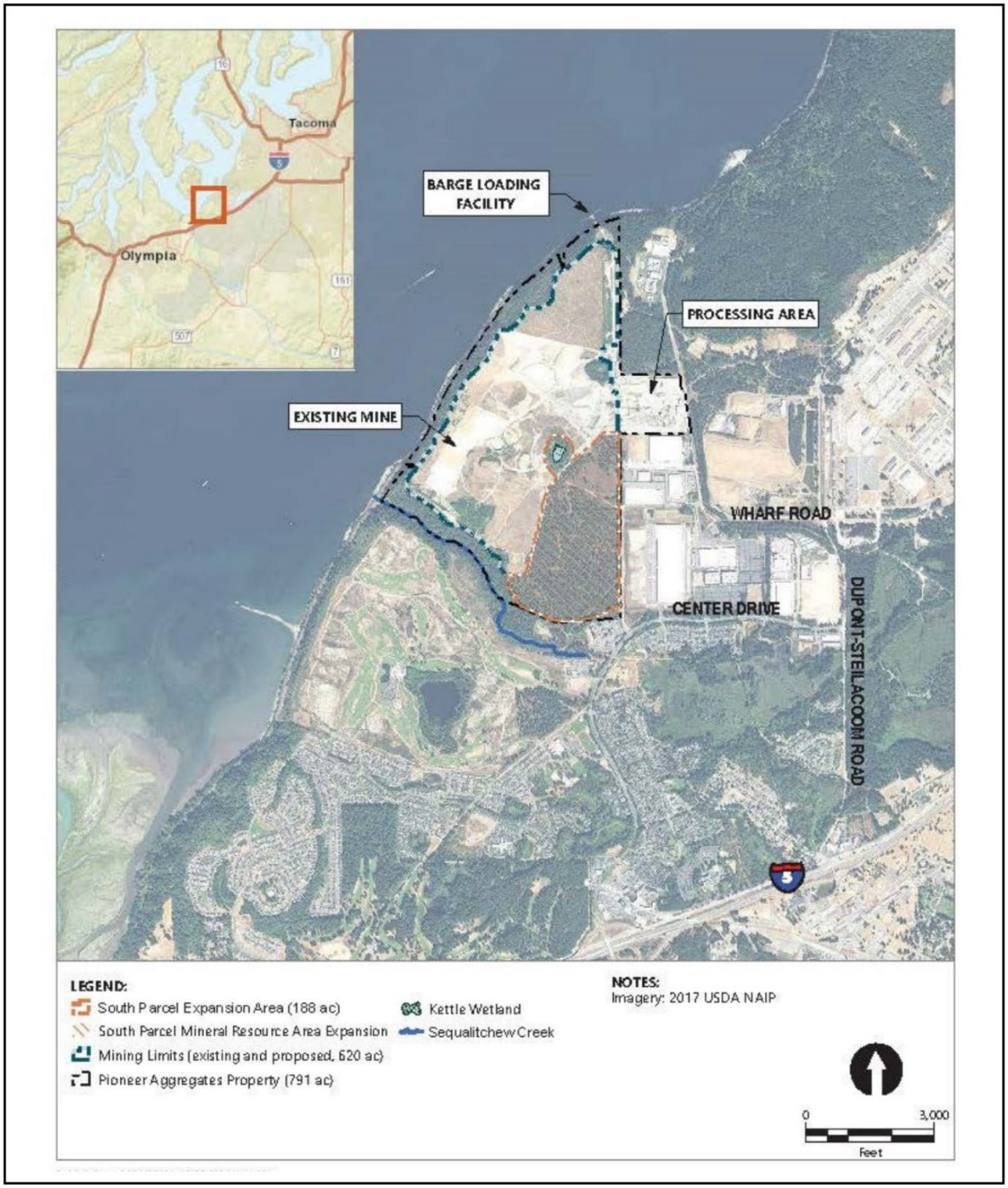
2.1 Overview of the Proposed Action

Project Location

The Pioneer Aggregates Mine is located in the City of DuPont, southwestern Pierce County, and Sections 22, 23, and 26, Township 19 North, Range 1 East of the Willamette Meridian (see **Figure 2-1 - Vicinity Map** and **Figure 2-2 – Site Map**). The mine is comprised of four areas: the Original Mine area, the North Parcel and the processing area that now comprise the Existing Mine, and South Parcel. The proposed *Pioneer Aggregates South Parcel Project* ("South Parcel Project") is focused on the easterly portion of the Existing Mine and the South Parcel (see **Figure 2-2**). The project site is bordered to the north by the Pioneer Aggregates North Parcel; to the east by industrial/distribution facilities including Amazon, Dania, Pier 1 Imports, and FedEx; to the south by Sequalitchew Creek and the Creekside Village residential development; and to the west by Puget Sound. The South Parcel Project would occur on lands owned by Weyerhaeuser Company and leased to CalPortland[1]

The South Parcel Project site includes areas previously undisturbed by mining deemed the Expansion Area. The 187.5-acre Expansion Area includes portions of the 167.5-acre South Parcel, the 10.8 acre kettle wetland and surrounding buffer and a 9.2-acre buffer strip between the Existing Mine and the south parcel property boundary. The South Parcel Project also includes a plan to mine deeper within a portion of the Existing Mine, referred to as the "Re-Mine Area". The Expansion Area is located southeast of the Existing Mine. The Existing Mine Area and the Expansion Area are included within the Mineral Resource Overlay in the City of DuPont's adopted Comprehensive Plan. The Re-Mine Area consists of

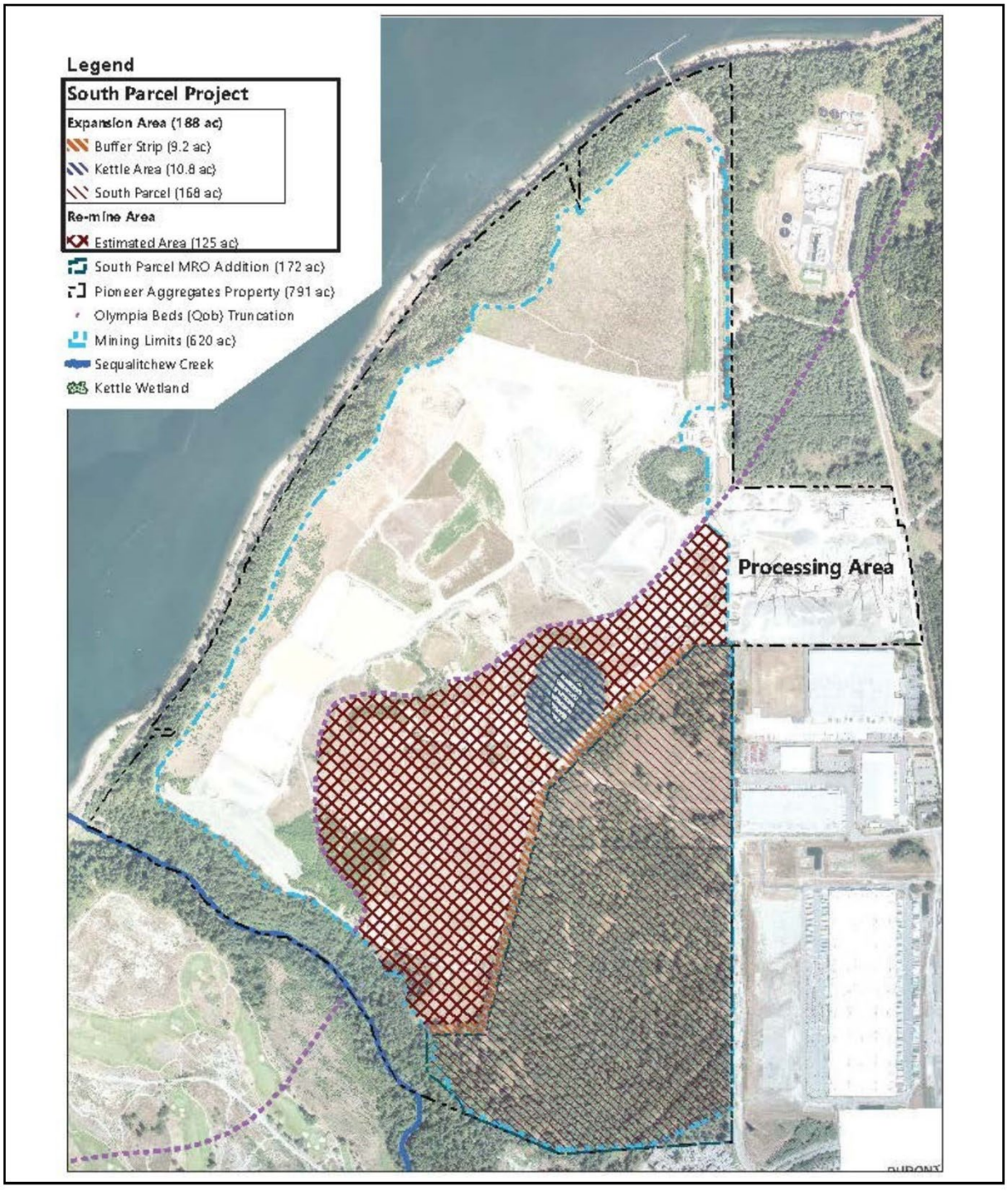
[1] *Glacier Northwest, Inc. (Glacier NW) does business as CalPortland in the State of Washington. Glacier NW leases the proposed expansion area from Weyerhaeuser. Glacier NW also owns the Pioneer Aggregates operation and maintains the bond required under the reclamation permit. The North Parcel Property and property where the aggregate processing plant are located are owned by Northwest Aggregates Co. a Wholly owned subsidiary of Glacier Northwest, Inc.*



Source: Anchor QEA, 2021

EA Engineering, Science, and Technology, Inc., PBC

Figure 2-1
Vicinity Map



Source: Anchor QEA, 2021

EA Engineering, Science, and Technology, Inc., PBC

Figure 2-2
Site Map

125.2 acres in the southeastern portion of the Existing Mine where current mining activities are permitted above current groundwater levels (see **Figures 2-1** and **2-2**).

The current proposal is for a new permit that would allow mining to occur in the Expansion Area and additional mining in the Re-Mine Area to deepen these areas to below the current groundwater level**.**

Current Mining Operations

CalPortland's original approximately 355-acre sand and gravel mine was permitted in 1996 and is referred to as the "Existing Mine".

In 2013 CalPortland applied for permits to allow mining of approximately 142 acres within the North Parcel; the North Parcel mining expansion was permitted in 2014.[2]

Current activities at the Pioneer Aggregates Mine include mining, processing, transport of sand and gravel, and manufacturing of concrete. The processing area is located adjacent to the mine site on a 52-acre parcel owned by Northwest Aggregates Co. a wholly owned subsidiary or Glacier Northwest, Inc. ("Glacier") (see **Figures 2-1** and **Figure 2-2**). Sand and gravel is removed from the mine by bull dozers and wheel loaders and transferred to the processing area by conveyor belts. At the processing facility, the material from the mine is crushed, washed, and separated into different size gradations. Aggregate products are stored in stockpiles in the processing area for distribution.

After completion of the production process, the majority (approximately 80%) of the finished aggregate products are transported from the plant area by conveyors and placed onto barges at Glacier's dock and barge-loading facility at Tatsolo Point on Puget Sound (see **Figure 2-1**). The remainder (approximately 20%) is sold as aggregate or used to make concrete onsite; in both cases it is transported by truck.

Water used to wash gravel during processing is recycled through a clarifying process to remove silt and clay. The fine sediments are then run through a belt press to remove excess water and transported by truck and placed in holding cells in the mine where it is allowed to dry for up to three years. After drying, fines may be used to raise the floor of the mine by placing the material in cells separated by rock curtains to facilitate drainage. The material is placed in approximately 6-inch lifts and compacted to a material dry density of 90% (ASTM:D-1557)[3] or greater. Once filled to the desired height with fines from the belt press in this manner, a gravel cap of not less than 10 feet is placed over the compacted fines to mitigate potential for settlement and facilitate drainage.

[2] *Consistent with applicable provisions of the 2011 Settlement Agreement (see Section 2-3 of this Chapter for detail).*
[3] *American Society for Testing and Materials (ASTM) D-1557 provides standard test methods for laboratory compaction characteristics of soil.*

Summary of Proposed Action

In May 2021, CalPortland applied for permits to allow horizontal expansion of mining into approximately 188 acres previously undisturbed by mining (the Expansion Area), and vertical deepening of approximately 125 acres where re-mining would deepen a portion of the Existing Mine (Re-Mine Area). In advance of the mining, the project proposes to install wells to intercept and pump groundwater to dry out gravels for mining. The intercepted groundwater would be conveyed by surface channels and infiltrated in ponds on the floor of the Existing Mine. As is the case currently, the pace of mining will depend on market conditions. The proposed South Parcel Project is anticipated to extend mining at the current average rate for approximately 14 additional years. Additionally, the method of mining and materials processing, and transport of materials within the South Parcel Project would not change from the methods used in the Existing Mine (see Section 2.4 of this chapter for additional detail on the Proposed Action).

2.2 Environmental Review and Purpose

Consistent with the provisions of the State Environmental Policy Act (SEPA) (RCW 43.21C and WAC 197-11-050), the City of DuPont is serving as the lead agency under SEPA and directing environmental review for the proposal.

The City of DuPont determined that the *Pioneer Aggregates South Parcel Project* may have a significant adverse impact on the environment, and that an Environmental Impact Statement (EIS) should be prepared, consistent with RCW 43.21C.030 (2)(c). Accordingly, the City of DuPont initiated the EIS scoping process for the South Parcel Project on September 17, 2021, by carrying out the following actions:

- Issued a SEPA Determination of Significance (DS)/Request for Comments on the Scope of the EIS. The DS/Request for Comments included notification of a public meeting on September 30, 2021, to provide the public with an opportunity to become more familiar with the proposal and to comment on the scope of the EIS. It also gave notice of the 30-day extended scoping period, ending on October 20, 2021 (the statutory requirement is for a 21-day scoping period). The DS/Request for Comments is available for review at: https://www.dupontwa.gov/DocumentCenter/View/4891/Pioneer-Aggregates-So-Parcel-DS_PLNG2021-006

- Mailed copies of the DS/Request for Comments to federal, state, regional and local agencies, and tribes;

- Published the DS/Request for Comments in the Washington State Department of Ecology's (Ecology's) SEPA Register;

- Posted the DS/Request for Comments on the City of DuPont's website;

- Published the DS/Request for Comments in the *Tacoma News Tribune* (on September 18, 2021); and,

- Posted on the City of DuPont bulletin board.

The EIS public open house was held on September 30, 2021, during the scoping period. This meeting offered an opportunity for the public to learn more about the Proposed Actions and to provide input on the scope of the EIS. A total of 21 people signed in at the meeting. An opportunity to provide written comments was provided throughout the open house. City staff and Pioneer Aggregates representatives were available throughout the open house to answer questions about the SEPA process and the proposal, respectively.

A total of 88 comment letters were received from 43 commenters during the EIS scoping period. All the comments are available for review at City of DuPont. **Appendix A** of the EIS includes a report containing a detailed summary of the EIS scoping process, comments received during the scoping period, and any revisions to the EIS scope based on public input received through the scoping process.

Based in part on the input received during the scoping period, the scope of the EIS was defined by City of DuPont. The following environmental elements were identified for analysis in the EIS.[4]

- *Earth*
- *Air Quality*
- *Surface Water & Groundwater*
- *Fisheries*
- *Plants & Animals*
- *Noise*
- *Land & Shoreline Use*
- *Aesthetics*
- *Cultural Resources*
- *Transportation*
- *Economic & Fiscal Conditions*

The EIS evaluates two alternatives:

- **Alternative 1** – No Action Alternative, and
- **Alternative 2** – Proposed South Parcel Project.

Three other possible alternatives - **1**- less mining on the South Parcel and/or at the Existing Mine, **2** - preserving the Kettle Wetland, and **3**- no dewatering by wells for mining and creation of an interceptor channel southeast of Edmond Marsh - are referenced in the EIS (see Section 2.5 later in this chapter for details on the EIS Alternatives).

[4] *Conditions associated with ground preparation, surface mine operations, and reclamation are analyzed under the EIS Alternatives.*

It is assumed that the Sequalitchew Creek Restoration Plan (as discussed later in this Chapter) is not part of the Proposed Action. The Restoration Plan, in combination with the Proposed Action, is analyzed in this EIS under Cumulative Impacts in the context of mitigation for the Proposed Action.

2.3 Previous Planning, Environmental Review and Settlement Agreement

The DuPont area has been the subject of numerous proposals and environmental studies over the last 40+ years. From approximately 1909 to 1975 the DuPont de Nemours Company conducted munitions manufacturing in the area. In the 1970s, the Weyerhaeuser Company studied the area for possible construction of a log export facility. The plan for the log export facility was later dropped and Weyerhaeuser began developing Northwest Landing, a mixed-use residential, commercial and employment center.

Recognizing the value of the aggregate resources (i.e., sand and gravel) in the DuPont area, Weyerhaeuser began working with CalPortland (then Lone Star Northwest) in the late 1980s to evaluate the hydrogeologic characteristics of the general area and its suitability as a source of construction aggregate materials. The area, including the Pioneer Aggregates Existing Mine and North and South Parcels, was identified as containing substantial deposits of high-quality aggregate materials. Groundwater studies, which encompassed the North and South Parcels, included deep well and aquifer tests for mine water supply, a conceptual assessment for groundwater inflow and dewatering, and an evaluation of the quality of groundwater flowing beneath the area from the Fort Lewis Landfill No. 5, which is located approximately one-half mile to the east of the South Parcel, on Joint Base Lewis-McCord (JBLM) property. Barge loading of aggregates at Tatsolo Point was also identified as an alternative mode of transport to trucks.

A summary of the previous planning and SEPA environmental review efforts specific to the site and relevant to the Proposed Action are listed below; see Section 3.7, **Land and Shoreline Use**, of this Draft EIS for additional detail.

Summary of Previous Planning and Environmental Review

The original Lone Star NW sand and gravel mine (Existing Mine) was permitted for an approximately 355-acre site in 1997. An EIS and Supplemental EIS (SEIS) were prepared for that proposal, which included construction of a dock at Tatsolo Point for shipment of mined material by barge.

The Washington State Growth Management Act requires cities and counties to designate mineral lands of long-term commercial significance in their comprehensive plans. In the City of DuPont, such lands are included within the City's Mineral Resource Overlay zoning district. In 2006, the City amended its Comprehensive Plan to revise its overall land use plan

to expand the City's Mineral Resource Overlay. The expanded Mineral Resource Overlay included an approximately 168-acre area leased by CalPortland southeast of the Existing Mine (South Parcel) and an approximately 201-acre area located north of the Existing Mine owned by CalPortland (North Parcel). After the City issued a SEIS for the South Parcel in 2007, CalPortland submitted permit applications to mine the South Parcel.

In 2009, in response to a prior application to begin mining the South Parcel, a group of environmental and conservation organizations formally disputed the proposed South Parcel activities and mitigation measures proposed at the time. This dispute process resulted in a Memorandum of Understanding (2009) and Feasibility Study (2010), which explored alternatives for mining and restoration, and the *2011 Settlement Agreement for DuPont Mine, Restoration of Sequalitchew Creek Watershed, and Preservation of Puget Sound Shorelands and Adjacent Open Space* (2011 Settlement Agreement). The 2011 Settlement Agreement set forth a process for the submittal and review of permit applications (including SEPA review) for the North Parcel first and then the South Parcel (see *2011 Settlement Agreement Summary* below).

As provided for in the 2011 Settlement Agreement, in 2013 CalPortland applied for permits to allow mining within the North Parcel. Following publication of a Final EIS ("North Parcel EIS") in 2013, the North Parcel mining expansion was permitted in 2014. The North Parcel EIS contemplated mining the South Parcel as an independent but related proposal and evaluated the cumulative impacts of mining both the North and South Parcels.

A summary of previous key mining permits, applications, and SEPA environmental review efforts applicable to the current Proposed Action is provided below.

- 1992, 1993 – *Pioneer Aggregates Mining Facility and Reclamation Plan EIS* issued.

- 1994 – *Settlement Agreement* between Ecology, City of DuPont, CalPortland, Weyerhaeuser Real Estate Company, Nisqually Delta Association, Black Hills Audubon Society, and the Anderson Island Quality of Life Committee. The 1994 Settlement Agreement includes agreements related to shoreline improvements, including aggregate dock facility at Tatsolo Point, Sequalitchew Creek/shoreline protection measures, and a process for resolving disputes related to enforcement of the Agreement's terms through consultation, mediation, or arbitration.

- 1995 – *Pioneer Aggregates Barge-Loading Facility and DuPont Shoreline Master Program Amendment SEIS* issued.

- 1996 – The original 355-acre sand and gravel mine (Existing Mine) permitted.

- 2001 – 1st *City of DuPont Comprehensive Plan EIS Addendum* issued.

- 2004 – Settlement Agreement between Quadrant Corporation, Weyerhaeuser Real Estate Company, the City of DuPont and the Nisqually Tribe, resulting in agreements for requirements that address archeological monitoring and inadvertent discovery of cultural resources or human remains prior to ground disturbance or during mining.

- 2005 – 2nd *City of DuPont Comprehensive Plan EIS Addendum* issued.

- 2006 – The City's Mineral Resource Overlay expanded to 201-acre area north of the Existing Mine (North Parcel) and 168-acre area south of Existing Mine (South Parcel)

- 2007 – *Glacier Northwest DuPont Mining Area Expansion and North Sequalitchew Creek Project SEIS* issued.

- 2007 – CalPortland submitted applications to permit mining on the South Parcel along with additional areas within the Existing Mine (including a proposal to collect groundwater in a new tributary to Sequalitchew Creek). A Final SEIS was issued for this proposal. Following issuance of the Final SEIS and preparation of the City of DuPont Staff Report, the Nisqually Delta Association invoked settlement discussions regarding potential impacts to Sequalitchew Creek (see below). After initiating settlement discussions, no further action was taken by the City or CalPortland on the 2007 South Parcel application.

- 2008 – The Nisqually Delta Association formally invoked the dispute resolution process under the 1994 Settlement Agreement.

- 2009 –A memorandum of understanding (MOU) was executed in November among the interested environmental organizations (Environmental Caucus non-governmental organizations), Washington Department of Ecology, City of DuPont and the applicant for the development of a feasibility study to evaluate various alternatives for expansion of the mine, and actions to improve water flows and habitat in the Sequalitchew Creek watershed. The MOU also established a process, including SEPA review, for separately considering future mining applications for the North Parcel and South Parcel, and for a settlement agreement.

- 2010 – Final Feasibility Study completed, analyzing 24 alternatives for mining of the North and South Parcels, dewatering options and actions to enhance and restore regional environmental resources.

- 2011- The studies and deliberations initiated in 2009 resulted in tentative agreement among the negotiating parties in June of 2011 who then presented the *2011 Settlement Agreement for DuPont Mine, Restoration of Sequalitchew Creek Watershed, and Preservation of Puget Sound Shorelands and Adjacent Open Space* to the DuPont City Council for consideration. Several town hall meetings and

hearings were held by the Council that included opportunities for citizens and interested stakeholders to provide verbal and written comments on the proposal. The Council ultimately approved the settlement agreement and it was finally executed on February 12, 2012 (see discussion below under *2011 Settlement Agreement Summary*).

- 2013 – *CalPortland DuPont North Parcel Mining Final EIS* issued.[5]

- 2014 – North Parcel Mining permitted.

- 2017 – CalPortland worked with the Environmental Caucus non-governmental organizations to develop the South Parcel Monitoring Plan. (The "Environmental Caucus" comprises the non-governmental environmental organizations listed in the Settlement Agreement Summary below.)

- 2018 – The non-governmental organizations who are parties to the 2011 Settlement Agreement incorporated input from JBLM and finalized the Sequalitchew Creek Watershed Restoration Plan.

- August 2020 – A Memorandum of Agreement (MOA) was executed by Joint Base Lewis-McChord (JBLM), CalPortland, the City of DuPont, the Environmental Caucus non-governmental organizations and the South Puget Sound Salmon Enhancement Group (SPSSEG) defining roles and responsibilities for Restoration Plan actions on JBLM.

- September 2020 – Application including Cleanup Action Plan (CAP) submitted to Washington State Department of Ecology for review under the Voluntary Cleanup Program for remediation of Asarco Tacoma Smelter Plume related contaminants in surface soils of the South Parcel property.

- February 2021 – Washington State Department of Ecology issued Opinion that implementation of Cleanup Action Plan would be likely to result in "no further action" being necessary to clean up the DuPont South Parcel Property.

- March 2021 – CalPortland and Environmental Caucus non-governmental organizations finalized the Sequalitchew Creek Restoration Plan Funding Agreement and CalPortland funded the Restoration Plan Permit Fund per the terms of the agreement.

[5] *The CalPortland DuPont North Parcel EIS included discussion and analysis of mining on the South Parcel as a Potential Similar Action.*

- May 2021 – CalPortland applied for permits to allow mining in the Expansion Area (including the South Parcel) and vertical extension within the Existing Mine (Re-Mine Area); the 2021 application is referred to as the Proposed Action.

The 1992/93, 1995, 2001, 2005, 2007 and 2013 EISs, Supplemental EISs, and EIS Addendums listed above are hereby incorporated by reference into this EIS, in accordance with WAC 197-11-625 and 754. Accordingly, all or part of the incorporated documents, including any studies or reports that provide information relevant to the proposal, become part of the City of DuPont's environmental documentation for the current proposal.

2011 Settlement Agreement Summary

The 2011 *Settlement Agreement for DuPont Mine, Restoration of Sequalitchew Creek Watershed, and Preservation of Puget Sound Shorelands and Adjacent Open Space*, was signed by CalPortland; the Nisqually Delta Association, the Black Hills Audubon Society, the Tahoma Audubon Society, the Seattle Audubon Society, the Anderson Island Quality of Life Committee, the Washington Environmental Council, and People for Puget Sound (collectively known as the "Environmental Caucus"); the Washington Department of Ecology; and the City of DuPont. The 2011 Settlement Agreement was also signed by WPP LLC who owned the property for a period of time and is both a successor and a predecessor in interest to Weyerhaeuser.

The 2011 Settlement Agreement set forth a process for the submittal and review of permit applications for the North Parcel first, and then the South Parcel. As a preferred alternative to the mitigation CalPortland had originally proposed in 2007 for the South Parcel, the Settlement Agreement also prescribed the process for the development, funding, and implementation of a Sequalitchew Creek Restoration Plan to help restore and enhance the Sequalitchew Creek watershed, including flows along the length of the Sequalitchew Creek. The Restoration Plan process provided for the approval of a separate Monitoring Plan for the South Parcel Mine by CalPortland and the Environmental Caucus non-governmental organizations. Further, the Agreement ensured that buffers along Puget Sound and Sequalitchew Creek would be maintained at a prescribed distance. To achieve these goals, the Settlement Agreement set forth a detailed series of mining and restoration actions to occur in a prescribed sequence over several years. See Section 3.3, **Surface Water**, Section 3.4, **Groundwater**, and Section 3.7, **Land and Shoreline Use**, for additional detail on the Settlement Agreement and relationship to the EIS Alternatives.

Sequalitchew Creek Restoration Plan

The Sequalitchew Creek Restoration Plan is sponsored by the South Puget Sound Salmon Enhancement Group (SPSSEG) which is one of 14 Regional Enhancement Groups (RFEGs) state-wide established by the Washington Legislature through RCW 77.95.060 as nonprofit corporations with state grant support with the mission of involving local citizens and agencies in salmon enhancement efforts. The plan is the result of a 2011 Settlement

Agreement for DuPont Mine, Restoration of Sequalitchew Creek Watershed, and Preservation of Puget Sound Shorelands and Adjacent Open Space which provides for (SPSSEG) to lead a multi-stakeholder effort to develop a restoration plan for the Sequalitchew Creek Watershed.

This agreement was the result of the CalPortland 2007 application to expand their aggregate mine and the resulting 2009 action by a group of environmental and conservation organizations to invoke a dispute resolution process with regard to a previous settlement agreement for the first phase of the mine. This dispute resolution process resulted in a mediation process that led to the 2011 Settlement Agreement between the environmental and conservation organizations, CalPortland, the Washington State Department of Ecology and the City of DuPont. This agreement described five major elements to be incorporated into a plan to restore flows to Sequalitchew Creek and directed the non-governmental parties to the agreement to execute a stakeholder process in order to receive input for development of a restoration plan. That stakeholder process was facilitated by the South Puget Sound Salmon Enhancement Group and involved a "Core Group" of representatives including: CalPortland Company, who operates and proposed to expand the aggregate mine on the north side of Sequalitchew Creek; the Nisqually Tribe; the Sequalitchew Creek Watershed Council, a non-profit organization; the Environmental Caucus which represents a number of non-profit organizations including the Nisqually Delta Association (NDA), the Black Hills Audubon Society, Washington Environmental Council (WEC), the National Audubon Society, People for Puget Sound, the Tahoma Audubon Society, the Seattle Audubon Society, and the Anderson Island Quality of Life Committee; Joint Base Lewis-McChord which controls the headwaters of Sequalitchew Creek; Pierce County; the City of DuPont; and the Washington Department of Ecology.

The Settlement Agreement directed the non-governmental entities involved to develop the restoration plan to sequentially restore flows in the creek, improve the sustainability of flows through the system, and restore aquatic habitat by removing flow-related fish passage barriers and increasing the habitat available to aquatic species through the restoration and enhancement of flows. The Agreement established a stakeholder "Core Group" of representatives to provide input. [6] The Core Group examined a number of alternatives with technical assistance provided by CalPortland consultants. In June, 2013 the group adopted a set of recommended restoration actions and solicited comments through August 30, 2013. The stakeholders adopted the final set of recommendations in December 2013 and prepared a Final Briefing Memo in January 2014. In March 2018 the Restoration Plan, Sequalitchew Creek Watershed, was released. That plan contains a set of

[6] *The "Core Group" includes representatives from CalPortland Company, who operates and proposed to expand the aggregate mine on the north side of Sequalitchew Creek; the Nisqually Tribe; the Sequalitchew Creek Watershed Council, a non-profit organization; the Environmental Caucus (*non-governmental organizations*) which represents a number of non-profit organizations including the Nisqually Delta Association (NDA), the Black Hills Audubon Society, Washington Environmental Council (WEC), the National Audubon Society, People for Puget Sound, the Tahoma Audubon Society, the Seattle Audubon Society, and the Anderson Island Quality of Life Committee; Joint Base Lewis McChord which controls the headwaters of Sequalitchew Creek; Pierce County; the City of DuPont; and the Washington Department of Ecology*.

goals and objectives with defined quantified performance standards, tied to each objective, together with an adaptive management process for determining if and when the goals and objectives have been achieved.

Mining of the South Parcel and the Restoration Plan for Sequalitchew Creek are separate, but interacting, projects. Each project is anticipated to have its own monitoring and adaptive management process tailored to achieving the goals and objectives of that project. The interaction between the two adaptive management processes include: 1) project schedules that encourage restoration in advance of the potential impacts from mining; 2) development of performance thresholds for mining that support restoration; this includes a monitoring plan for the South Parcel, which was drafted with the input of the Environmental Caucus non-governmental organizations; and, 3) coordinated monitoring and open sharing of information. The Settlement Agreement also specifies that mining permits will not be legally effective unless and until permits for the Restoration Plan are issued by the responsible government agencies.

Consistent with the 2011 Settlement Agreement, the Restoration Plan was developed by the non-governmental parties to the Settlement Agreement (CalPortland and the Environmental Caucus). Although it builds upon the five components of Sequalitchew Creek restoration identified in the Settlement Agreement and involved input from both the non-governmental and governmental members of the Core Group, the Plan has not been formally reviewed and approved by any governmental agency. The Settlement Agreement references the understanding that State Environmental Policy Act (SEPA) review will be required at the time specific implementation actions are pursued. Under Section 4.5.3 of the Agreement, CalPortland and the Environmental Caucus agreed that CalPortland's commitments regarding the Restoration Plan "shall be deemed, adequate mitigation of all direct and indirect impacts of mining on Sequalitchew Creek" and that implementation of the plan is intended to constitute "more than 'mitigation" as defined in WAC 197-110-768 and other similar definitions. This part of the agreement is binding only on the non-governmental entities. The agreement also acknowledges that further mitigation measures may be suggested and implemented through the applicable permit processes.

2.4 Description of the Proposed Action

The following identifies the Applicants Objectives for the *Pioneer Aggregates South Parcel Project* and describes the Proposed Actions necessary to implement these objectives.

Applicant's Objectives

The Applicant's goals and objectives for the South Parcel Project are as follows:

- Extract and utilize mineral resources of long-term commercial significance, consistent with the Growth Management Act and DuPont Comprehensive Plan.

- Continue to meet the Puget Sound regional demand for high-quality aggregates from designated mineral resource lands, including the existing mine and the South Parcel site in DuPont, using existing processing and transport facilities, and to achieve consistency with the terms of the 2011 Settlement Agreement.

- Expand mining horizontally into approximately 188 acres previously undisturbed by mining (including South Parcel), and vertical expansion of the depth of mining on approximately 125 acres where re-mining will deepen a portion of the Existing Mine to:
    - Fully utilize the site's high-quality reserves of sand and gravel that exists below the current permitted depth on the Existing Mine and under the surface of the South Parcel.
    - Extend the useful life of the existing processing and transport facilities by providing a reliably supply of quality aggregates for processing and transport.
    - Continue to provide the quality product mix to the sand and gravel market.

- Maintain barge export of the majority of mined aggregate materials to continue to limit the amount of export by truck and to maximize the environmental and other benefits associated with marine transport.

- Carry out a mine plan for the site that minimizes environmental impacts associated with mining activity, adheres to state and local regulations, and maximizes the economic value of the site;

- Ultimately, reclaim the site, including regrading, replacement of topsoil, and revegetation.

- Implement applicable provisions of the 2011 Settlement Agreement

Description of the Proposed Actions

To implement the Applicants Objectives for the site, the Proposed Actions for the Pioneer Aggregates South Parcel Project includes the following reviews and approvals:

- City of DuPont Community Development – Site Plan Review, Tree Modification Review, Critical Areas Permit, Determination of Transportation Concurrency.

- Washington State Dept. of Natural Resources - Reclamation Permit, and Forest Practices Permit.

The need for additional permits or approvals could be identified during the project review process.

2.5 Description of EIS Alternatives

Consistent with the September 2021 EIS Scoping Summary (see **Appendix A**), and to conduct a comprehensive environmental review, the alternatives analyzed in the Draft EIS include: Alternative 1 - Proposed Action and Alternative 2 - No Action. Other possible alternatives are also discussed.

Alternative 1 - Proposed Action

Overview

The proposed South Parcel Project includes horizontal expansion of the mine footprint by approximately 188 acres onto the Expansion Area (including the South Parcel), vertical deepening on the approximately 125-acre Re-Mine Area where re-mining would deepen a portion of the Existing Mine, and extension of the existing rate of mining for an additional approximate 14-year period (depending on market conditions), increasing the available sand and gravel resources by 30 to 40 million tons. The Expansion Area is located within a Mineral Resource Overlay applied by the City of DuPont's Comprehensive Plan. The purpose of the overlay is to conserve mineral resources of long-term commercial significance for eventual extraction, as required by the Grown Management Act.

The geologic character of the site (and the Existing Mine) follows the configuration of geological features that determine the location of high-quality aggregate resources. The aggregate proposed to be mined is part of a geologic deposit known as the Steilacoom gravels that were deposited in the waning years of the last ice glaciations in the area. The Steilacoom gravels were deposited as a result of a glacial outburst, probably the failure of an ice dam that previously impounded a large lake. The resulting flood carried sands and gravels some distance and the associated transport, rework, and sorting washed much of the silt and clay out of the gravels. That makes this source of aggregate particularly well suited to a variety of applications, particularly as a component of concrete. In this area, the Steilacoom gravels were deposited over older Vashon outwash and Olympia Beds (Qob) deposits. The Steilacoom gravels are deepest in the western portion of the site and become increasingly shallower to the east, as shown in the geologic cross section in **Figure 2-3**.

Mining on the site would generally proceed from north to south and east to west in the same manner as occurs in the Existing Mine. Annual mining quantities would be similar to quantities from the current mine as shown in **Table 2-1** (provided later in this Chapter) and would be extracted after groundwater flowing into the materials is intercepted. A 20-foot high noise berm would be constructed along the southern boundary of the site; the noise berm would be located behind existing vegetation on the site.

The South Parcel Project would involve seven primary activities: logging, clearing and topsoil removal, groundwater management, stormwater management, mining, processing & transport, and reclamation. These activities would overlap, with multiple actions occurring at any one time, as described below.

Logging

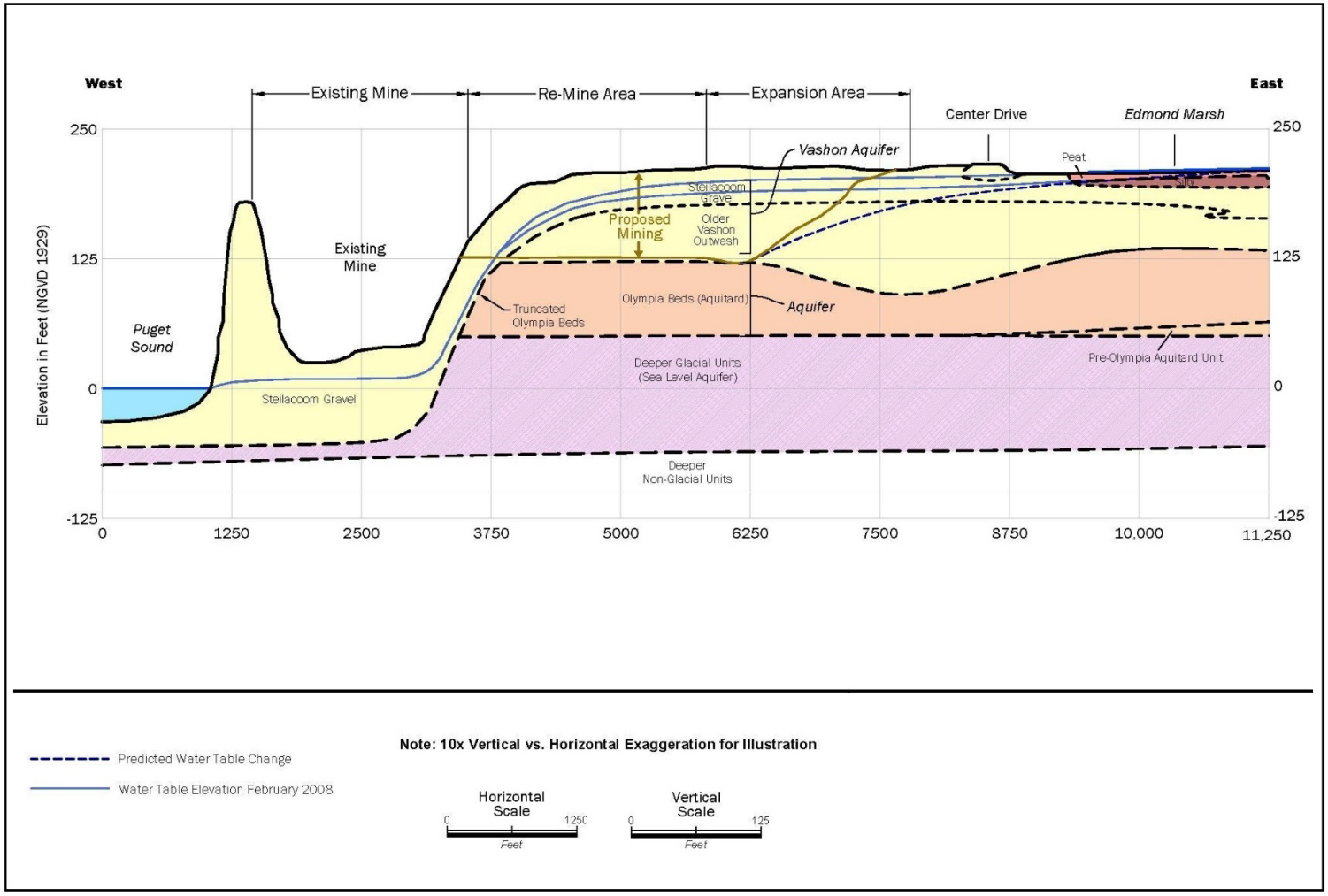
Timber was last logged from the South Parcel several decades ago, but tree cutting would be required on the majority of the South Parcel prior to clearing and mining in the Expansion Area. A substantial portion of the proposed mining would occur in areas where logging is not required, for example within previously reclaimed areas of the Existing Mine (i.e., the Re-Mine Area) or in previously unmined areas of the Existing Mine where Scot's broom shrub dominates the landscape.

The Expansion Area (including South Parcel, kettle wetland and buffer strip) would be logged at a single time prior to initiating mining, including proposed removal of trees meeting the definition of Landmark trees (DMC 25.10.120.005) within the mine footprint such as Oregon white oak, Douglas fir, western red cedar, Pacific madrone, and Pacific yew.

Clearing and Topsoil Removal

Prior to mining, excavators would be used to remove stumps and vegetation. This material would then be processed through a portable tub grinder and used to amend topsoil for use in reclamation. Clearing and topsoil removal would occur in the mine area, in segments as mining advances into the Expansion Area, over the life of the project.

Past industrial activities have resulted in elevated metals concentrations in portions of the Expansion Area. The Former DuPont Works Site is a clean-up site associated with the historical explosives and commercial munitions facility that operated from 1909 through 1976. The primary contaminants are arsenic and lead in surface soils. Cleanup activities were completed in 1993 to address the highest concentrations of lead, generally found along the foundations of the former buildings. Weyerhaeuser entered a Consent Decree with Ecology that required implementation of a restrictive covenant limiting land use on the Former DuPont Works Site to industrial uses, which is the origin of the Manufacturing and Research Park zoning for much of the site. The Expansion Area is also located downwind of the former Asarco copper smelter and refinery in Ruston, Washington. Airborne pollution emitted from the former smelter has resulted in a 1,000-square-mile, area-wide plume of arsenic- and lead-contaminated soil known as the Tacoma Smelter Plume ("TSP"). Surficial soils in the Expansion Area that have been undisturbed since the mid-1980s may contain arsenic and lead at concentrations above cleanup levels. These soils would be cleaned up in consultation with Ecology through the Voluntary Cleanup Program ("VCP"). Under the VCP, CalPortland has submitted a Cleanup Action Plan to Ecology describing the plan to address arsenic and lead in surface soils resulting from the TSP and remaining from the Former DuPont Works Site. The plan incorporates the same process that is being implemented on



Source: Aspect Consulting, 2022.

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Figure 2-3

Hydrogeologic Cross Section

the North Parcel. Ecology has reviewed the Cleanup Action Plan and issued an opinion letter stating that after implementation of the plan "no further remedial action will likely be necessary at the Property to clean up contamination." The letter also describes the potential steps required to remove the restrictive covenant after arsenic and lead concentration in the surface soils have been reduced on the property.

Groundwater Management

As described under "Mining" later in this chapter, mining under the Proposed Action would proceed slowly from the north to the south over a period of five to eight years, extracting gravel to create a broad trough along the eastern property boundary.

An aquifer is present in the sands and gravels proposed to be mined under the South Parcel Project. Wells would be installed and pumped in advance of mining to intercept groundwater and dry out the gravels for mining. Pumped water is proposed to be infiltrated in the Existing Mine. The purpose of mining a trough would be to minimize the amount of time that active dewatering by pumping wells is required. Once mining of each section of the trough is completed, the adjacent wells would be turned off, allowing groundwater to passively seep from the stable mine slope and flow by gravity via a surface conveyance system to an infiltration facility on the floor of the western margin of the Existing Mine. After mining the trough along the perimeter, gravel would be extracted from the interior area.

A detailed dewatering plan has been developed and involves four steps, occurring over the lifetime of the proposal (see **Figure 2-4, Groundwater Dewatering**). The four steps are:

- **The initial step** is a 60-day pumping test that would be completely reversible (i.e., no gravel would be extracted during the test). The results of that test would be analyzed to confirm predictions from the groundwater drawdown model and would be used to adjust the dewatering plan (well spacing, well screening, etc.) as necessary prior to commencing the next phase.

- **The second step** would involve installing and pumping additional dewatering wells to lower water levels in the first mine segment in preparation for mining. This step would last about six months and would function as a greatly expanded pumping test. As with the initial step, it would also be completely reversible. Groundwater observations during pumping would be compared to model predictions in order to confirm that actual changes in groundwater are within the range predicted during project planning, when potential impacts from the project are evaluated. This step would confirm model predictions before any gravel is removed from the Expansion Area.

- **The third step** – active dewatering during mining – would involve mining the trough described above. Additional dewatering wells would be installed and pumped as mining progresses. Mining would begin at the northerly location farthest from the Edmond

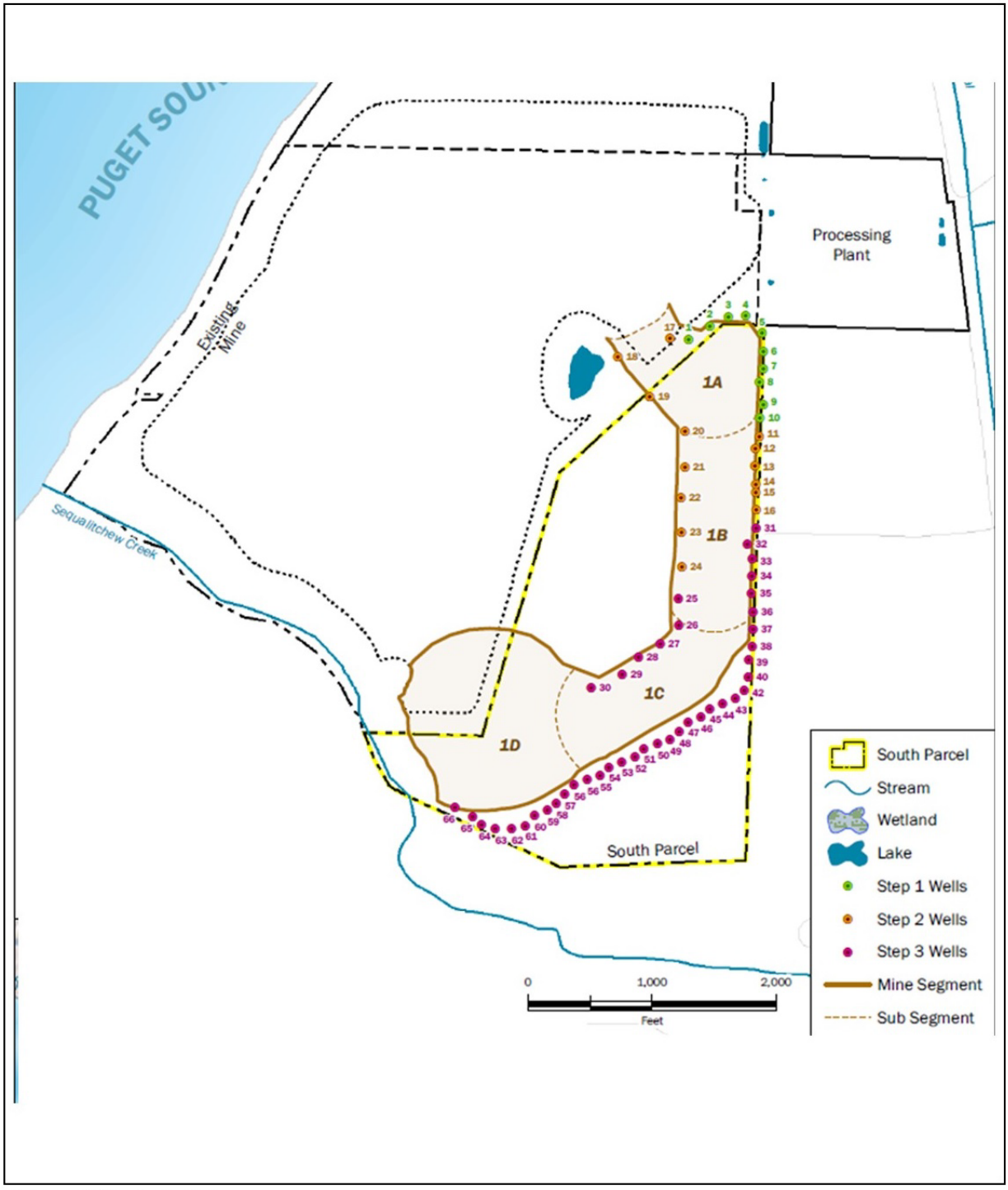
Marsh and Sequalitchew Creek and proceed slowly south. Completing the trough would require five to eight years depending on market conditions and the success in meeting predicted groundwater levels. The potential impact on groundwater levels would build slowly over time as wells would be added and mining would progress to the south. This would allow ample opportunity to monitor, confirm model predictions, and adapt to the conditions observed before mining proceeds into each dewatered segment.

- **The final step** – passive dewatering – would begin when mining of the trough described above is complete and the last dewatering well is turned off. Passive dewatering represents the groundwater condition that would continue in perpetuity. Groundwater, no longer intercepted by wells, would form seeps at the toe of the eastern mine slope. It would flow by gravity down the slopes and into and through a conveyance ditch to newly created wetlands on the bottom of the Existing Mine and eventually to an infiltration facility at the western margin of the Existing Mine. Once this step has begun, further mining activities in the interior of the South Parcel would not have additional effects on groundwater. See Section 3.3, **Surface Water**, and Section 3.4, **Groundwater,** for additional detail.

An adaptive management plan aimed at observing and responding to changes in groundwater levels has been developed to guide dewatering activities during all four dewatering steps. The adaptive management plan, called the Monitoring Plan (Aspect Consulting. 2017), was developed in consultation with the Environmental Caucus non-governmental organizations as required by the Settlement Agreement. During dewatering, adaptive management involves the following steps: (1) monitoring at groundwater wells throughout each dewatering step; (2) comparing those monitoring results with thresholds established for each well; and (3) adapting dewatering activities if water levels are below the thresholds. The thresholds established in the Monitoring Plan were developed using a groundwater model based on 12 years (2004-2015) of data, using available data for observed groundwater levels at wells throughout the watershed. The thresholds are established for each well, in each month of the year, at each dewatering step. The Monitoring Plan also includes a process for notification of results below the thresholds and any adaptive management actions taken, and routing periodic reporting.

Stormwater Management

A stormwater management system would be installed onsite, consistent with City of DuPont's stormwater requirements which adopt the minimum requirements of the *Washington State Department of Ecology's (Ecology) Stormwater Management Manual for Western Washington* (as amended in 2014). These facilities would be constructed as mining advances and would serve the site at the completion of mining. They would also be used as the primary components of temporary stormwater management during construction. The proposed stormwater management system would preserve the natural drainage pattern of the site. Precipitation falling on the site would be collected and infiltrated internally within the site. From there it would join the sea-level aquifer beneath



Source: CalPortland, 2021

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Figure 2-4

Groundwater Dewatering Plan

the site and flow to Puget Sound, as it does currently. Once the site is reclaimed, stormwater from the eastern slope of the proposed mine expansion would be collected along with groundwater inflows and drain to a mitigation wetland to be constructed on the floor of the Existing Mine to provide hydrologic support to the wetland. There are no outfalls or other discharges of stormwater to surface water proposed. Stormwater runoff best management practices (BMPs) -- two-celled wet ponds – would be included upstream of the proposed infiltration facilities to prevent contamination of surface or groundwaters.

A Stormwater Pollution Prevention Plan (SWPPP) developed under Ecology's Sand and Gravel General Permit would be implemented to control erosion and sedimentation. (See Section 3.3, **Surface Water***,* for further details.)

Mining

Mining under the Proposed Action would begin by proceeding slowly from the north to the south over a period of five to eight years, extracting gravel to create a broad trough along the eastern property boundary (see **Figure 2-5, Mine Phasing**). The method of mining would be similar to that currently used in the permitted mine area. A dozer would push excavated material from the top of the mine face to two front-end loaders working on the mine floor. The front-end loaders would scoop up the sand and gravel and dump it into portable hoppers that would feed conveyors leading to the processing area.

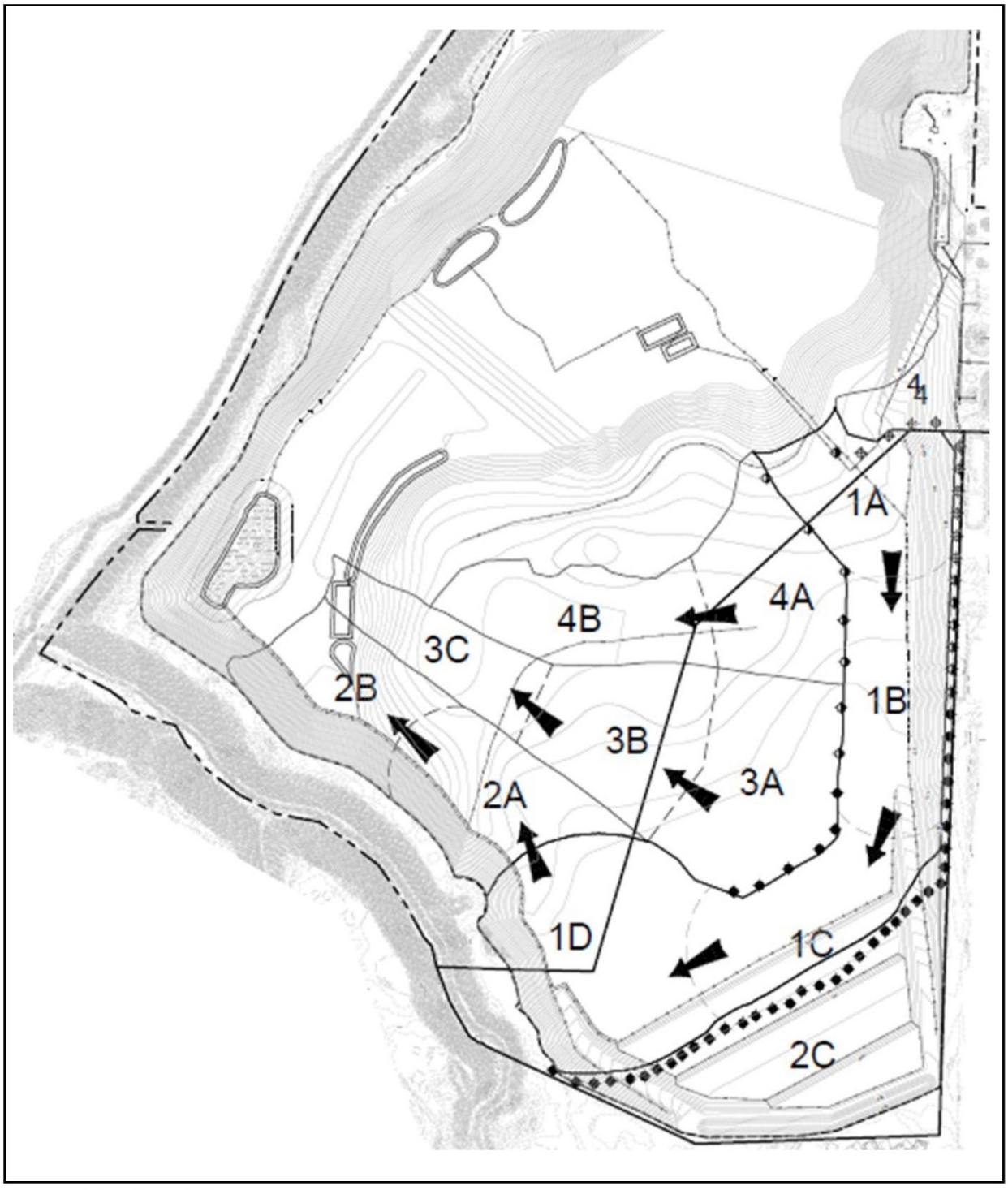
The mine face would be a maximum of 80 feet high and would decrease as mining progresses east. During reclamation, as described further below, the graded side slopes and mine areas would be revegetated and stabilized in accordance with the mine reclamation plan.

A conveyor would start at the north end of the Expansion Area and would be extended south as mining progresses. The conveyor would be comprised of a 48-inch-wide rubberized belt that would be supported by a series of rollers, called idlers, mounted on steel framed segments that would support the conveyor about five feet off the ground.

As indicated above, clearing (topsoil stripping and stump removal) of the Expansion Area would occur in sequences lasting approximately one year, in coordination with mining. Mass clearing of the site would not occur.

A 20-foot-high noise berm would be constructed along the southern boundary of the South Parcel, behind retained vegetation. The berm would help reduce potential noise associated with mining for adjacent land uses. The berm would be constructed prior to clearing in the adjacent portion of the South Parcel.

The Proposed Action would directly impact an approximately 1.78-acre kettle wetland located within the Existing Mine immediately west of the South Parcel. The kettle wetland is supported by groundwater and would be impacted by dewatering in preparation for mining,



Source: CalPortland, 2021

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Figure 2-5

Mine Phasing Plan

then removed during the initial phases of mining of the South Parcel Project. Impacts to the kettle wetland are proposed to be mitigated by creation of a larger wetland within the Existing Mine. See Section 3.5, **Plants and Animals**, for discussion on wetland impacts and mitigation under the EIS Alternatives.

Processing and Transport

Material mined with the South Parcel Project would be conveyed from the mine to the existing processing facility and would be processed in the same general manner as at present. The material extracted under the South Parcel Project is anticipated to have a higher moisture content and fines content than the aggregate currently being extracted. As a result, there may be minor adjustments to some of the equipment used in the processing area, but the overall process and most of the equipment would remain unchanged from current conditions.

Water would be used to wash the raw material conveyed from the mine to remove silt and clay. Sand and gravel smaller than 1.5 inches would pass through a screening and classifying process that would separate and convey the material to a series of stockpiles sorted by size and stacked on the south side of the processing plant. Stones larger than 1.5 inches would be crushed, sorted by size, and conveyed to a series of crushed-rock stockpiles sorted by size north of the processing plant. Screening equipment, rock crushers, and other processing equipment would be located between the stockpiles of sorted rock products. Custom blended rock products would also be made to customer specifications.

As under current conditions, approximately 95% of water used to process the mined material would be recycled through a treatment system where silt and clay would be removed so the water could be reused to process more raw material from the mine.

The mode and extent of transporting aggregate products from the site would not change relative to existing operations. Approximately 80% of the product would be loaded onto barges at the existing barge loading facility at Tatsolo Point and transported to the Puget Sound regional market by barges (refer to **Figure 2-1, Vicinity Map**). Approximately 20% of the product would be transported to the local market by truck. Some material would continue to be incorporated into concrete at the existing on-site concrete batch plant serving the local market.

Estimated Volume and Extraction Rates

Estimated mining quantities are shown in **Table 2-1**. Based on past market demand, material would be extracted at an average rate of approximately 2.8 million cubic yards per year. In total, an estimated 30 to 40 million cubic yards of material would be extracted under the South Parcel Project, which would extend the life of the current operation by approximately 14 years. The actual extraction rate and life of the mine would depend on the market demand for materials.

Table 2-1
ANNUAL AGGREGATE MINING QUANTITIES / TIMING

Timing	Existing Mine[1] in Cubic Yards	Proposed Action in Cubic Yards
Years 1 – 14	1.4 Million	1.4 Million
Years 15 – 19	0	2.8 Million

Source: CalPortland, 2021.

[1] Includes North Parcel.

Reclamation

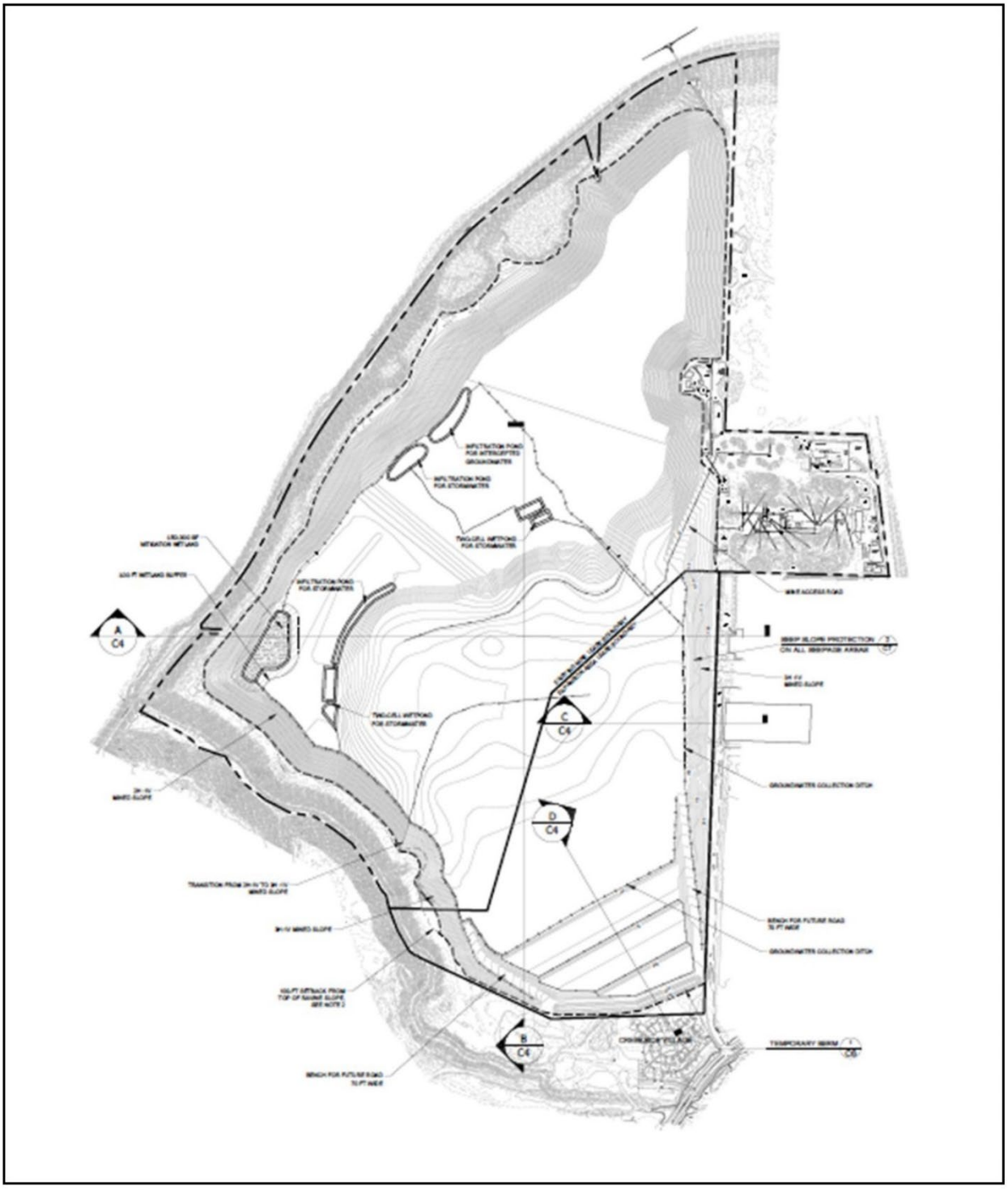
As mining progresses, completed mine segments would be reclaimed. The reclamation plan would be reviewed by the Washington State Department of Natural Resources ("DNR") for consistency with the Surface Mining Act (RCW 78.44). In general, reclamation would consist of regrading, replacement of topsoil, and revegetation. CalPortland is in the process of preparing an application to revise the existing reclamation plan incorporated into the surface mining permit. DNR cannot approve the revised reclamation plan until after the City's permits are issued. The proposed reclamation plan will be similar to the plan approved by DNR for the Existing Mine. See **Figure 2-6, Reclamation Plan** for an illustration of the reclaimed site.[7]

Table 2.2 provides a comparison of existing site conditions with site conditions under the Proposed Action (post-reclamation).

Alternative 2 - No Action

A No Action alternative is required by SEPA. "No action" is interpreted to mean that the South Parcel Project mining proposal would not be implemented. It does not necessarily mean that nothing would happen on the subject site. The site (including a portion of the Existing Mine and the South Parcel) could remain undeveloped or could be developed in the future in residential and manufacturing and research park uses, based on the existing zoning in this area. Accordingly, the No Action Alternative includes two scenarios: Scenario A – Continuation of Existing Site Conditions; and, Scenario B – Site Development under Existing Zoning.

[7] *Includes Existing Mine, North Parcel, and South Parcel.*



Source: CalPortland, 2021

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Figure 2-6

Reclamation Plan

Table 2-2
SITE CONDITIONS COMPARISON

Land Use	Area [1] in Acres									
	Existing Conditions					Proposed Action - Post-Reclamation				
	Expansion Area			Re-Mine Area	Total	Expansion Area			Re-Mine Area	Total
	South Parcel	Kettle Area	Buffer Strip			South Parcel	Kettle Area	Buffer Strip		
Built Areas										
Buildings	--	--	--	--	0.00	--	--	--	--	0.00
Roads, Access, and Parking	--	--	0.4	9.2	9.55	--	--	--	--	0.00
Processing Areas	--	--	0.2	17.9	18.08	--	--	--	--	0.00
Active Mining	--	--	--	--	0.00	--	--	--	--	0.00
Active Reclamation	--	--	0.2	20.5	20.62	--	--	--	--	0.00
Cleared for Mining	--	--	--	--	0.00	--	--	--	--	0.00
Water Management Ponds	--	--	--	--	0.00	--	--	--	--	0.00
Total Built Areas	**0**	**0**	**0.8**	**47.5**	**48.26**	**0**	**0**	**0.00**	**0.00**	**0.00**
Natural & Reclaimed Areas										
Areas Reclaimed as Forest	--	--	--	3.3	3.3	29.4	0.6	0.6	35.8	0.6
Areas Reclaimed as Grass	--	--	--	68.5	68.5	138.2	10.2	8.6	89.4	10.2
Wooded Areas	146.2	5.6	7.4	5.8	165.1	--	--	--	--	0.0
Grass Areas	21.3	--	1.0	0.21	22.5	--	--	--	--	0.0
Wetland	--	1.8	--	--	1.8	--	--	--	--	0.0
Wetland Buffer	--	3.4	--	--	3.4	--	--	--	--	0.0
Total Natural & Reclaimed Areas	**167.5**	**10.8**	**8.4**	**77.7**	**264.5**	**167.5**	**10.8**	**9.2**	**125.2**	**312.7**
Total	**167.5**	**10.8**	**9.2**	**125.2**	**312.7**	**167.5**	**10.8**	**9.2**	**125.2**	**312.7**

Source: CalPortland, 2022.

Notes: -- Indicates no area of this type.

1) Totals may not exactly equal the sum of their components due to rounding.

No Action Scenario A – Continuation of Existing Conditions

The No Action Alternative assumes that the South Parcel Project (including horizontal expansion into the Expansion Area and vertical deepening into the Re-Mine Area of the Existing Mine) would not occur. Mining activities associated with the Re-Mine Area of the site and the Existing Mine would continue as currently permitted. The kettle wetland within the Re-Mine Area would remain intact, the wetland buffers would remain vegetated, and mining operations would continue in other portions of the Existing Mine. The Existing Mine has an estimated remaining life of 6 to 10 years with mining currently limited to 10 feet above groundwater.[8] For Scenario A, it is assumed that annual extraction of approximately 2.8 million cubic yards associated with the currently permitted mining activities on the Existing Mine would continue, with processing and export as at present. However, actual extraction, processing, and export would depend on market conditions.

The South Parcel portion of the site is assumed to remain undeveloped and would continue in its vegetated condition.

The Sequalitchew Creek Restoration Plan developed by CalPortland and the Environmental Caucus non-governmental organizations in accordance with the 2011 Settlement Agreement includes a commitment from CalPortland for funding, monitoring data, and advocacy The plan also requires coordination between the Environmental Caucus non-governmental organizations, South Puget Sound Salmon Enhancement Group (SPSSEG), and Joint Base Lewis-McCord (JBLM). In the absence of CalPortland, the advocate and sponsor for the Sequalitchew Creek Restoration Plan under the No-Action Alternative would be SPSSEG.

The No-Action Alternative Scenario A includes the potential for the Sequalitchew Creek Restoration Plan to be implemented without the Proposed Action. The Restoration Plan entails Creek restoration activities both on JBLM property and outside JBLM within the City of DuPont. Funding for alterations to the diversion system on JBLM property is currently programmed by JBLM. For the portions of the plan outside JBLM, other funding sources (e.g., grants) would be required to implement the plan and may include a variety of sources of watershed restoration funds including Washington State salmon recovery funds. Such funds would likely need to be obtained through a competitive process and may or may not be at the same level of funding and/or at the same timeline as under the Proposed Action. At the present time, CalPortland is the only confirmed source of funding available to complete the portion of the work that the Restoration Plan requires outside JBLM.

No Action Scenario B – Site Development Under Existing Zoning

As indicated above, the No Action Alternative assumes that the proposal would not occur and the site (including the Re-Mine Area and South Parcel) could be developed in the future

[8] *Currently permitted mining includes mining activities on the Existing Mine and North Parcel.*

in residential and manufacturing and research park uses, based on the primarily R-4, R-R, and MRP zoning in this area. Accordingly, No Action Alternative Scenario B assumes site development under existing zoning.

Portions of the site are zoned for Manufacturing and Research Park (MRP; 136.2 acres), Residential-4 (R-4; 16.1 acres), Residential Reserve (RR; 22.3 acres), and Open Space/Sensitive Area (3.8 acres) uses. The MRP zoned areas are currently subject to restrictive covenants related to the former DuPont Works Cleanup Site, which restrict use of the property to industrial uses.

The extent of development could vary considerably depending on zoning/density, site planning, economic considerations, and numerous site-specific, project-specific and regulatory requirements (e.g., setbacks, open space, and the presence of critical areas). The following is intended to be a general estimate of the possible intensity of development for purposes of analysis only and is based primarily on zoned density and permitted site coverage. Development estimates are based on assumptions of building and parking areas as a percentage of developable area and do not represent a specific or detailed development proposal.

Areas zoned MRP would be available for development of up to 112 acres of light manufacturing and research park. Buildings may be up to 65 to 70 feet tall and there are no maximum lot coverage requirements other than necessary to meet required setback (25 feet on the front property line, 15 feet on the sides and rear) and landscaping (20% of lot area) requirements. This MRP zoned area could yield approximately 109 acres of impervious area at up to 80% lot coverage. The areas of the South Parcel zoned R-4 could be developed at a density of up to 4.5 single-family residences per gross acre, resulting in a total of approximately 76 residences with 69% impervious coverage. An additional four single-family residences could be developed in the smaller portion zoned for Residential Reserve density (one dwelling unit per 5 gross acres) and 34% impervious coverage.

There would be no changes in the use of the areas of the South Parcel zoned for Open Space. These areas are currently the naturally vegetated slope of the Sequalitchew Creek ravine and the Sequalitchew Creek pedestrian trail.

The No-Action Alternative Scenario B also includes the potential for the Sequalitchew Creek Restoration Plan to be implemented without the Proposed Action. However, as described under No Action Scenario A, while it is theoretically possible that another advocate could be identified and other funding could be obtained to implement the Sequalitchew Creek Restoration Plan developed by CalPortland and the Environmental Caucus non-governmental organizations, there are no other known likely substantial funding sources.

Alternatives Considered but not Carried Forward

SEPA requires that an EIS consider "reasonable alternatives" to a proposal, in addition to "no action" (i.e., not implementing the proposed action). A reasonable alternative is defined in the SEPA rules as one that can feasibly attain the proponent's objectives at a lower environmental cost (WAC 197-11-440(5)(b)). Existing regulations and commitments are also relevant considerations when determining whether a particular course of action is reasonable. This Draft EIS evaluates the Proposed Action and No Action. Three additional alternatives that were suggested in scoping comments are considered further below.

Prior environmental documents, including four EISs and SEISs for mining proposals within DuPont's Mineral Resource Overlay, have considered numerous alternatives for the location, design or operation of mining plans and components, key mining facilities and modes of transporting. The range of options has included processing plant locations, dock locations, conveyor route alignments, access road locations, varied transportation modes (barge, truck and rail) and mode split options, barge staging locations, alternative process water recycling methods, mining methods and mining area boundaries, alternative dewatering methods, and mitigation actions. These options are summarized in the North Parcel Draft EIS (2013) in Table 2-4. In addition, some options, and some elements of prior proposals, have been identified or eliminated by the terms of past Settlement Agreements. The 2011 Settlement Agreement, for example, eliminated several options for mining the North Parcel and established a mining boundary that avoided mining the bluffs along Puget Sound.

The *Final Feasibility Study* (2010), which provided information for the 2011 Settlement Agreement, identified and evaluated 24 alternatives for mining, dewatering and mitigation actions within the Sequalitchew Creek Watershed. Evaluation criteria that were applied to screen the full range of alternatives included operational viability, cost, environmental effects, uncertainty and regulatory viability, as well as several others. Mining options evaluated for the South Parcel included the following: (1) Mining Above the Aquifer; (2) Subaqueous (Wet) Mining Within the Aquifer; and (3) Various Dewatering Options, a category of actions to manage groundwater that consisted of several options for conveying groundwater for discharge to Sequalitchew Creek, including creation of an open channel (North Sequalitchew Creek), micro-tunneling, or diversions by pipe using other routes. The Feasibility Study's list of recommended options did not include alternatives that would involve conveying dewatering water to Sequalitchew Creek by gravity via tunnels or artificial structures (e.g., FS Alternatives 3.2.5) and these alternatives were not carried forward into the 2011 Settlement Agreement. The micro tunneling option of conveying groundwater to Sequalitchew Creek discussed in this EIS is among the potential mitigation measures that could be evaluated and implemented as part of adaptive management if necessary and

appropriate and would require resolution of conflicting provisions in the in the 2011 Settlement Agreement.

The Feasibility Study evaluation concluded that the mining options (wet mining or mining above the aquifer) were infeasible or unreasonable. The most salient reasons for eliminating these options included exorbitant capital and/or operational costs (wet mining in the aquifer and North Sequalitchew Creek dewatering options); and unreasonable reduction in the amount of sand and gravel that could be extracted (mining above the aquifer).

Additional Alternatives Considered

Comments received during the scoping process for the EIS suggested three possible additional alternatives which are discussed below.

1. Reduced Mining Alternative

Several comments received during EIS scoping suggested a "reduced mining" alternative. Reduced mining could be interpreted to mean a reduced area that is mined, a reduced depth of mining, and/or a reduced amount of material that is extracted by mining. The areal extent and depth of mining is based on site geology and the amount of material the Applicant proposes to extract is based on stated project objectives, the economics of mining, and the market demand for sand and gravel resources. The proposal would also maintain the same rate of mining as for the original mine and the North Parcel. The proposed area of the South Parcel Project is also based on maintaining a buffer around the active mine area to mitigate noise and visual impacts, and to maintain separation from adjacent off-site historical resources required by applicable conditions of approval. Reducing the size of the mine area by some additional amount would not, by itself, likely result in noticeable reductions in impacts to the environment that could not also be achieved through mitigation measures that are or could be incorporated into the proposal. For example, noise impacts to adjacent land uses could be effectively mitigated by the proposed noise berm as well as reducing the mine area and/or providing greater separation between uses. A smaller mining area would not, per se, result in less traffic or different impacts to land use, for example. In developing the Proposed Action, CalPortland revised the mining plan from prior submittals to increase the distance between the noise berm and the Creekside Village development to leave intact the existing vegetation. The proposed berm is set back an average of 145 feet from the property line, compared with 30 feet under earlier proposals. This change reduced the mine footprint in the shallowest portion of the mine.

"Reduced mining" could also suggest reducing the depth of mining. A potential rationale for this scenario could be to avoid mining into the aquifer. As noted in the previous discussion of this potential alternative in the 2010 Final Feasibility Study, the site's high seasonal groundwater level would result in effectively prohibiting commercially viable mining under

this scenario. The prior analysis concluded that this alternative does not meet the criteria for reasonable alternatives because it could not feasibly attain or approximate the proposal's objectives and does not appear to reduce environmental impacts.

2. Preserve the Kettle Wetland Alternative

The 1.8-acre kettle wetland, which is discussed in Section 3.5, **Plants and Animals**, is located on the original Pioneer Aggregates mine site and was maintained pursuant to a condition of approval. The South Parcel Project proposes to remove the wetland and to mitigate for the impact by creating a 3.4-acre wetland complex off-site within the existing mine. The amount of sand and gravel material that would be extracted as a result of removing the wetland would not be significant and is not the reason for its removal. Because the kettle wetland is supported by groundwater from the site's aquifer, mining and dewatering as proposed would remove its source of water and the wetland would dry up over time. It is not feasible to retain the wetland and to mine into the aquifer. Any reduction in environmental impact from retaining the wetland would be offset by the wetland mitigation that is proposed.

3. No Dewatering for Mining Using Wells, and Creation of an Interceptor Channel

This alternative, which was suggested during the EIS scoping process, would involve construction of an interceptor channel along the western edge of Edmond Marsh. The comment hypothesized that the Olympia Beds rise to near the ground surface in the vicinity of Edmond Marsh, forming a convenient location for constructing an interceptor channel to collect groundwater flow. The interceptor channel would be an open channel, much like a ditch. To be effective at dewatering to support mining, it would need to extend vertically to the depth of the Olympia Beds and horizontally the full length of the east side of the South Parcel.

Extensive drilling conducted in the 1980s during initial geologic and groundwater studies for the Pioneer Aggregates mine indicates that the Olympia Beds are found between 87 to 139 feet below the ground surface in the borings closest to Edmond Marsh. Several of the borings closest to the marsh did not encounter the Olympia Beds at their completion depths of 65 to 103 feet. None of these borings encountered the Olympia Beds near the ground surface. These borings are located in the southeast corner of the South Parcel and in the southern portion of the parcel now occupied by the Amazon Fulfillment Center. In 2002, a boring was completed in the western end of Edmond Marsh and encountered the Olympia Beds at a depth of 84 feet. Thus, it is reasonable to expect that the Olympia Beds are present under Edmond Marsh at around 80 to 100 feet below the ground surface (see **Appendix E** for details on the borings and depth of the Olympia Beds).

The shallow interceptor channel along the western and southern perimeter of Edmond Marsh envisioned in public comment would not capture sufficient groundwater to allow for mining of the South Parcel. To be effective, an interceptor channel would need to be approximately 80 to 100 feet deep and extend several thousand feet to the north, crossing

through existing developed areas. An open channel 80 to 100 feet deep would be at least 500 to 600 feet wide at the top. Such an interceptor channel would have dramatic land use impacts, and by being closer to Edmond Marsh would likely have a greater impact on wetland water levels than the Proposed Action.

Evaluation of the interceptor channel alternative concluded the following: (1) the alternative relies on a presumed geologic structure (the rise of the Olympia Beds to near the ground surface) that is not supported by the borings completed in the vicinity; and (2) it is not feasible to construct an open channel along the western edge of Edmond Marsh that extends from the surface to the depth of the Olympia Beds and runs along the full length of the South Parcel. Therefore, this alternative was determined to be infeasible and is not carried forward for detailed analysis.

In summary, prior studies, environmental documents, feasibility analyses and the provisions of settlement agreements over a period of almost two decades have considered a wide range of options for mining, locating mining facilities, and mitigating for environmental impacts and, in combination, have narrowed the range of reasonable alternatives to the Proposed Action and No Action. The additional alternatives that were considered and are discussed in this section of the Draft EIS are not consistent with the objectives of the proponent, are not considered feasible, and are not reasonable alternatives for purposes of SEPA analysis.

2.6 Benefits and Disadvantages of Deferring Implementation of the Proposal

The benefits of deferring approval of the Proposed Action include the following:

- Potential impacts associated with vertical deepening of mining in the current mining area and horizontal expansion into the area not mined, including changed conditions associated with surface and groundwater, plants and animals, noise, air quality, and traffic.

- Alternative uses of the property allowed under the underlying zoning could provide for uses without the constraints of developing within the reclaimed mine pit.

The disadvantages of deferring the approval of the Proposed Action include the following:

- Development pressure in the City for alternative uses of the property could compromise preservation of a commercially valuable deposit of high-quality sand and gravel, which deposit is designated as Mineral Resource Land of long-term commercial significance in the City's Comprehensive Plan, in conformance with the State Growth Management Act.

- Deferring mining would limit the supply of sand and gravel material for infrastructure and building projects in the Puget Sound region. Public and private sector builders would be required to travel further distances to obtain sand and gravel, with greater impact to the regional road system, air quality, and greenhouse gas emissions.

- Diminished ability to continue to utilize water transportation of mined sand and gravel resource to the Puget Sound region from this source. The availability of alternate aggregate sources with barge access has not been documented.

- Funding for the Sequalitchew Creek Restoration Plan, pursuant to the 2011 Settlement Agreement could be deferred. Alternative funding from competitive grants likely would be required for implementation.

- Remediation of surface soil contaminants in the expansion area would occur in the future, consistent with the Cleanup Action Plan, as part of a future mining proposal or other development.

- Excise taxes and other revenues to the state and City of DuPont would be deferred.

- Jobs associated with the CalPortland's mining operation in DuPont would be reduced over time as the Existing Mine is exhausted. This reduction would also reduce indirect employment supported by the aggregate industry and associated wages and spending.

Chapter 3

AFFECTED ENVIRONMENT, IMPACTS, ALTERNATIVES, MITIGATION MEASURES, & SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

CHAPTER 3
AFFECTED ENVIRONMENT, IMPACTS, MITIGATION MEASURES, AND SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

This chapter of the Draft Environmental Impact Statement (DEIS) describes the affected environment (i.e., existing conditions), impacts of the EIS Alternatives, mitigation measures, and any significant unavoidable adverse impacts on the environment that would be anticipated under the EIS Alternatives.

3.1 EARTH

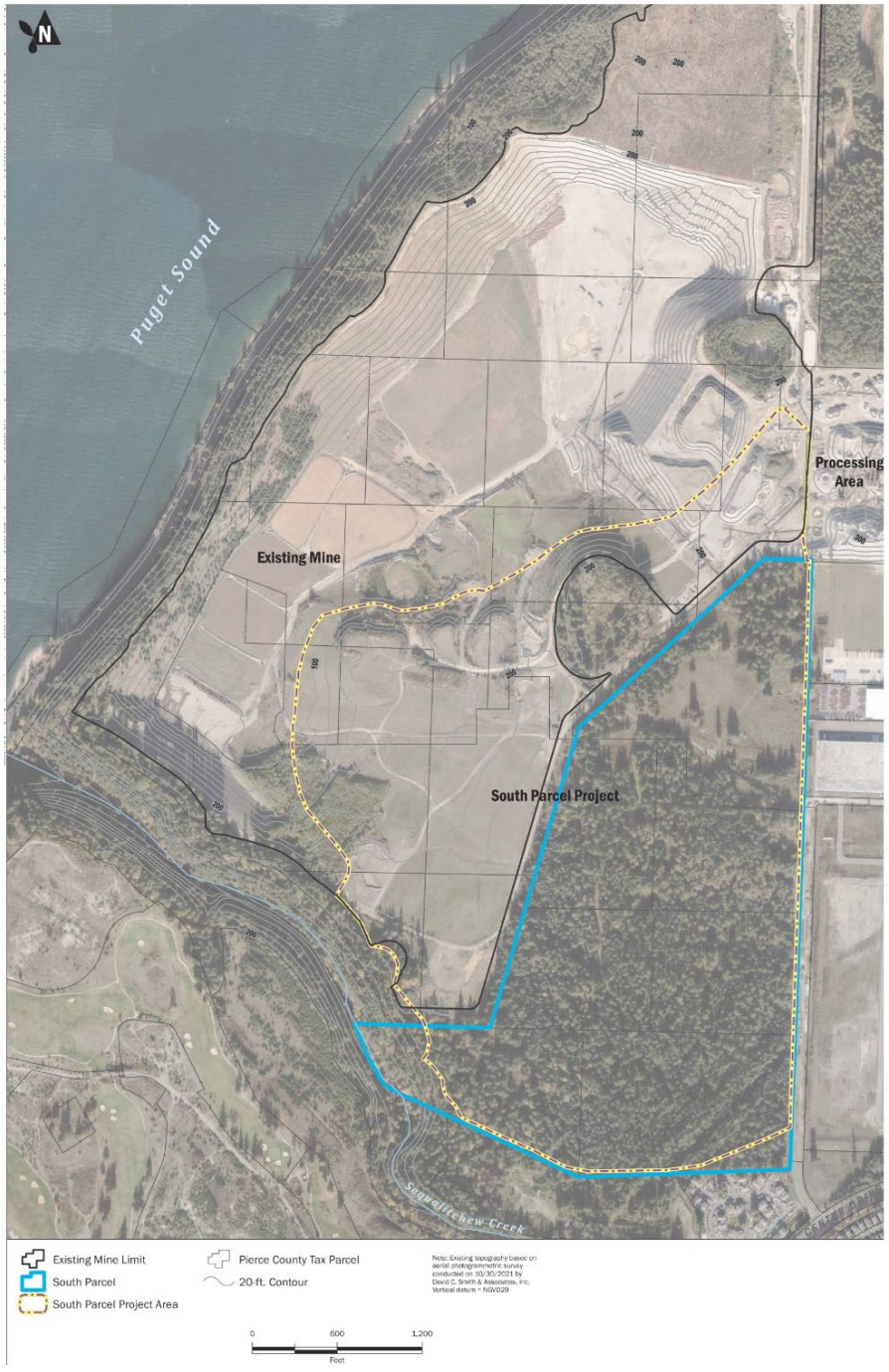
This section of the DEIS describes the existing topographic, soils, and geologic conditions on and in the vicinity of the site (including the approximately 188-acre Expansion Area and approximately 125-acre Re-mine Area onsite). Potential impacts associated with the EIS Alternatives are evaluated and mitigation measures identified. This section is based on the *Earth and Water Resources Report* (May 2023) prepared by Aspect Consulting and peer reviewed by Landau Associates (see **Appendix B**).

3.1.1 Affected Environment

Geologic and geotechnical analyses were performed to determine geologic conditions beneath the existing ground surface of the Pioneer Aggregates South Parcel Project site (including both the Expansion Area and Re-Mine Area portion of the site). These analyses were completed to evaluate the stability of proposed cut slopes and identify areas prone to geologic hazards, such as slope failure or seismically-induced soil liquefaction. The analyses rely on geologic investigations conducted over a period of more than 30 years, notably including over 109 borings completed in the late 1980s to facilitate planning of the initial Pioneer Aggregates mine (see **Appendix B** for detail).

Topography and Landform Geography

The site is comprised of the Expansion Area, which is undisturbed by mining, and the Re-Mine Area, which is a portion of the existing mine. Existing topography of both areas is shown on **Figure 3.1-1**. The Expansion Area portion of the site is generally flat and at an elevation of approximately 200 feet. The Re-Mine Area has a rolling slope toward the west down to the floor of the existing mine (western boundary of the site). The slopes to the west within the Re-Mine Area portion of the site vary between a grade of 10% to 70% locally.



Source: Aspect, 2022.

EA Engineering, Science, and Technology, Inc., PBC

Figure 3.1-1
Existing Topography

The Sequalitchew Creek ravine is located south and southwest of the site; this ravine forms most of the southern boundary of the existing mine. The ravine deepens as it approaches Puget Sound to a maximum depth of 175 feet below the plateau elevation. Slopes along the northern side of the Sequalitchew Creek ravine range from approximately 30% to 75%. A narrow-gauge railroad associated with the former E.I. DuPont de Nemours Company munitions facility was constructed on a bench cut into the northern slope of the ravine; it has since been converted to a public trail.

Regional Geology and Geologic History

The geology of the region, and South Parcel Project site, is dominated by past glaciation. The most recent ice-sheet glaciation of the Puget Lowland is termed the Vashon Stade of the Fraser Glaciation. Global and regional scientific observations indicate that there were many cooler climatic periods prior to the Vashon glaciation that produced ice-sheet glaciations, and deposits from a number of these pre-Vashon glacial and non-glacial periods in the Puget Lowland have been identified.

During the southward advance of the Vashon ice sheet, ice blocked the normal northward drainage of water from the Puget Sound Lowland, creating a lake into which silt, clay, and fine sand were deposited. As the Vashon ice sheet advanced farther southward, meltwater streams and rivers filled the remaining low areas with a blanket of sand and gravel that extended throughout the lowland. These subglacial troughs are visible today as the major waterways of Puget Sound, Hood Canal, Lake Washington, and Lake Sammamish, and many of the broad river valley bottoms in the Puget Lowland. A discontinuous layer of basal till (also described as lodgment till) was deposited where the glacial ice sheet contacted previously deposited sediment.

The Vashon ice sheet was short lived in the lowland and the advance of glacial ice appears to have stagnated abruptly. Sediment that was entrained on or within the ice was deposited on the landscape when the ice melted. These deposits are called ablation till and are found largely intact where they were deposited on the uplands. Ablation till deposited in low areas was reworked by meltwater streams that flowed from the melting glaciers to form recessional outwash. In places, the deposits were influenced by shifting ice margins creating highly variable ice contact deposits, which contain both water-worked sands and gravels, and interbeds and lenses of silt and clay and till-like deposits.

These recessional sand and gravel deposits and interbedded ice contact deposits are collectively identified as Vashon Recessional Outwash (Qvr). The recessional outwash generally consists of clean (containing very little silt and clay) sand and gravel, or sand and gravel with variable amounts of silt and interbeds and lenses of silty sands and gravels.

As the glaciers melted and receded, a lobe of ice blocked the northward drainage of the Puyallup valley, creating Glacial Lake Puyallup. A prominent late recessional gravelly outwash member called the Steilacoom Gravel is interpreted to have formed when a series

of ice dam bursts (jokulhlaups) released the glacially impounded water in Glacial Lake Puyallup. Floodwaters spilled and transported coarse-grained sediments into a broad outwash plain in the Sequalitchew Creek area. These coarse-grained deposits created thick deltas where the outburst channels flowed into a lower elevation lake (Glacial Lake Russell) that had formed behind the remaining Vashon glacial ice.

Glacial Lake Russell (which is now partially occupied by modern Puget Sound) was deep and had steep sided walls in the site area, similar to those of the modern coastal bluffs. The contact between the sediments exposed in the former walls of Glacial Lake Russell and the overlying late glacial delta and flood deposits derived from Glacial Lake Puyallup is similarly steep and exhibits a marked change in soil types. The contact is called the "Olympia Beds Truncation". The location of the Olympia Beds Truncation is a key geologic and hydrologic feature at the site; see Figure 6 of **Appendix B**).

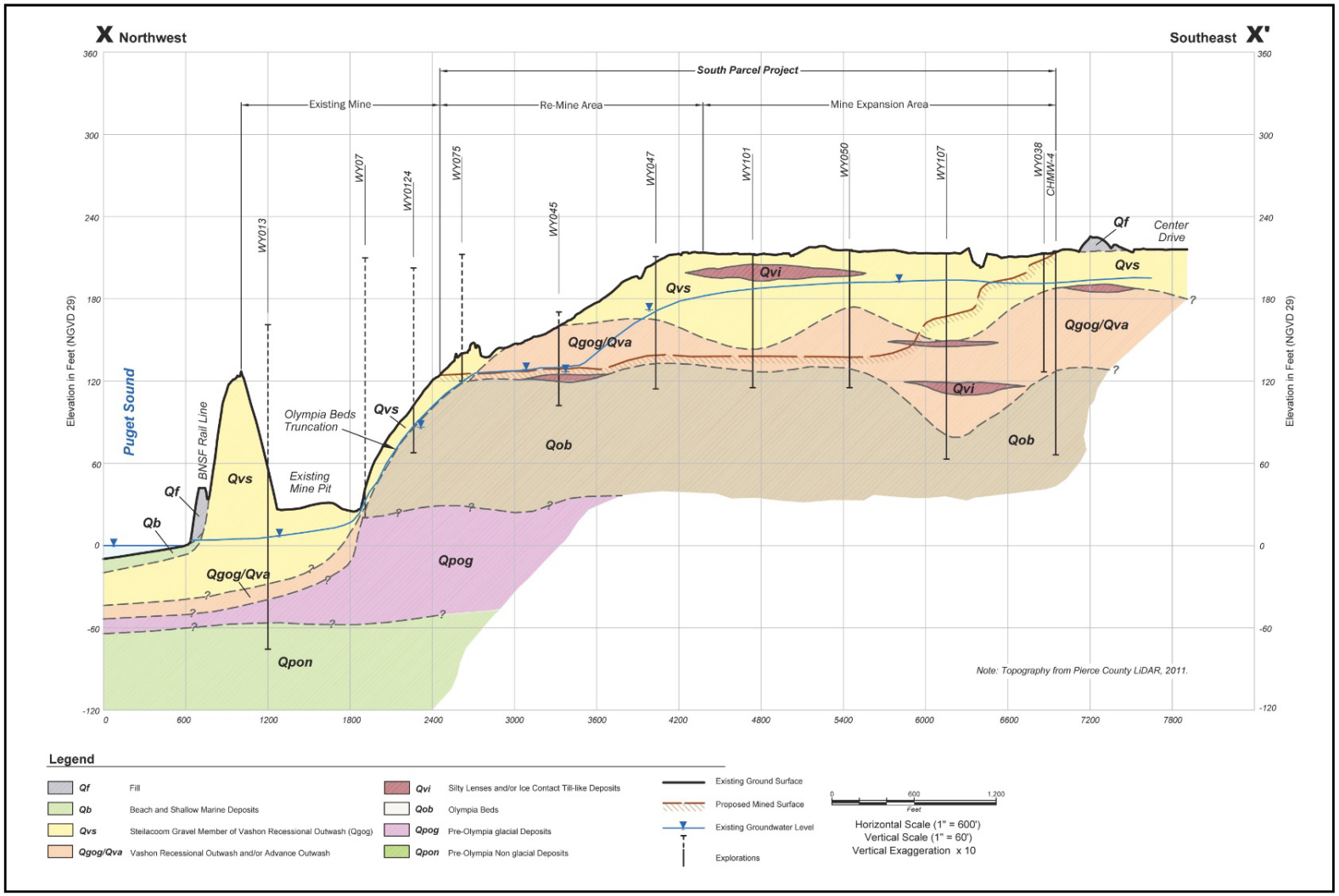
Site Geology

The geologic units of glacial and non-glacial origin were deposited at the site vicinity before, during, and after the Vashon glaciation. Understanding of site geologic conditions was further informed through borings and monitoring well explorations installed at the site (see Figures 5 and 6 of **Appendix B**). **Figure 3.1-2** shows the extent of the geologic units. These units are described below (see **Appendix B** for details.)

The surface geology of the site area consists primarily of Vashon-age recessional sand and gravel (Qgog) locally known as Steilacoom Gravel (Qvs). The recessional glacial unit is underlain by older Vashon-age glacial deposits, pre-Vashon non-glacial deposits, and pre-Vashon glacial deposits – all comprised primarily of sand and gravel.

The uppermost pre-Vashon non-glacial sequence at the site is identified as the Olympia beds. These non-glacial deposits are generally marked by an increase in silt, organics, and wood fragments. Older unnamed glacial and non-glacial deposits lie below the Olympia beds. These are identified as pre-Olympia non-glacial deposits (Qpon) and pre-Olympia glacial deposits (Qpog).

Steilacoom Gravel, which is comprised of the late-glacial delta and flood deposits, is a member of the Vashon Recessional Outwash unit and is identified as Qgog on the geologic map (see **Figure 3.1-2**). Steilacoom Gravel is located at the site and is considered an aggregate resource; this is the same geologic unit currently being mined in the existing mine area.



Source: Aspect, 2022.

EA Engineering, Science, and Technology, Inc., PBC

Figure 3.1-2

Geologic Cross-Section

After the end of the Vashon glaciation, non-glacial conditions resumed in the site area. Post-glacial geologic units deposited at the site included beach and shallow marine deposits, colluvium on slopes, and alluvium in drainage bottoms. Topsoil developed on soils in stable and forested uplands areas.

The site's geology was and continues to be influenced by tectonic/seismic events. The site lies within the Puget Sound Lowland, between the Cascade and Olympic Mountain Ranges. The Cascade and Olympic Mountains and the Puget Sound Lowland resulted from tectonic forces. These forces cause moderate-size earthquakes that are frequently felt throughout the region as well as infrequent large earthquakes.

Subsurface Conditions

Subsurface conditions at the site are inferred from review of the existing soil boring and well logs, published geologic data and maps, and geological reconnaissance. Based on the available information, the inferred geologic units at the site are described in sequence below.

Topsoil

Topsoil, including up to several inches of forest duff (organic debris), is present at the site. The duff layer is primarily present within upland forested areas. Portions of the site (primarily the Expansion Area) are vegetated with conifer and deciduous trees. The Re-Mine Area portion of the site has been previously cleared and is now vegetated with shrubs and grasses. Undisturbed, native topsoil is generally not present in the Re-Mine Area; however, topsoil has been placed over portions of the Re-Mine Area as a component of mine reclamation.

Steilacoom Gravel Subunit of Vashon Recessional Outwash

The majority of near-surface Vashon recessional outwash in the area is composed of the Steilacoom Gravel subunit (Qvs) of the Vashon Recessional Outwash (Qgog) deposit. This deposit consists of sandy gravel and gravelly sand with minor amounts of silt, ranging between 2 and 6%.

The Steilacoom Gravel has not been glacially overridden and is anticipated to be medium dense at the surface, grading to dense at depth. Like most outwash deposits, Steilacoom Gravel possesses a minor degree of cohesion which gives it a good intermediate-term standup time that is exhibited by the near vertical temporary cuts up to 70 feet high in the active area of the existing mine.

Olympia Beds

The Olympia Bed (Qob) deposits are located below the Steilacoom Gravel. The Qob unit is generally composed of interbedded lacustrine (lake sediments) and fluvial (river and stream sediments) deposits. Lacustrine deposits consist of silt and clay. The fluvial deposits consist primarily of sand but may contain oxidized gravelly lenses and layers. Interbed thickness of this unit ranges from inches up to about 10 feet. Some organic silt and peat layers that were deposited in wetlands and bogs are also generally present in this unit. The Qob unit has been overridden by the Vashon ice sheet and is generally very dense to hard in its natural state. Where exposed to seepage or weathering, its surface degrades and loosens.

The Qob deposits generally are considerably finer grained than the Vashon deposits above and can perch groundwater. Seepage has been noted at the top of the Qob unit where exposed in the road cut and natural ravine slopes along Sequalitchew Creek. If a lacustrine bed perches groundwater and is intersected by the surface of the slope, it could result in seepage onto the slope.

The contact between the top of the Olympia Beds and the overlying outwash deposits is generally encountered in the Olympia Beds at 80 to 140 feet below the ground surface.[1] (See **Appendix B** for detail).

Hydrogeology

Surficial site soils are generally highly transmissive to water. Stormwater tends to infiltrate into the natural soil surface rather than collect as runoff. The Steilacoom Gravel is generally highly transmissive to groundwater flow and storm water will infiltrate until it encounters the regional groundwater table, or until it encounters a silty interbed that locally perches groundwater. Additional information on surface water and groundwater is provided in Section 3.3, **Surface Water and Groundwater**, of this DEIS.

Geologically Hazardous Areas

Geologically hazardous areas (GHAs) are areas "susceptible to erosion, sliding, or other potentially hazardous geological events" as described in Section 25.105.030 of the DuPont Municipal Code (DMC). GHAs are defined in DMC 25.105.030, including the following:

- Landslide Hazard Areas

[1] *Olympia Beds are found between 87 to 139 feet below the ground surface in the borings closest to Edmond Marsh. Several of the borings closest to the marsh did not encounter the Olympia Beds at their completion depths of 65 to 103 feet. These borings are located in the southeast corner of the South Parcel and in the southern portion of the parcel now occupied by the Amazon Fulfillment Center. In 2002, a boring was completed in the western end of Edmond Marsh and encountered the Olympia Beds at a depth of 84 feet. Boring logs for these explorations are provided in* ***Appendix B.***

- Steep Slopes
- Erosion Hazard Areas
- Seismic Hazard Areas

The presence of GHAs in the Expansion Area and Re-Mine portions of the site are shown in **Figure 3.1-3** and described below. GHAs associated with the existing mine and Sequalitchew Creek areas immediately off the site are also identified and described.

Expansion Area Portion of Site

The Expansion Area portion of the site does not include any areas that meet the definition of GHAs. Topography is generally characterized by level ground or gentle slopes, typically inclined at gradients less than 15% that do not fall under the GHA criteria.
Areas interpreted as old rail grade cut and fill slopes steeper than 40% that locally exceed more the 10 feet of vertical relief were observed in the southeast portion of the Expansion Area. These do not qualify as GHAs because they do not intersect a geologic contact with relatively impermeable sediment or bedrock; do not have spring or groundwater seepage (DMC 25.105.030.345); and include stable constructed slopes that have historically performed well.

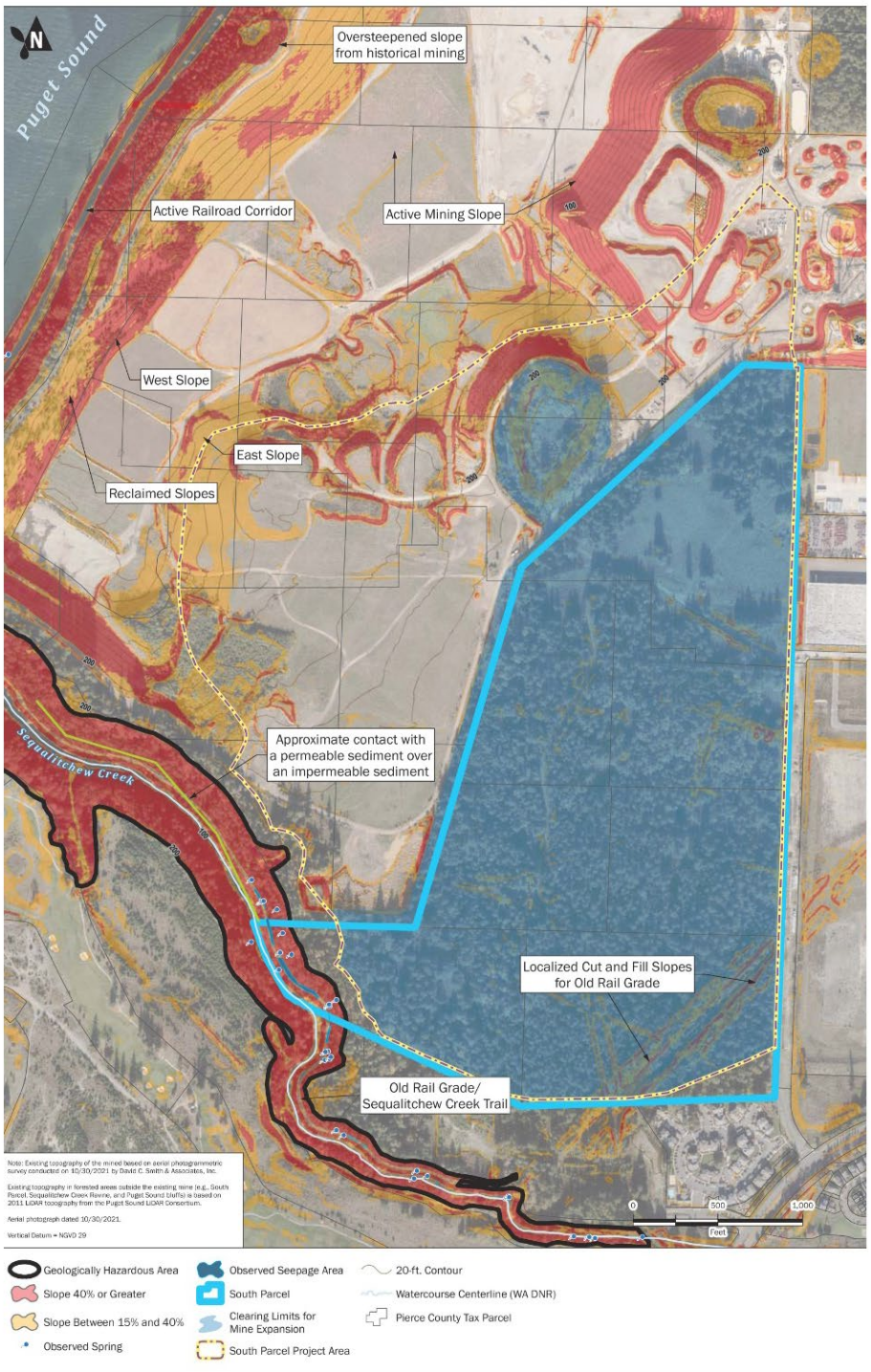
There are no channels, channel forming processes, or areas subject to coastal erosion within the Expansion Area, and there are no erosion hazard areas as defined by the City.

The Expansion Area does not include soils on slopes greater than 40% that are expected to be seasonally or perpetually saturated that pose a specific risk of settlement, movement, or liquefaction for seismic hazard areas as defined by the City.

Re-Mine Area Portion of Site

Existing conditions in the Re-Mine Area portion of the site do not meet the definition of GHAs, although there are areas with slopes steeper than 15% (see **Figure 3.1-3**). The topography of the Re-Mine Area generally consists of a gentle slope to the northwest descending toward the floor of the existing mine. Steeper slopes are present to the northwest of the Kettle wetland, where the slope is greater than 40%, and along the westernmost portion of the Re-Mine Area, where it typically varies between 15 to 40% Some of the steeper slopes shown on **Figure 3.1-3** within the Re-Mine Area represent temporary stockpiles or fill placement.

The areas of steeper slopes within the Re-Mine Area do not qualify as GHAs as they are either temporary slopes within an active mine or were designed and approved by a qualified professional experienced with the site and are thus exempted from being a GHA. There are no channels, channel-forming processes, or areas subject to coastal erosion within the Re-Mine Area, so there are no erosion hazard areas as defined by the City.



Source: Aspect, 2022.

EA Engineering, Science, and Technology, Inc., PBC

Figure 3.1-3

Geological Hazardous Areas—Existing Conditions

The Re-Mine Area does not contain seismic hazard areas because the soils on slopes greater than 40% are not expected to be seasonally or perpetually saturated and do not pose a specific risk of settlement, movement, or liquefaction.

Existing Mine Area (Off-Site)

The existing mine includes constructed slopes on the south and west sides that have been graded to their final configuration and reclaimed with topsoil and planting. The west slope is about 175 feet high and is smoothly graded at about 30% up to 50%, as shown on **Figure 3.1-3**. The subsurface soil under the topsoil of the west slope is sand and gravel with a trace of fines. The slope has been planted with grasses and conifer trees.

The west slope has a slope gradient of greater than 40% with a vertical relief greater than 10 feet, but it does not meet GHA criteria because it was designed and approved by a qualified professional experienced with the site, and thus is exempted from being a GHA.

No indication of past or imminent slope failure, land sliding, or erosion was observed (see **Appendix B** for detail). There are no topographic features that would suggest slumping or calving (when chunks of slopes are released), and there are no areas of exposed soil. The vegetation shows no evidence of disturbance from slope instability or erosion.

There are no channels, channel forming processes, or areas subject to coastal erosion within the existing mine, so there are no erosion hazard areas as defined by the City.

The existing mine does not contain seismic hazard areas because the soils on slopes greater than 40% are not expected to be seasonally or perpetually saturated and do not pose a specific risk of settlement, movement, or liquefaction.

Sequalitchew Creek Ravine (Off-Site)

Most of the Sequalitchew Creek ravine lies offsite, along the southern boundary of the existing mine and the site (see **Figure 3.1-3**). A small portion of the Sequalitchew Creek ravine is located within the Expansion Area portion of the site, but outside the proposed mining area. The ravine runs westward for approximately 1.5 miles down to the creek confluence with Puget Sound. The slopes on the northern side of the ravine range from approximately 30% to 75%.

The north slope of the Sequalitchew Creek ravine includes a bench cut for a former railroad grade that ran down the full length of the ravine. The railroad grade has been redeveloped into the Sequalitchew Creek Trail, surfaced with asphalt on the upper portion and crushed rock lower down.

Perennial groundwater seeps from the ravine's north slope at several locations, as shown on **Figure 3.1-3**. On the eastern two-thirds of the ravine, the subsurface soil in the upper

part of the slope (from the top of the ravine at approximate elevation 200 feet down to about elevation 110 feet) is permeable sand and gravel with minor silt; below approximately elevation 110 feet, the soil is silty and relatively impermeable. In the western third of the ravine, the subsurface soil is permeable sand and gravel for the entire height of the ravine valley wall.

The channel of Sequalitchew Creek is a relatively confined channel formed by historically higher flows (see Section 3.3, **Groundwater**, and Section 3.4, **Surface Water**, for details). The creek currently experiences limited flow and thus has limited channel-forming processes. No indication of an active channel migration zone is evident (see **Appendix E** for details).

The existing Sequalitchew Creek ravine includes areas with soils on slopes greater than 40% that are expected to be seasonally or perpetually saturated that pose a specific risk of settlement, movement, or liquefaction associated with seismic hazards, as defined by the City.

Based on the slope steepness, the presence of the seeps, and the contact between permeable and impermeable soils, the north slope of the Sequalitchew Creek ravine qualifies as a landslide hazard area, steep slope, and seismic hazard under DMC GHA criteria. The slope is identified by the DNR as susceptible to shallow landslides.

DMC 25.105.050 (3) defines erosion hazards as including channel migration zones (areas along a river or stream where the channel can be reasonably predicted to migrate over time). The Sequalitchew Creek migration zone is considered an erosion hazard.

3.1.2 Impacts of the Alternatives

This section identifies and analyzes impacts to topography, soils, and geologic hazard areas on and in the vicinity of the Pioneer Aggregates South Parcel Project site under the EIS Alternatives.

ALTERNATIVE 1 – PROPOSED ACTION

Topography

Site (Expansion Area and Re-Mine Area Onsite)

Natural deposits of sand and gravel would be removed from a 313-acre area, altering the topography and leaving an irregular-shaped bowl feature where the mine operated. Additional slopes would be created in an area where slopes did not previously exist, thus providing more opportunity for shallow slope instability and erosion. However, proper

reclamation and erosion control measures as planned for in the Proposed Action would limit any potential slope instability and erosion impacts (as illustrated in **Figure 3.1-4)**.

Following mining, the slopes on the eastern edge of the Expansion Area would be about 80 to 120 ft. tall and would be inclined at 3H:1V (33%). Benches would be excavated in the southeast corner of the Expansion Area. The bottom surface of the Expansion Area would generally follow the contours of the top of the Olympia Beds. A thin layer of gravel, several feet thick, is anticipated to be left on top of the Olympia Beds to provide a stable working surface.

Within the Re-Mine Area portion of the site, topography would also substantially change as the current rolling slopes would be mined down to the Olympia Beds. As with the Expansion Area, a working surface of gravel would be left atop the Olympia Beds. Slopes within the Re-Mine Area would be inclined at 3H:1V (33%), where groundwater is expected to emanate from the toe of the slope and 2H:1V (50%), where the slopes are anticipated to be dry.

The proposed finished slopes would be less steep than other areas that have been mined and reclaimed to the west. The slopes steeper than 40% (up to 50%) and the slopes along the Sequalitchew Creek Trail exceeding 60% all appear to be performing well (see **Appendix B**). The soils are fairly homogenous across the active mine area and Re-Mine Area and are generally expected to perform similarly to in the past (**see Appendix B** for details).

Existing Mine (Off-Site)

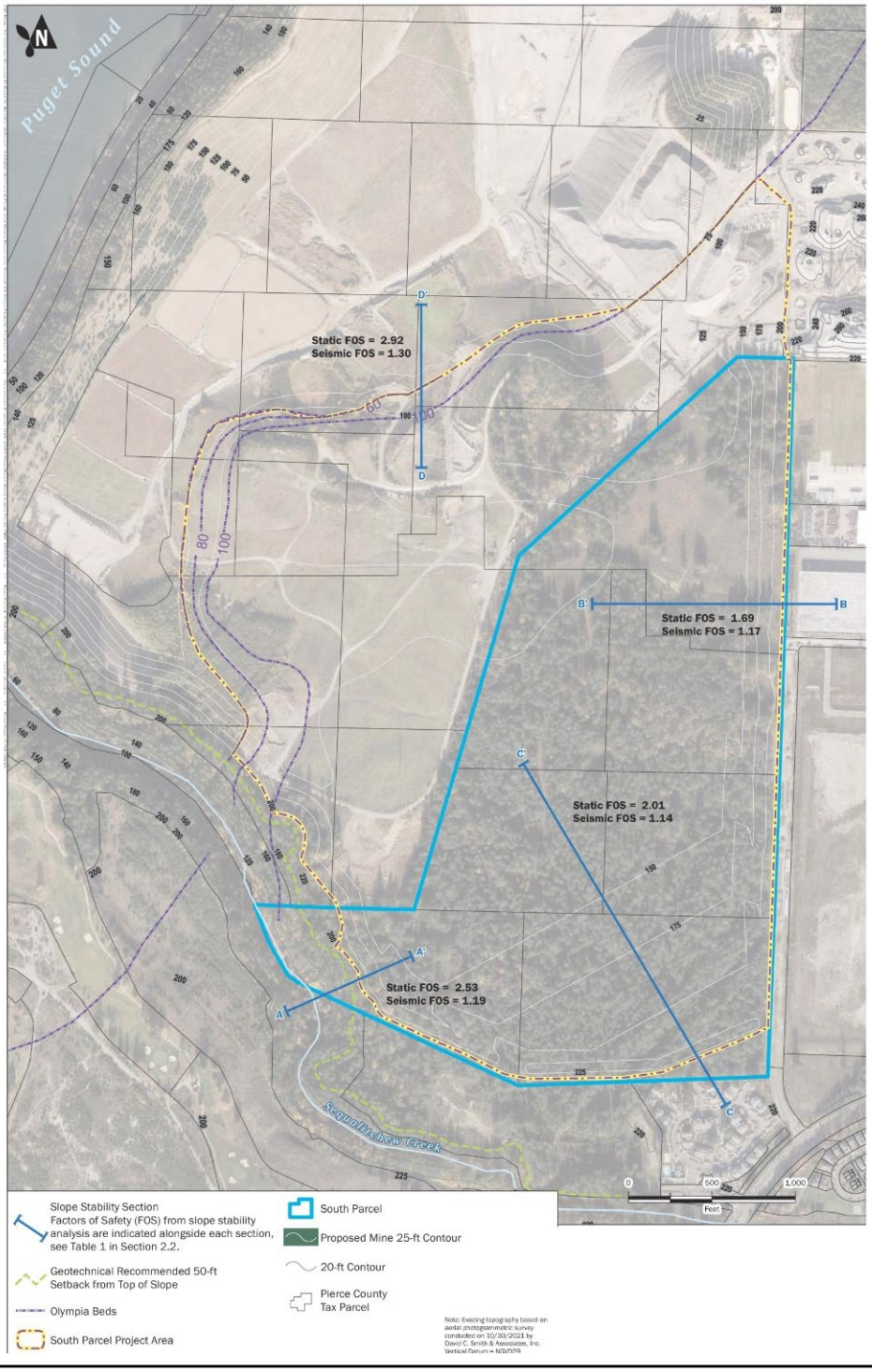
There would be no change to the topography of the slopes of the Existing Mine as a result of the Proposed Action. However, these slopes may be modified under the current permits as mining activity continues and have already been evaluated for potential impacts in SEPA analysis associated with the current permits. Changes to the existing slopes under the current permits are not evaluated in this DEIS.

A constructed wetland mitigation area has been proposed near the toe of the west slope at the base of area where mining has already been completed. The constructed wetland slopes would be at gradients less than 15%.

Other minor changes within the existing mine include the construction of storm water conveyance, treatment, and infiltration facilities, and groundwater conveyance and infiltration facilities.

Sequalitchew Creek Ravine (Off-Site)

Topography in the Sequalitchew Creek ravine would not be altered as a result of the Proposed Action (see **Figure 3.1-4**).



Source: Aspect, 2022.

EA Engineering, Science, and Technology, Inc., PBC

Figure 3.1-4
Proposed Topography

The dewatering and grading associated with the Proposed Action would reduce groundwater flow toward the steep slopes of Sequalitchew Creek ravine along the east portion of the Expansion Area onsite. The Proposed Action would also route groundwater that would potentially flow toward the creek instead toward the mined areas. Ultimately, this is anticipated to reduce the potential for landslides and slope failures within the Sequalitchew Creek ravine. The seeps and springs identified on **Figure 3.1-3** are expected to be reduced or dewatered in their entirety, which may reduce the level of landslide hazard susceptibility within the ravine (see Section 3.3, **Surface Water** and Section 3.4, **Groundwater**, for details on groundwater and surface water flow).

Slope Stability

A geotechnical analysis (Aspect 2021) evaluated the stability of the proposed cut slopes of the South Parcel Project during mining operations is. The analysis showed acceptable factor of safety values (that exceed 1.5 static and 1.1 for seismic conditions) for slope stability for the mined condition within the site area and the adjacent Sequalitchew Creek ravine (see **Appendix B** for detail).

Under a post-mining reclamation plan approved by the DNR, the mine slopes would be progressively reclaimed over the life of the Proposed Action. Mine slopes would be graded to 3H:1V or flatter where groundwater seepage is expected (i.e., on the eastern and southern slopes of the Expansion Area portion of the site) once the slope is no longer being mined. Slopes where groundwater is not anticipated to be present, such as along the southern boundary of the Re-Mine Area portion of the site, would be graded to 2H:1V.

Backfill is not required to achieve the reclaimed configuration; however, backfill may be used to enhance reclamation, as has been done elsewhere within the Existing Mine, to improve vegetation performance. The backfill would consist of retained finer material from the Expansion Area and imported clean fill. The proposed slope angles are flatter than the natural angle of repose of the remaining original soils and would provide the long-term erosion control and landscape base for planting. After establishment of vegetation, any long-term slope stability impact to earth-related features is expected to be low. The already high stability of newly created slopes would generally increase with the establishment of vegetation.

Erosion Potential

Due to their generally coarse-grained nature and good infiltration characteristics, the soils in the site area possess a low erosion risk and are generally not moisture sensitive. The erosion potential is increased by the removal of vegetation and construction of mine slopes; however, with proper storm water management techniques in place, these conditions are not anticipated to result in significant erosion of the coarse soils. The primary element of

the Proposed Action potentially susceptible to erosion is the placement of loose topsoil for revegetation on the final cut slopes. Revegetation would minimize the potential for erosion.

Under the Proposed Action, mining activities would create a closed depression and all surface water runoff would drain internally. Therefore, erosion is not anticipated to impact on- or off-site surface water bodies or aquatic resources. However, management of erosion remains important for establishment of vegetation during reclamation, visual appearance of the slopes, and the long-term performance of the infiltration ponds. The Proposed Action includes erosion control Best Management Practices (BMPs), consistent with Ecology's Sand and Gravel General Permit and City of DuPont's requirements as defined in DMC 25.105.030.25, that would reduce the potential for off-site transport of sediment.

To reduce the risk for erosion impacts to the Sequalitchew Creek ravine slopes south of the site, the Proposed Action includes a 100-foot buffer along the top of the slope along the Sequalitchew Creek ravine (**see Figure 3.1-3**). This buffer exceeds that required by DMC 25.105.070(2)[2], which requires a 50-foot buffer between proposed development activity and hillslopes of 40% (22 degrees or approximately 2.5H:1V) and is also greater than the buffer recommended in a previous geotechnical report, and therefore provides greater protection to the off-site ravine. The 100-foot buffer is intended to provide protection for erosion of steep slopes along with other recommended mitigation measures and Best Management Practices (BMPs) identified under 3.1.3 Mitigation Measures.

The City of DuPont requires preparation of an erosion control plan per DMC 22.01.180 for all sites disturbing more than one acre. The erosion control plan for the Pioneer Aggregates South Parcel Project identifies the specific BMPs to be used during and after mining for erosion and sediment control.

Topsoil Removal and Replacement

Topsoil contains fines and organic material that is not suitable for construction aggregate and has physical characteristics that are not compatible with efficient use of the equipment used to transport and process aggregate materials extracted from the mine. Topsoil is also generally the most fertile part of soil, containing soil structure, organic matter, and micro-organisms beneficial to plants and an essential component for successful reclamation of the mine.

Washington's laws governing Surface Mine Reclamation (RCW 78.44) require the conservation of topsoil as a component of reclaiming surface mines for future uses. The

[2] *Note that the Geotechnical Engineering Report (Aspect Consulting, 2021a) on file with the City of DuPont recommended maintaining at least a 50-foot buffer from the top of steep slopes.*

Proposed Action includes the steps typically used to conserve topsoil on aggregate mines. Topsoil would be stripped and stockpiled as the mining operation advances into the property and topsoil would be replaced as the mined areas are reclaimed following extraction.

Heavy Metals

Past industrial activities have resulted in elevated metals concentrations in portions of the Expansion Area. The Former DuPont Works Site is a clean-up site associated with the historical explosives and commercial munitions facility that operated from 1909 through 1976. The primary contaminants are arsenic and lead in surface soils. Cleanup activities were completed in 1993 to address the highest concentrations of lead, generally found along the foundations of the former buildings. Weyerhaeuser entered a Consent Decree with the Washington State Department of Ecology (Ecology) that required implementation of a restrictive covenant limiting land use on the Former DuPont Works Site to industrial uses, which is the origin of the Manufacturing and Research Park zoning for much of the site.

In addition, the Expansion Area is located within the Tacoma Smelter Plume (TSP) in an area where Ecology predicts concentrations of arsenic in surface soils may range between 40 and 100 parts per million (ppm). Ecology has established cleanup levels for properties within the TSP. The cleanup levels are conservative and support residential use. Ecology's cleanup level for arsenic in soil is 20 ppm and the cleanup level for lead in soil is 250 ppm. For comparison, the United States Environmental Protection Agency (EPA) has established an action level of 230 ppm for arsenic and 500 ppm for lead to guide cleanup decisions in areas near the former smelter. Ecology has pre-approved certain approaches to achieve the established cleanup levels at properties within the TSP. Mixing of impacted surface soils with deeper clean soils is one of the approved approaches under the Final Interim Action Plan

The proposed mining and reclamation activities are intended to serve as a permanent and final remedy for any lead- and arsenic-impacted soils within the Expansion Area. Under the Proposed Action, topsoil within the Expansion Area would be removed to facilitate extraction and would be conserved and maintained on site to be incorporated into the reclaimed mine landscape and support re-vegetation and reclamation of mined areas consistent with the potential subsequent residential land use identified in the City of DuPont Comprehensive Land Use Plan. Stripping, stockpiling, and replacement of topsoil would be completed using methods and procedures that are generally the same as those used in the existing mine area, including employment of BMPs to control erosion and fugitive dust. Samples would be collected from stockpiled topsoil for each mine segment and analyzed in accordance with a Cleanup Action Plan developed for the Pioneer Aggregates South Parcel Project. If the sample results indicate the topsoil does not contain arsenic in concentrations exceeding 20 ppm (the conservative cleanup level established by Ecology for the TSP) or lead in concentrations exceeding 250 ppm, then the topsoil would

be used in reclamation. If the sample results indicate the topsoil contains arsenic in concentrations equal to or greater than 20 ppm, then clean soil would be mixed with the topsoil to reduce the arsenic concentration. Stockpiled topsoil would not be used for reclamation until sample results confirm the concentrations of arsenic and lead meet cleanup criteria.

Geologically Hazardous Areas

The impacts of the Proposed Action relative to landslide and steep slope hazards, and seismic hazards and liquefaction hazards are discussed below (also see **Figure 3.1-5)**. The identified Geologically Hazardous Areas are shown in **Figure 3.1-5** encircled with a bold black line. **Figure 3.1-5** also includes shading to indicate slope angles; shaded areas are not necessarily Geologically Hazardous Areas.

Landslide and Steep Slope Hazardous Areas

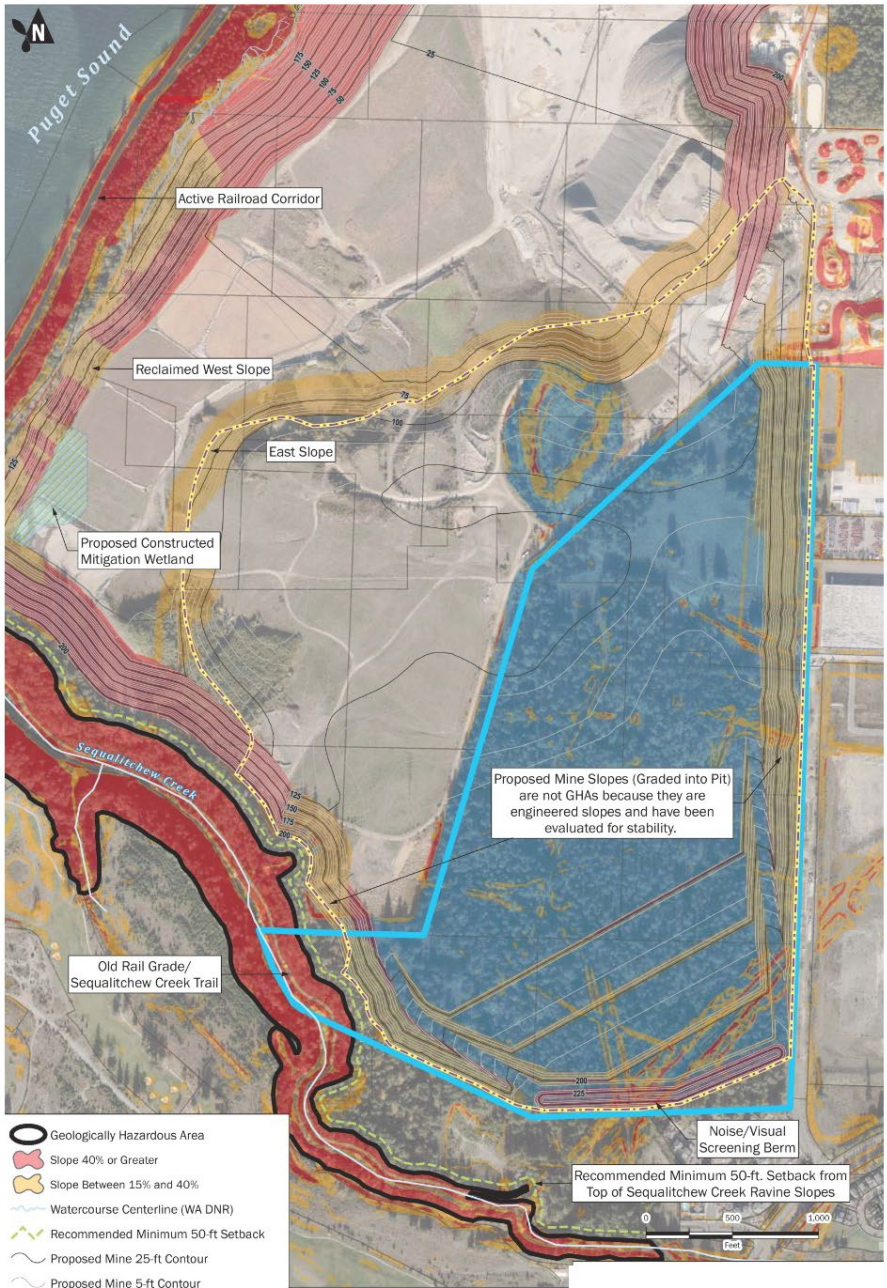
Landslide and steep slope hazards are not present within the site area but are present nearby in the Sequalitchew Creek ravine. The proposed mined slopes would be contoured to drain away from the ravine as shown on **Figure 3.1-5**. The slope stability analysis (see **Appendix B**) determined acceptable factor-of-safety values (greater than 1.5) for each of the profiles in the Expansion Area and Re-Mine Area portions of the site, as shown on **Figure 3.1-4**. Thus, the mined slopes would not be considered landslide or steep slope hazards.

Mining under the Proposed Action would locally reduce seeps and springs that have been observed in the Sequalitchew Creek ravine, as shown on **Figure 3.1-3**, resulting in an improvement in slope stability (see Section 3.5, **Plants and Animals**, for discussion on wetland habitat conditions). The Sequalitchew Creek ravine slope would also have an acceptable Factor of Safety greater than 1.5, as shown on **Figure 3.1-4**.

The hazard mitigations listed in Section 3.1.3, Mitigation Measures are intended to protect landslide and steep slope hazards located outside of, but nearby, the site area.

Erosion Hazardous Areas

The channel migration zone within the Sequalitchew Creek ravine, which is defined as an erosion hazard area, is not anticipated to be impacted by the Proposed Action. The flows from ravine springs would be reduced by the proposed dewatering process which would reduce the potential for channel migration and its associated potential for erosion. Therefore, no significant adverse impacts are anticipated to erosion hazards from the Proposed Action at the site or in adjacent areas.



Source: Aspect, 2022.

EA Engineering, Science, and Technology, Inc., PBC

Figure 3.1-5

Geological Hazardous Areas—Proposed Action

Seismic Hazard Areas

No adverse impacts are anticipated to seismic hazards from mining under the Proposed Action at the site or in adjacent areas. The slope stability analysis for seismic condition shows acceptable factor of safety values (greater than 1.1) in the Expansion Area portion of the site, Re-Mine Area portion of the site, and Sequalitchew Creek ravine.

Topography at the Expansion Area portion of the site would be permanently altered as a result of mining activities. These changes are illustrated by comparing **Figures 3.1-3** and **3.1-5**. The proposed conditions would include finished slopes inclined at 3H:1V (33%) toward the interior of the existing mine (**Figure 3.1-5**). A 20-foot-high soil berm would be constructed with side slopes at 2H:1V (50%) along the south side of the Expansion Area portion of the site.

The proposed finished slopes would be less steep than other areas that have been mined and reclaimed to the west. As within the reclaimed mine areas, the slopes steeper than 40% (up to 50%) and the slopes along the Sequalitchew Creek Trail exceeding 60% are all performing well.

There would be no seismic hazard areas created, as slopes in the Expansion Area portion of the site would be below 40%.

CUMULATIVE IMPACTS

The annual amount of earth moving mining activity with the Proposed Action in combination with mining at the Existing Mine would not exceed existing levels, and cumulative earth impacts associated with mining are not anticipated. In addition, earth-related impacts associated with mining would be temporary in nature and would occur some distance from potential future development that could occur in the vicinity. Therefore, no significant cumulative earth-related impacts from the combination of mining and future development are anticipated.

ALTERNATIVE 2 – NO ACTION

The No Action Alternative includes two scenarios: Scenario A - Continuation of Existing Conditions; and Scenario B - Site Development Under Existing Zoning.

Scenario A

Under Scenario A - Continuation of Existing Conditions, mining activities associated with the Re-Mine Area portion of the site and the Existing Mine would continue as currently permitted. The mining operation would retain a vegetated buffer at its perimeter, and active mining conditions that currently exist would continue. The Existing Mine has an estimated remaining life of 6 to 10 years with mining currently limited to 10 feet above

groundwater. The Expansion Area is assumed to remain undeveloped and would continue in its vegetated condition.

Scenario B

Under Scenario B - Site Development Under Existing Zoning, the proposal would not occur. The site would be developed for urban uses consistent with the City's Future Land Use Map. The majority of the area affected is currently designated by the City of DuPont as Manufacturing/Research, with a portion designated Residential. Mining and reclamation would continue within the currently permitted footprint of the existing mine. The kettle wetland and its buffer would remain undisturbed.

Development of the Expansion Area portion of the site would likely occur over time on one or more individual parcels at a time. As each parcel is developed, it would likely be mostly logged and cleared, then graded and developed consistent with applicable zoning regulations. Logging and clearing along with the development would likely leave a 50-foot buffer along the top of the Sequalitchew Creek ravine, as required under the DuPont Municipal Code, rather than the 100-foot buffer required for the mine under the Settlement Agreement. Topography would be expected to remain relatively flat, with the minor topographic depressions filled to level building sites. Under the existing zoning, a portion of each parcel would need to remain vegetated, either as the existing forest or as landscaped areas.

Clearing would increase the potential for surface erosion during construction; however, standard erosion and sediment control BMPs would reduce adverse impacts. Future development would be required to comply with City of DuPont Sensitive Areas Code, and state and local erosion and sediment control requirements.

Development would also increase the volume of stormwater generated as permeable soils with established vegetation (forest) are replaced with impervious areas (including building roofs and pavement) and landscaped areas. Stormwater would likely be managed through infiltration, which would result in an increased volume of groundwater flow, although the change would likely be minor relative to the groundwater flow in the aquifer.

Individual development of the parcels would not be likely to address the metals-contaminated soils as comprehensively as the Proposed Action. It is more likely that capping would be used as a remedy given the lower cost compared with mixing, as well as consistency with the likely developed condition (e.g., paved parking lots and building footprints). The use of capping, combined with differences in parcel remediation extent and approach as individual parcels are developed separately, would likely prevent lifting of the restrictive covenants from the former DuPont Works site and rezoning of the Manufacturing and Research Park area.

3.1.3 Mitigation Measures

The following mitigation measures have been included in the Proposed Action to reduce impacts on slope stability and erosion (see Section 3.3, **Groundwater**, and Section 3.4, **Surface Water**, for additional discussion and mitigation measures related to surface water and groundwater):

Proposed Mitigation Measures

- A reclamation plan would be prepared and implemented in accordance with the Surface Mining Act (RCW 78.44). The reclamation plan would be submitted to DNR for review and approval prior to mining. Prior review by the City is also required as part of that process.

- Mining would occur in segments; no mass clearing of the Expansion Area portion of the site would occur.

- An erosion and sediment control plan would be prepared and implemented in accordance with the requirements of the City of DuPont Municipal Code (DMC 22.01.180) and the NPDES Sand and Gravel General Permit. Erosion control features would include storm water drainage into the interior of the mine and onsite storm water disposal.

- A vegetated buffer would be maintained between the proposed mine area and the top of steep slopes in accordance with the City of DuPont's Sensitive Areas Code [DMC 25.105.070(2)].

- A 100-foot setback would be maintained from the top of slopes greater than 40% within the Sequalitchew Creek ravine, consistent with the conditions for the existing mine and the 1994 and 2012 Settlement Agreements.

- Earthwork for excavation and reclamation would be in accordance with the federal and state statutes of the Mine Safety and Health Act and the Surface Mining Act.

- Topsoil would be stockpiled and used for reclamation of mined areas. Consistent with the approved Reclamation Plan, Cleanup Action Plan developed for the South Parcel Project and published Ecology guidance, samples would be collected from stockpiled topsoil to confirm arsenic concentrations meet Ecology standards.

- After application of the topsoil, slopes would be re-vegetated by planting with trees and grass. When reclamation is complete, heavy equipment would generally not operate on the reclaimed slopes except for construction or maintenance of pedestrian paths, access roads, utilities, or other permitted facilities.

- The Expansion Area would be cleared in segments corresponding to the mining plan.
- Internal drainage would be maintained during mining.
- Mine slopes would be track-walked to tamp soils and create surface roughness to encourage infiltration of storm water on the slope.
- Mine slopes would be reclaimed with soil amendments and vegetation according to a DNR-approved Reclamation Plan.
- The existing wheel wash, or equivalent equipment, would continue to be used and maintained for vehicles exiting the mine.
- Settling ponds would be constructed upstream of the infiltration ponds.
- Mine slopes would be periodically inspected and repaired or revegetated to reduce erosion or improve surface stability.

3.1.4 Significant Unavoidable Adverse Impacts

The Proposed Action would result in the unavoidable alteration of topography and creation of new slopes. With implementation of proposed mitigation measures, however, no significant unavoidable adverse earth-related impacts are anticipated from the Proposed Action.

3.2 AIR QUALITY

This section of the DEIS describes existing air quality conditions on the site and in the site vicinity. Potential impacts associated with the EIS Alternatives are evaluated and mitigation measures are identified. This section is based on the *Air Quality Assessment* (September 2022) prepared by Landau Associates and peer reviewed by EA Engineering (see **Appendix C**).

3.2.1 Affected Environment

Regulatory Context

Air quality is generally assessed in terms of whether concentrations of air pollutants are higher or lower than ambient air quality standards established to protect human health and welfare. Three agencies have jurisdiction over ambient air quality in the project area: the U.S. Environmental Protection Agency (EPA), the Washington Department of Ecology (Ecology), and the Puget Sound Clean Air Agency (PSCAA). These agencies establish regulations that govern both the concentrations of pollutants in the outdoor air and contaminant emissions from air pollution sources. Although their regulations are similar in stringency, each agency has established its own standards. Unless the state or local jurisdiction has adopted more stringent standards, the EPA standards pertain.

To track air quality conditions over time, Ecology and PSCAA maintain a network of monitoring stations throughout the Puget Sound region. These stations are typically located where air quality problems may be expected to occur, and so are usually in or near urban areas or close to specific large air pollution sources. Other stations are used to indicate regional air pollution levels. Based on monitoring information collected over a period of years, the EPA and Ecology designate regions as being "attainment" or "nonattainment" for particular air pollutants. Attainment status is therefore a benchmark of whether air quality in an area complies with the National Ambient Air Quality Standard (NAAQS) for one or more "criteria" air pollutants.[1] Regions once designated nonattainment that have since attained the standard are considered air quality "maintenance" areas through two 10-year cycles of review, after which the area achieves "attainment" if the ambient standards have been maintained.

The site area is considered in attainment for all monitored air pollutants. This suggests that air quality in the site vicinity is generally good. Pertinent air pollutants are discussed in greater detail below.

[1] *The criteria air pollutants are particulate matter, CO, SO_2, NO_2, ozone, and lead.*

Existing Air Quality

Carbon Monoxide

Carbon monoxide (CO) is a by-product of incomplete combustion. CO is generated by vehicular traffic and other fuel-burning activities, such as residential space heating, especially space heating using solid fuels such as coal or wood. There are two short-term air quality standards for CO: a 1-hour average standard of 35 ppm and an 8-hour average standard of 9 ppm.

The impacts of CO are usually localized near the source(s), with the highest ambient concentrations typically occurring near congested roadways and intersections during periods of cold temperatures (autumn and winter months), light winds, and stable atmospheric conditions. Such weather conditions reduce the atmospheric mechanisms that disperse and dilute pollutants.

The site is located next to a past CO maintenance area where the 20-year maintenance period ended in 2016. Due to violations of the federal 1-hour CO standard, the Puget Sound region was designated as nonattainment for CO. In 1996, EPA determined that the Puget Sound ozone nonattainment area had attained the health-based CO standard in effect at that time. EPA then reclassified the Puget Sound region as attainment for CO and approved the associated air quality maintenance plan. Under present plans and policies, the CO attainment/nonattainment status of the area would have no direct effects on the proposed Pioneer Aggregates South Parcel Project.

Ozone

Ozone is a reactive form of oxygen created by sunlight-activated chemical transformations of nitrogen oxides and volatile organic compounds (hydrocarbons) in the atmosphere. Ozone problems tend to be regional in nature because the atmospheric chemical reactions that produce ozone occur over a period of time, during which ozone precursors can be transported far from their sources. Transportation sources like automobiles and trucks are among the sources that produce ozone precursors.

The site is located next to a past ozone maintenance area within the Puget Sound region where the 20-year maintenance period ended in 2016. In the past, due to violations of the federal 1-hour ozone standard, the Puget Sound region was designated as nonattainment for ozone. In 1997, EPA determined that the Puget Sound ozone nonattainment area had attained the health-based ozone standard in effect at that time. EPA then reclassified the Puget Sound region as attainment for ozone and approved the associated air quality maintenance plan. In 2005, EPA revoked the 1-hour ozone standard in most areas of the US including the Puget Sound region, which ended the ozone maintenance status of this region. In March of 2008, the EPA adopted a new more stringent 8-hour average ozone standard of 75 parts per billion (ppb). The 8-hour standard was later strengthened to 70 ppb for most

areas, effective December 2015.[2] Under present plans and policies, the ozone attainment/nonattainment status of the area would have no direct effects on the proposed Pioneer Aggregates South Parcel Project.

Particulate Matter (PM_{10} and $PM_{2.5}$)

Particulate matter air pollution is comprised of particles either emitted directly into the air (e.g., dust) or formed when hot gases cool and condense. Such air pollution is generated primarily by industrial activities and operations involving fuel combustion and material handling, and by other fuel combustion sources like motor vehicle engines, vessel engines, and residential wood burning. Federal, state, and local regulations set limits for particle concentrations in the air (i.e., weight per unit volume) based on the size of the particles and the related potential threat to health. When first regulated, particle pollution limits were based on "total suspended particulate," which included all size fractions. As sampling technology improved and the importance of particle size and chemical composition became more apparent, ambient standards were revised to focus on the size fractions thought to be most dangerous to human health. Based on the most recent studies, EPA has redefined the size fractions and set new, more stringent standards for particulate matter based on fine and coarse inhalable particulate matter to focus control efforts on the smaller size fractions. The previous PM10 maintenance area for health-based ambient air quality standards for PM10, or particles less than or equal to about 10 micrometers (microns) in diameter, was for all of Pierce County. The 20-year maintenance period ended in 2021 and is now classified as an attainment area for PM10. This site is close to a current maintenance area for PM2.5, or particulate matter less than or equal to 2.5 microns in diameter, which was designated in 2015. The latter size fraction and even smaller (ultra-fine) particles are now considered the most dangerous size fractions of airborne particulate matter because such small particles (e.g. a typical human hair is about 100 microns in diameter) can be breathed deeply into lungs. In addition, such particles are often associated with toxic substances that are deleterious in their own right and that adsorb to the particles and be carried into respiratory system.

The nearest PM2.5 maintenance area encompasses Tacoma and surrounding lowland areas in Pierce County.[3] The site is south of Tacoma in the lowlands of Pierce County and is considered part of this maintenance area.

In gravel excavation and processing operations, particulate matter (dust) is typically the only pollutant emitted in sufficient quantities to be a potential concern. Therefore, particulate emissions, inhalable and fine particulate matter (PM10/PM2.5), are a focus of this discussion.

[2] *80 Fed. Reg. 65,292 (Oct. 26, 2015).*

[3] *The maintenance area is called the Tacoma – Pierce County area. See information and maps at: https://ecology.wa.gov/Regulations-Permits/Plans-policies/State-implementation-plans/Maintenance-SIPs.*

PSCAA states that reasonable precautions must be in place to control fugitive dust if visible emissions are present. PSCAA must respond to any emission of fugitive dust that is or can be damaging to human health, plant or animal life, property, or the enjoyment of life. The Agency can respond to complaints and will take enforcement action if necessary.

Greenhouse Gases (GHGs) and Climate Change

The GHGs of primary importance are CO_2, methane, and nitrous oxide. Because CO_2 is the most abundant of these gases, GHGs are usually quantified in terms of CO_2e (carbon dioxide equivalent), based on their relative longevity in the atmosphere and the related "global warming potential" of these constituents. CO_2 is not considered an air "pollutant" that causes direct health-related effects, so it is not subject to ambient air quality standards used to gauge pollutant concentrations in the air.

Fuel combustion used for transportation is a substantial source of GHG emissions, primarily through the burning of gasoline and diesel fuels. National estimates indicate the transportation sector (including on-road, construction, airplanes, and vessels) accounts for about 29% of total domestic CO_2e emissions from fossil fuels in 2017.[4] In a tabulation of 2017 emissions within Washington, Ecology estimated transportation accounted for about 45% of statewide GHG emissions;[5] the higher percentage is due to lower GHG emissions from electrical generation because the state relies heavily on hydropower for electricity.

No specific federal, state, or local emission reduction requirements or targets are applicable to the site, and there are no generally accepted emission level thresholds against which to assess potential localized or global consequences of GHG emissions. Therefore, this assessment includes a qualitative consideration of GHG emissions that may be associated with emissions related to operations at the facility.

3.2.2 Impacts of the Alternatives

This section identifies and analyzes impacts to air quality on and in the vicinity of the site under the EIS Alternatives.

ALTERNATIVE 1 – PROPOSED ACTION

Construction Impacts

Construction related to the Proposed Action includes site preparation activities such as logging and clearing, topsoil removal, and construction of perimeter berms using diesel-

[4] *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2017*, February 2020, https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks

[5] *2017 Greenhouse Gas Data,* https://ecology.wa.gov/Air-Climate/Climate-change/Greenhouse-gases/2017-greenhouse-gas-data

powered, heavy equipment (e.g., dozers and loaders). During construction, fugitive dust from site preparation may temporarily cause a localized ambient concentration increase of particulate matter (PM_{10} and $PM_{2.5}$). In addition, heavy machinery would emit diesel engine exhaust pollutants that could slightly degrade local air quality in the immediate vicinity of the activity. However, these emissions will be temporary and localized and are expected to be minimal in comparison to regional emissions considering the limited amount of this equipment.

In addition to emissions from diesel-powered equipment, logging of the site in preparation of mining may result in GHG emissions due to the removal of the trees. The extent of the GHG emissions would ultimately depend on the final use of the logs. For example, use of the trees to produce wood products used in construction would result in the storage of some of the GHG emissions. Regardless of the ultimate use of the trees, GHG emissions resulting from the logging of the site would be minimal in comparison with other local sources, such as truck and vehicular traffic.

Operational Impacts

Fugitive Dust

Fugitive dust emissions could continue to be emitted in the current and new pit, in the processing areas, and on the transport roads from a number of sources, including wind erosion over exposed surfaces and stockpiles; automobiles and off-site haul trucks; heavy equipment operation; and, on-site haul trucks. Fugitive dust emissions from these sources are likely to be greatest in the dry summer months. It is not likely that gravel extraction would significantly affect particulate matter concentrations during the winter months (when existing concentrations are typically higher due to residential wood burning and other factors) because greater precipitation keeps the material wet.

Due to the nature of the process, excavation associated with the Proposed Action may cause dust deposition in the surrounding area. Although fugitive dust deposition is not a health issue, excess dust deposition is considered a nuisance as it can increase the soiling of surfaces, such as parked cars or the exterior of buildings.

The State of Washington does not have any quantitative standards pertaining to dust deposition. However, Section 9.11 of PSCAA Regulations states that “It shall be unlawful for any person to cause or allow the emission of any air contaminant in sufficient quantities and of such characteristics and duration as is, or is likely to be, injurious to human health, plant or animal life, or property, or which unreasonably interferes with enjoyment of life and property.” Members of the public can contact PSCAA if they feel the project is interfering with the use and enjoyment of their property due to a dust deposition issue. The Agency will respond to complaints and potentially issue a Notice of Violation to the facility if the concern is determined to be valid. In that event the facility would likely have to pay a fine and provide assurances to PSCAA that measures to resolve the dust problem have been

implemented and impacts will not continue. In the event of repeated violations, PSCAA may levy an enforcement action against the facility. This scenario could result in a shutdown of the facility, criminal penalties for the operators and firm requirements for changes at the facility.

Greenhouse Gas Emissions

A GHG emission inventory was prepared for the Proposed Action which separates associated GHG emissions into three categories, or scopes. Scope 1 GHG emissions are direct emissions from sources that are owned or controlled by the facility, such as on-site fossil fuel combustion and industrial processes. Scope 2 GHG emissions are indirect emissions from the generation of electricity, heat or steam purchased by the facility from a utility provider. Scope 3 GHG emissions are all indirect emissions linked to facility operations and production that are not included in Scope 2.

GHG emissions emitted by operation of the loaders and dozer are classified as Scope 1 emissions. GHGs emitted by off-site sources that generate electricity used by the conveyor drives and water pumps are Scope 2 emissions. Because the annual production and operating time would not change, Scope 3 emissions are not expected to change as a result of the Proposed Action.

Annual Scope 1 emissions were estimated using CO_2-equivalent (CO_2e) emission factors, expected annual operating hours, and the estimated fuel usage for each piece of equipment. It is anticipated that the Proposed Action would be operated 2,080 hours per year and is expected to be the area of highest production. Total Scope 1 GHG emissions are expected to be 1,497 metric tons per year (mtpy) of CO_2e. It should be noted that the expansion of mining into the Expansion Area portion of the site would not require the addition of new equipment to the site but would instead redirect use of existing equipment into the Expansion Area. In this way, the overall annual hours of operation of the dozer and loaders are not expected to increase over current active mining operations. In this way, the emission calculations can be considered a very conservative estimation of the GHG emissions due to the Proposed Action (see **Appendix C** for details).

Scope 2 emissions were estimated using CO_2e emission factors, expected annual South Parcel operating hours, and the quantity of electricity required to operate the conveyor belt and water pumps. The South Parcel is expected to require approximately 1,200 feet of conveyors when operations begin, and approximately 5,000 feet of conveyors when operations are at their maximum expected extent (i.e., driver motors totaling approximately 1,667 HP). It was assumed that the conveyor belts would be operated the same number of hours per year as the loaders (i.e., 2,080) because they would be operated jointly with the loaders.

There are expected to be a total of approximately 50 water pumps used at the Expansion Area portion of the site to intercept water at the edge of the pit, and each pump would be

driven by a 10 HP electric motor. Total Scope 2 emissions attributable to planned operations associated with the Proposed Action are expected to range from 2,034 to 3,062 mtpy of CO_2e as the extent of the conveyor system increases from an initial 1,200 ft to a maximum of 5,000 ft (see **Appendix C** for details).

Adding the worst-case potential Scope 1 and Scope 2 emissions at the maximum extent of mining results in overall annual GHG emissions of 4,559 mtpy of CO_2e under the Proposed Action. There are no well-established nor well-recognized thresholds for determining whether GHG emission rates from an individual project would be considered significant, although there are reporting thresholds established by the USEPA and by Ecology for stationary sources. Furthermore, GHG emission rates are reported by Ecology for the State of Washington, by USEPA for the United States, and by the World Resources Institute (and others) for the entire globe. The large-scale (United States and global) emission inventories are relevant since the impacts due to GHG emissions are considered to be global in scale. Even these maximum potential worst-case GHG emissions from the proposed sources are less than half of the reporting thresholds identified by Washington State (10,000 mtpy CO_2e) and federal agencies (25,000 mtpy CO_2e). Therefore, the GHG emissions from the Proposed Action would represent a very small percentage of the total state-wide inventory.

CUMULATIVE IMPACTS

The annual amount of mining activity, and associated air quality conditions, with the Proposed Action in combination with mining at the Existing Mine would not exceed current levels, and cumulative mining air quality impacts are not anticipated. In addition, air quality impacts associated with mining would be temporary in nature and would occur some distance from potential future development that could occur in the vicinity, and no significant cumulative air quality impacts are anticipated.

ALTERNATIVE 2 – NO ACTION

There are two No Action Alternatives- Scenario A Continuation of Existing Conditions; and Scenario B Site Development Under Existing Zoning.

Scenario A

In Scenario A, mining activities associated with the Re-Mine Area of the site and the Existing Mine would continue as currently permitted. The mining operation would continue to generate emissions as under the existing conditions. The Existing Mine has an estimated remaining life of 6 to 10 years with mining currently limited to 10 feet above groundwater. The Expansion Area portion of the site is assumed to remain undeveloped and would continue in its vegetated condition.

Scenario B

In Scenario B, the proposal would not occur. The site would be developed for urban uses consistent with the City's Future Land Use Map. The majority of the area affected is currently designated by the City of DuPont Comprehensive Plan as Manufacturing and Research, with a smaller area designated for residential uses. The corner of the property near Center Drive is designated as Residential 12, which would allow higher density residential development where multifamily density averages 12 units per acre. Urban development, as permitted under current planning and zoning designations, is assumed to occur east of the lease line demarcating existing mining operations. The timing and nature of any such development would be driven by market forces.

Development of individual parcels would result in construction-related impacts including fugitive dust emissions, exhaust emissions from equipment and vehicles, and GHG emissions from construction. Operation of development on individual parcels would also generate emissions from operational activities, including GHG emissions associated with potential manufacturing/research uses and residential development.

3.2.3 Mitigation Measures

The following mitigation measures have been included in the Proposed Action to reduce air quality impacts.

Proposed Mitigation Measures

- The use of control equipment, enclosures, and wet (or chemical) suppression techniques, as practical, and curtailment during high winds.
- Surfacing roadways and parking areas with asphalt, concrete, or gravel.
- Treating temporary, low-traffic areas (e.g., construction sites) with water or chemical stabilizers, reducing vehicle speeds, constructing pavement or rip rap exit aprons, and use of the existing wheel wash system or equivalent equipment by vehicles before they exit to prevent the track-out of mud or dirt onto paved public roadways.
- Covering or wetting truck loads or allowing adequate freeboard to prevent the escape of dust-bearing materials.

Other Possible Mitigation Measures

- Converting incandescent lighting systems to LED and implementing motion-activated lighting.

- Regenerating electricity from the conveyor belt leading downhill to the barge load-out facility.

- Participating in PSE's Schedule 258 electricity energy efficiency program.

3.2.4 Significant Unavoidable Adverse Impacts

With the application of some or all the mitigation measures described above and consistent use of best management practices, no significant air quality impacts are expected from the proposed project.

3.3 WATER RESOURCES - GROUNDWATER

This section of the DEIS describes the existing groundwater conditions on the site and in the site vicinity (including the Sequalitchew Creek watershed). Potential impacts associated with the EIS Alternatives are evaluated and mitigation measures identified. This section is based on the *Earth and Water Resources Report* (May 2023), *Stormwater Management Report* (February 2021)*, Groundwater Model Update* (June 2017), and *South Parcel Monitoring Plan* (November 2017) all prepared by Aspect Consulting and peer reviewed by Mott MacDonald (see **Appendices B**, **D**, **E**, and **F**).

3.3.1 Affected Environment

Groundwater Hydrology

Groundwater occurs in five primary hydrogeologic units at or near the surface in the site area, which are described in **Table 3.3-1** and depicted in generalized cross section **Figure 2-3** in **Chapter 2**. From top to bottom, these include the Steilacoom Gravel, the Upper Confining Unit, the Vashon Outwash, the Olympia Beds, and the Sea Level Aquifer. The Steilacoom Gravel (Qvs) is coarse-grained and primarily composed of extremely permeable gravel; the Upper Confining Unit is a thin (five to 10 foot thick) silty zone and is not uniformly present across the site area; the Vashon Outwash (Qgog/Qva) is composed of sand and gravel; the Olympia Beds (Qob) are composed of fine-grained silts and clays deposited during an interglacial period; and the Sea Level Aquifer (Qpog) is composed of pre-Olympia sand and gravel glacial drift deposits.

These hydrologic units reflect the glacial history of the Puget Lowland. The oldest geologic deposits of the Sea Level Gravel (Qpog) are the result of earlier (pre-Vashon) glacial advance and retreat. The Olympia Beds (Qob) were deposited above the Qpog sediments during the interglacial period preceding the most recent Vashon glaciation and include fine-grained deposits of low permeability. After the OlympiaBeds (Qob) were deposited, the advancing Vashon-era continental glacier carved a valley through the Qob and partially into the underlying Sea Level Aquifer (Qpog), depositing Vashon Outwash sediments within the valley. As the Vashon glacier melted and receded, a lobe of ice blocked the northward drainage of the Puyallup valley, creating a lake. The Steilacoom Gravel (Qvs) is interpreted to have formed when a series of ice dam bursts released the glacially impounded water, which transported coarse-grained sediments into a broad outwash plain in the Sequalitchew Creek area. These flood deposits filled in low areas, created thick deltas, and flowed over the then-existing coastal bluffs within the Olympia Beds and into the glacial valley. The contact between the new Qvs sediment deposits and the former steep bluffs is referred to as the “Olympia Beds Truncation”.

Table 3.3-1
SUMMARY OF HYDROSTRATIGRAPHIC UNITS AND CALIBRATED PARAMETER VALUES

Hydrostratigraphic Unit in DuPont Model	Correlated USGS Hydrogeologic Unit and Partial Description	Principal Layers in DuPont Model	Horizontal Hydraulic Conductivity (feet/day)					Vertical Anisotropy (-)	Specific Yield (-)	Specific Storage (1/foot)	for Horizontal Hydraulic Conductivity (feet per day)	
			Max.	75 percentile	Average	25 percentile	Min.	horizontal: vertical			USGS median	Dupont Works RI
Steilacoom Gravel	A1 – "recessional outwash…sand and gravel deposited by large meltwater streams…"	1,2	3,900	1,600	1,100	350	36	2.7	0.07	6.1E-05	933	18
Upper Confining Unit	A2 – "low-permeability unit composed of Vashon till and lesser amounts of ice-contact, moraine and fine-grained glaciolacustrine deposits…"	3	1.61	0.47	0.33	0.16	0.017	1.0	0.07	5.0E-05	18	
Vashon Outwash	A3 – "aquifer composed of Vashon advance outwash…"	4,5	49	11	7.7	2.4	0.27	15.1	0.09	2.7E-05	122	34
Olympia Beds (Qob)	B – "low-permeability unit composed of fine-grained silts and clays deposited during the Olympia interglacial…"	6,7	0.018 (uniform)					10.0	0.09	1.1E-04	21	
Sea Level Aquifer	C – "aquifer composed of pre-Olympia glacial drift deposits consisting of sand and gravel…"	8,9	690 (uniform)					6.3	0.18	6.0E-05	96	63

Notes:
1 USGS reference: Savoca et al., 2010.
2 Dupont Works RI reference: Hart Crowser, 1994.

Source: Aspect Consulting, 2022.

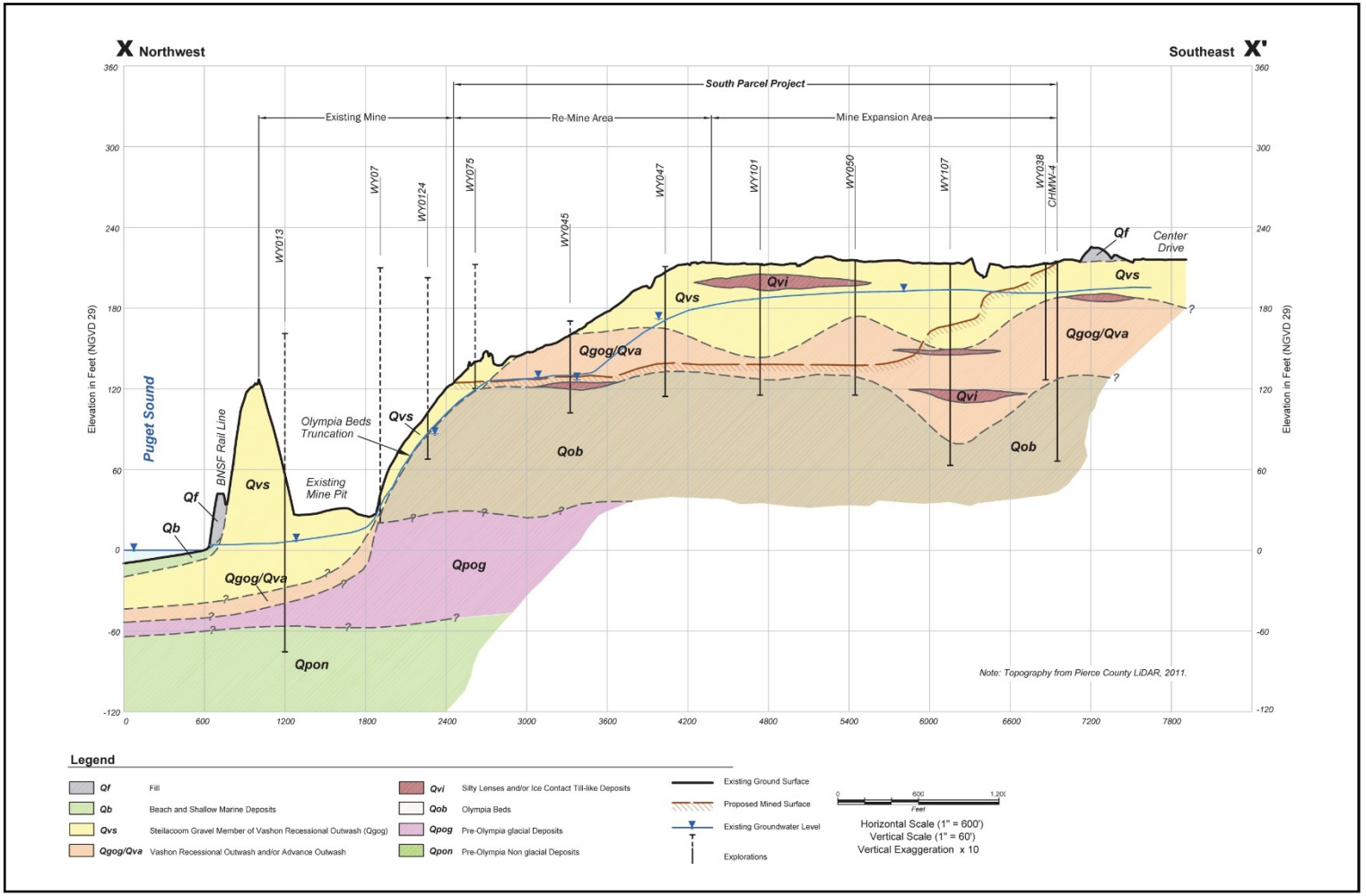
The Steilacoom Gravel (Qvs) and the Vashon Outwash (Qgog) form the uppermost shallow groundwater aquifer underlying the site area (herein referred to as the Vashon Aquifer), which is unconfined. The Upper Confining Unit present within the Vashon Aquifer behaves neither as an aquifer nor a competent aquitard (which is a geologic stratum that restricts but does not prevent movement of water); it nonetheless somewhat separates the uppermost Qvs portion of the Vashon Aquifer from the lower Qgog/Qva portion, and in cross section (**Chapter 2**, **Figure 2-3** and **Figure 3.3-1,** is represented by the dashed line that underlies the Steilacoom Gravel (Qvs) and separates it from the Vashon Outwash (Qgog/Qva). The Qvs is a subunit of the more regionally extensive Vashon Recessional Outwash (Qgog) geologic unit, both of which are shown in **Figure 3.3-1**.

The Vashon Aquifer is separated from the Sea Level Aquifer by the Olympia Beds (Qob), which behaves as an aquitard and is approximately 40 to 80 feet thick in the site area. The Sea Level Aquifer is a highly productive regional aquifer that is generally confined, (i.e. its water is pressurized due to aquitard layers that overlie and underlie the aquifer) except in areas west of the Olympia Bed Truncation, with the approximate location of the truncation shown in **Figure 3.3-2**.

Surface soils overlie the major surficial geologic units. Over most of the site area surficial soils do not appreciably alter the hydrology; however, in wetland areas peaty soils are present and underlain by silty ice-contact deposits, as depicted in **Chapter 2**, **Figure 2-3** and **Figure 3.3-3**. The presence of finer-grained materials beneath the primary wetland complex in the area (e.g., Bell, McKay, Hamer, East Edmond, and West Edmond marshes) affects the relationship between wetland waters and groundwater. Where peaty soils occur, the amount and rate of surface water that can flow into (or out of) the Vashon Aquifer is limited due to their low permeability. In areas where historical activities removed peat and/or fine-grained marsh soils from the wetlands (such as near roadways, the former railway grade that separates East and West Edmond marsh, and channelized areas of Edmond Marsh where former fish hatchery activities removed peat to improve fish passage) surface water and groundwater have a greater degree of hydraulic connection, and therefore the local wetland response to aquifer drawdown is greater (aquifer drawdown is the decrease in groundwater level that occurs due to dewatering).

Groundwater Flow and Water Levels

Groundwater flow occurs primarily in the Vashon Aquifer and Sea Level Aquifer. Surface water features may also reflect aquifer water levels and/or interact with shallow groundwater as locations of groundwater recharge or discharge; therefore, local surface water relationships with groundwater are also discussed in this sub-section.



Source: Aspect, 2022.

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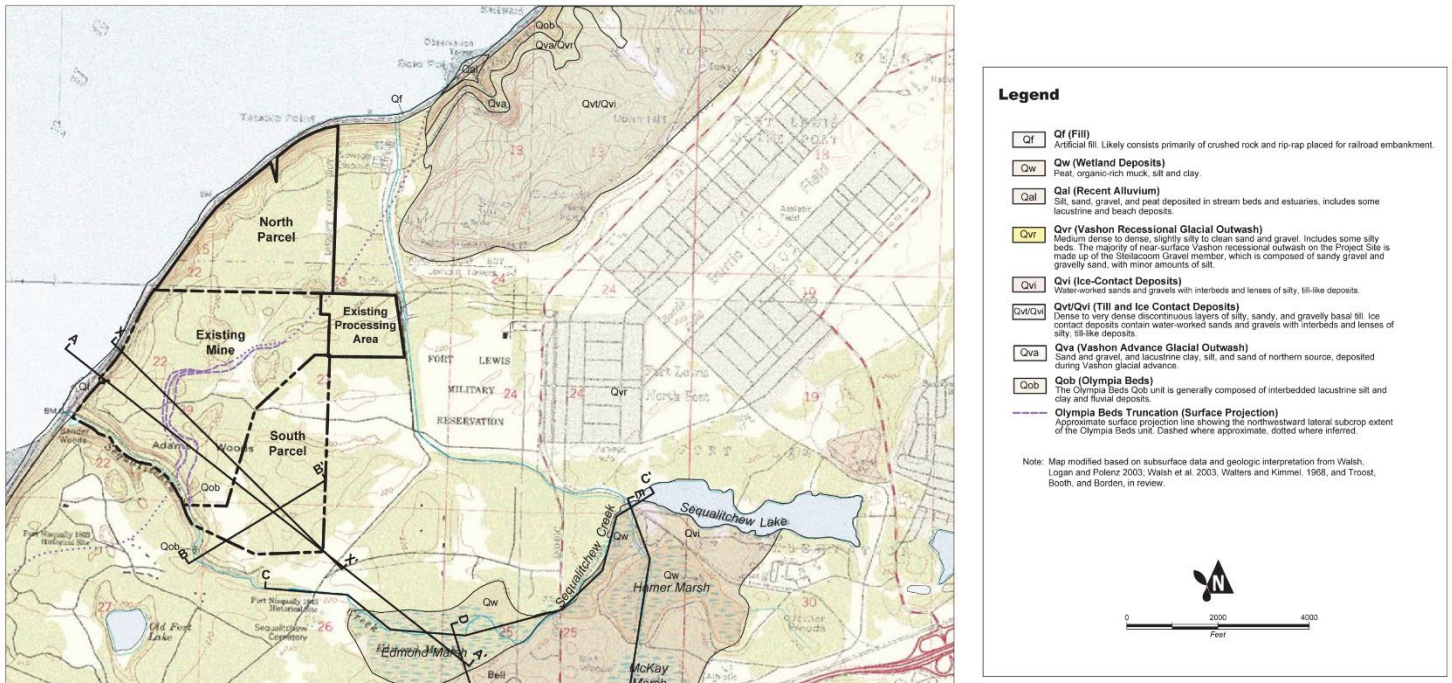
Figure 3.3-1

Generalized Geologic Cross Section



Source: Aspect, 2022.

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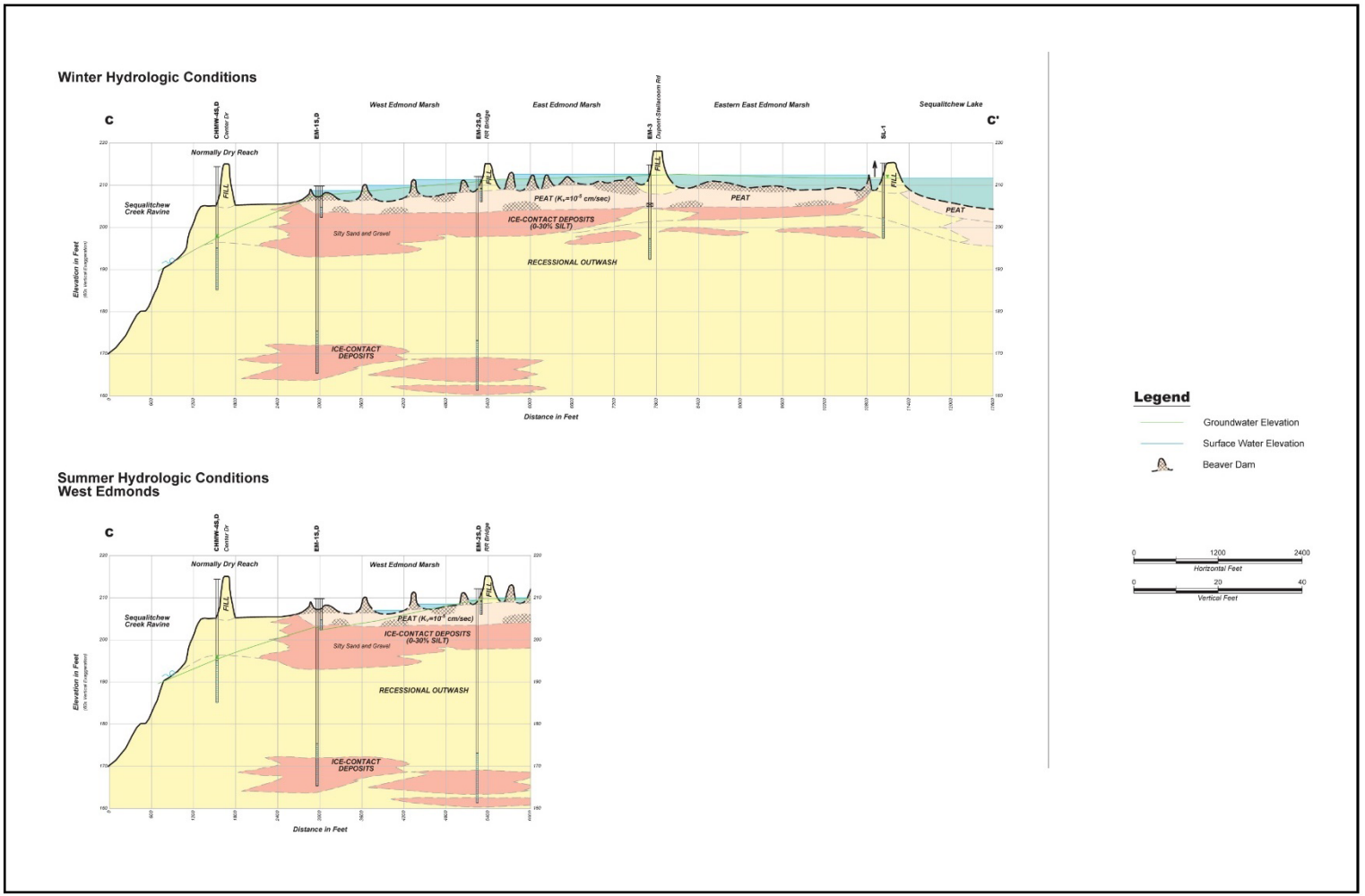
Figure 3.3-2

Regional Geologic Map



Source: Aspect, 2022.

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Figure 3.3-3

Edmond Marsh Cross Section

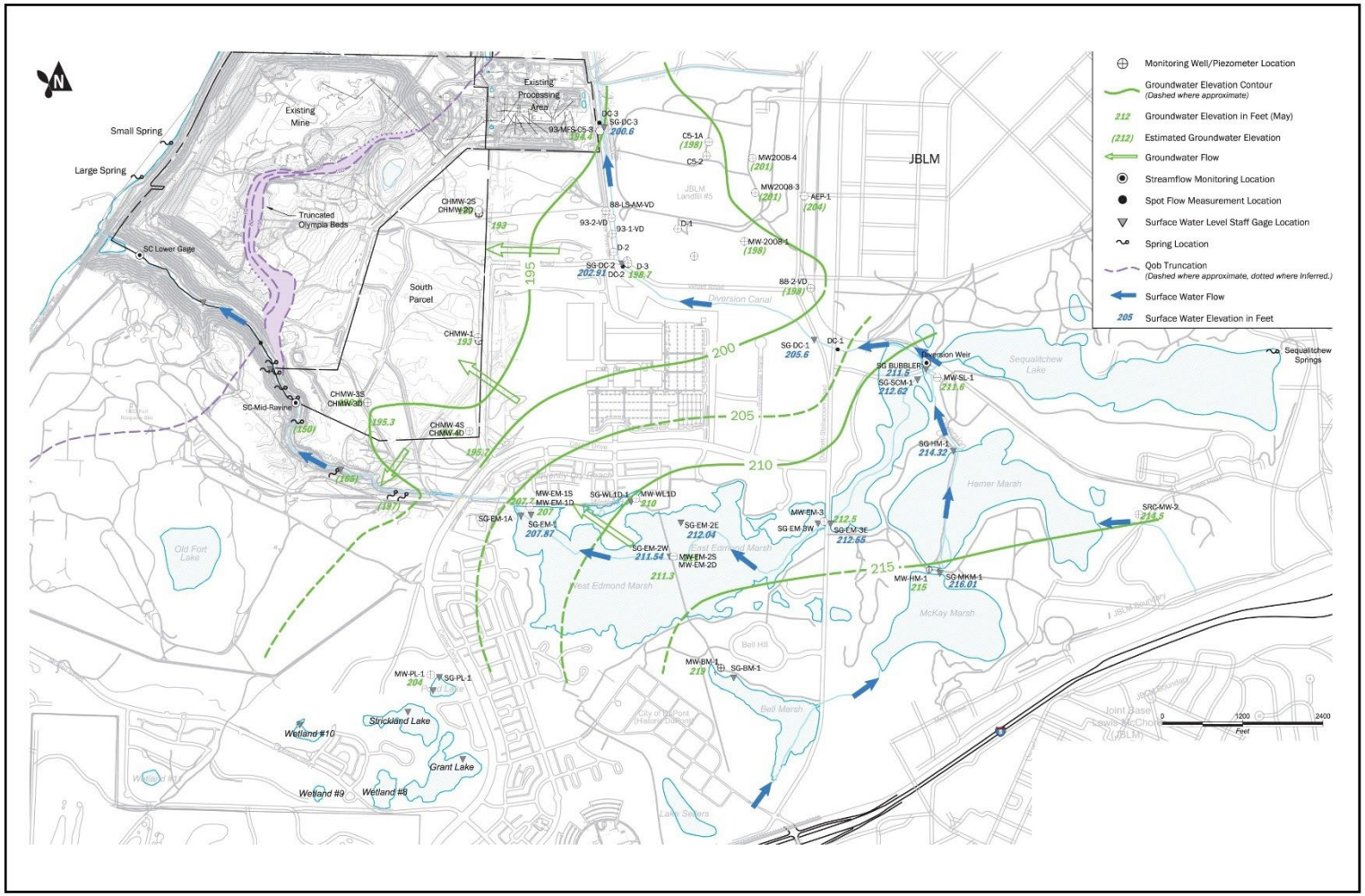
Vashon Aquifer water level monitoring as well as lake and wetland stage monitoring has occurred near the site on a monthly basis since 2003. **Figure 3.3-4** presents observed Vashon Aquifer water levels elevations and surface water elevations from May 2010, which represents approximate average annual conditions. Vashon Aquifer water levels east of the Olympia Bed Truncation are significantly higher (ranging from approximately 190 to 215 feet) than water levels to the west, where groundwater elevations in the merged Vashon-Sea Level Aquifer are approximately 15 feet). As depicted in **Figure 3.3-1**, the water table drops steeply across the truncation and has an elevation close to sea level in the merged Vashon-Sea Level Aquifer.

Vashon Aquifer water level elevations presented in **Figure 3.3-4** indicate that groundwater flow is generally to the northwest. Local variations however occur, with local groundwater flow paths to the southwest near the upper Sequalitchew Creek ravine where groundwater discharge occurs and adds flow to the creek. The JBLM Diversion Canal about a mile to the northeast has some stretches where it gains flow due to groundwater discharge and some reaches where it loses surface water to groundwater.

Seasonal water level fluctuation is variable in the Vashon Aquifer, with groundwater levels varying by two to three feet near Edmond Marsh and by greater than 10 feet at monitoring well CHMW-3S on the South Parcel near the Sequalitchew Creek ravine. Seasonal water level variations are lower near large surface water features that potentially recharge groundwater (such Edmond Marsh) and higher near perennial groundwater discharge locations (such as at the Olympia Beds truncation and the Sequalitchew Creek ravine above the truncation). Groundwater levels are typically highest in early or mid-spring and lowest in fall.

Because the Sea Level Aquifer is separated from the Vashon Aquifer in most of site area by the low-permeability Olympia Beds, where the Olympia Beds are present the vertical flow of groundwater between the Vashon Aquifer and the Sea Level Aquifer is significantly impeded. Because of this, water levels in the Sea Level Aquifer east of the truncation do not require as much monitoring or characterization in as much local detail as the Vashon Aquifer. In the Sea Level Aquifer groundwater flow is generally to the northwest towards Puget Sound based on regional mapping by the USGS.

Water level elevations measured in kettle depression lakes and wetlands can be representative of aquifer water levels if they do not receive significant surface water inflows and/or if fine-grained sediments do not separate the surface water body from the underlying aquifer. However, because these lakes and wetlands are surface water features and future changes in their water levels will not notably impact flow into or out of the Vashon Aquifer, these features and changes in their surface water level elevations are discussed in Section 3.4, **Surface Water**. These surface water features include Old Fort Lake, Pond Lake, Strickland Lake, Grant Lake, Wetlands #8, #9, #10 and #11, Wetland 1-D, and the onsite Kettle Wetland.



Source: Aspect, 2022.

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Figure 3.3-4

Surface Water System

Aquifer recharge typically occurs if precipitation infiltrates past the root zone in the subsurface. This direct precipitation-based recharge occurs through soils throughout the site area. Groundwater recharge can also occur if the water level elevation of a surface water body is higher than the water level in the aquifer beneath it. The rate of recharge entering groundwater from a surface water body is proportional to the permeability of the sediments (i.e., their ability to transmit water) connecting the two water bodies and the difference in water level elevation between them. The rate of groundwater discharge to a surface water body is controlled by the same relationship but occurs when the groundwater elevation is higher than the surface water elevation. Groundwater recharge and discharge relationships between surface water and the underlying aquifer can vary with seasonal changes in water levels. Areas or features where groundwater recharge or discharge occurs are discussed below.

Lakes

Sequalitchew Lake, the headwater of Sequalitchew Creek, is fed by Sequalitchew Springs (which serve as JBLM's primary water supply) at the eastern end of the lake. Spring discharge not consumed by JBLM flows into Sequalitchew Lake. Sequalitchew Lake has a surface water outlet to Sequalitchew Creek at its western end, which currently flows into the Diversion Canal due to beaver dam blockages. Water levels at Sequalitchew Lake are currently controlled by a weir at its outlet. Sequalitchew Lake water levels likely represent the approximate average groundwater elevation in its vicinity; however, due to its surface water inflows and controlled outlet elevation, lake water levels do not solely reflect aquifer water levels. Additional detail is provided in Section 3.4, **Surface Water**.

As previously mentioned, kettle lake and wetland features that do not have surface water inflows or outflows (and therefore do not cause significant aquifer recharge or discharge) are discussed in Section 3.4, **Surface Water**.

Wetlands

Bell, McKay, Hamer, East Edmond, and West Edmond marshes comprise the large wetland complex southeast of the site. Groundwater-surface water interactions in these wetlands are complex and vary both seasonally and by location. Wetland water level elevations are typically higher than local groundwater elevations and provide net aquifer recharge. However, due to surface water inflows and diversions, beaver activity, seasonality, and the sloping water table, variations in the groundwater/surface water relationship can potentially occur in each wetland and can affect the amount of groundwater recharge/discharge that occurs there. Groundwater recharge and discharge can jointly occur if a wetland overlays a sloping water table, with groundwater discharge occurring on the upgradient side of the wetland and recharge occurring on its downgradient side.

Bell Marsh has the highest elevation of these marshes and receives surface water inflow from JBLM stormwater runoff. It has a surface water outflow to McKay Marsh, and likely supports some shallow groundwater recharge and groundwater flow to the north to Edmond Marsh

(which has a water level elevation typically 6 to 7 feet lower). McKay Marsh receives surface water inflow from Bell Marsh; its primary outflow is surface water flow to Hamer Marsh, though based on surface water elevations some shallow groundwater recharge is likely and may flow west-northwest parallel to a small chain of wetlands toward Edmonds Marsh. Hamer Marsh receives surface water inflow from McKay Marsh and JBLM stormwater. Its primary surface water outflow is to the Diversion Canal and to East Edmond Marsh when its water level elevation exceeds 214 feet (which is the invert elevation of a connecting culvert). Shallow groundwater recharge and subsurface flow west to East Edmond Marsh also likely occurs. Hamer Marsh has been characterized as having greater connection to and receiving more discharge from groundwater than Bell or McKay marshes based on water level monitoring data; however, some seasonal groundwater discharge into Bell and McKay marshes is likely. For current conditions, groundwater modeling for this EIS (introduced in the Groundwater Modeling sub-section below) estimates average annual aquifer recharge from Bell, McKay, and Hamer Marshes combined to be 0.9 cfs.

East Edmond Marsh is separated from the outlet of Sequalitchew Lake and the Diversion Canal by a large beaver dam, which maintains higher water levels within the marsh relative to Sequalitchew Lake. Inflows to East Edmond Marsh (including its areas both east and west of DuPont-Steilacoom Road) are primarily via shallow groundwater flow from the north or east from Bell, McKay, and Hamer Marshes, the culvert previously mentioned from Hamer Marsh, and inflow from a small stormwater system draining a portion of Center Drive runoff on the north side of the marsh. It currently has surface water outflow to the Diversion Canal (via overtopping the beaver dam) and surface water outflow to West Edmond Marsh (via a culvert beneath the railway grade west of DuPont-Steilacoom Road, which separates East and West Edmond Marsh, though it is frequently blocked due to beaver activity). Subsurface outflows include flow to West Edmond Marsh through the railroad grade sediments, or downward into the Vashon Aquifer. Greater downward flow into the Vashon Aquifer likely occurs on the north side of the marsh since the regional water table is lower there (as shown in **Figure 3.3-4**). For current conditions, groundwater modeling (further discussed in the Groundwater Modeling sub-section) estimates average annual aquifer recharge from East Edmond Marsh to be 3.3 cfs.

Surface water levels in West Edmond Marsh are controlled by multiple beaver dams, as shown in **Figure 3.3-3**. The most consequential beaver dam is the westernmost dam, which controls the western extent of the marsh in the wet season. Outflow from this dam to Sequalitchew Creek generally occurs only in winter months, and typically infiltrates to groundwater due to the absence of low-permeability wetland soils (this portion of Sequalitchew Creek immediately east of Center Drive is referred to as the “dry reach” and surface flow rarely extends from the marsh outlet to downstream reaches of Sequalitchew Creek). Subsurface inflows to West Edmond Marsh primarily include groundwater inflow from upgradient (including from Bell Marsh), subsurface inflow from East Edmond Marsh, and possibly shallow subsurface inflow flow from several stormwater infiltration ponds located on the marsh’s periphery.

Seasonal surface water level variations are greater in the western portion of West Edmond Marsh compared to elsewhere in the marsh complex, and generally range from four to five feet. During most summers the westernmost portion of the marsh typically goes dry, as shown

in cross section **Figure 3.3-3**. The western two-thirds of West Edmond Marsh typically have "perched" conditions between May and October, meaning the water table is below the marsh bottom elevation. Because surface water and groundwater are seasonally disconnected in this area, decreases in aquifer water levels during summer months would not cause local surface water levels to decrease. However, for the majority of the marsh complex surface water and groundwater levels are similar and hydraulically connected to one another, and therefore aquifer drawdown generally will cause surface water elevations to decrease. These locations are farther from the Site and the decreases in groundwater levels diminish with distance from the mine.

For current conditions, groundwater modeling (discussed in the Groundwater Modeling sub-section) estimates average annual aquifer recharge from West Edmond Marsh to be 0.1 cfs, with the total marsh-complex recharge rate (which includes Bell, McKay, Hamer, East Edmond, and West Edmond marshes) estimated to average approximately 5.3 cfs.

Streams

Vashon Aquifer discharge to Sequalitchew Creek currently occurs in the upper portions of the ravine west of Center Drive, primarily through spring and seep discharges east of the Olympia Beds truncation. Spring-fed discharge along the walls and near Sequalitchew Creek within the ravine provide year-round baseflow to Sequalitchew Creek. Average annual baseflows measured at the mid-ravine monitoring location (**Figure 3.3-4**) are 1.6 cfs, with baseflows ranging from 0.5 cfs in the summer to 2.5 cfs in winter.

Groundwater discharge to the Diversion Canal occurs between the Diversion Weir and SG-DC-1 (**Figure 3.3-4**). Groundwater recharge to the Vashon Aquifer from Diversion Canal stream loss occurs downstream of SG-DC-1.

Groundwater recharge to the combined Vashon-Sea Level Aquifer from Lower Sequalitchew Creek also occurs near where the creek discharges to Puget Sound. These areas where stream loss is interpreted to occur are based on water level data. The associated recharge quantities have not been quantified but are likely small relative to other sources of recharge/inflows to the combined Vashon-Sea Level Aquifer and are not key to understanding the effects of the Proposed Action.

Springs

As discussed above, spring discharge from the Vashon Aquifer occurs at Sequalitchew Springs at the east end of Sequalitchew Lake which has reported discharge rates of up to 9,000 gpm (or roughly 20 cfs), and generally provides more water than JBLM consumes. Excess spring water not used for water supply flows into Sequalitchew Lake, though during dry summers, periods can occur where Sequalitchew Spring discharge is fully consumed by JBLM, causing there to be no surface water flow from Sequalitchew Lake to the Diversion Canal.

Vashon Aquifer discharge also occurs at numerous unnamed seeps and springs within the Sequalitchew Creek ravine, as discussed above. The average annual discharge rate for

combined springs in the Sequalitchew Creek ravine is approximately 1.6 cfs with flows ranging from 0.5 cfs in the summer to 2.5 cfs in winter.

Spring discharge to Puget Sound from the comingled Vashon-Sea Level Aquifer occurs at intertidal and subtitle seeps and springs. The largest of these springs (Large Spring, shown in **Figure 3.3-4**) has observed discharge rates ranging from 9.1 to 18 cfs. It is estimated that approximately 15 to 23% of the freshwater discharge at the intertidal springs comes from the Vashon Aquifer, while the remainder comes from the Sea Level Aquifer. The total average groundwater discharge rate to Puget Sound from the project area is estimated to be 131.5 cfs.

Groundwater Quality

Groundwater quality sampling from select wells within the mine and completed in the Steilacoom Gravel occurred in 2005, and were tested for pH, specific conductance, and nitrate as nitrogen. No water quality standards were exceeded.

Fort Lewis Landfill 5 is a closed landfill and former Superfund Site located northeast of the South Parcel (see **Figure 3.3-4**, labeled JBLM Landfill 5) and historically has had groundwater quality exceedances for select volatile organic compounds, manganese, and iron. Landfill 5 was removed from the federal National Priorities List of contaminated sites in 1995 because site cleanup was completed, and all cleanup goals were achieved. The most recent groundwater quality data reviewed from the site is from 2010, and both iron and manganese concentrations were found in exceedance of secondary drinking water standards (for aesthetics rather than health concerns) at wells upgradient and downgradient of the landfill. Elevated iron and manganese concentrations are reported to be regional phenomenon and have been observed at other wells in the area. Landfill 5 is upgradient of the northern part of the South Parcel, and therefore groundwater with elevated iron or manganese concentrations may flow beneath the site under existing conditions within the Vashon Aquifer.

Saltwater intrusion can occur in the comingled Vashon-Sea Level aquifer due to its close proximity and hydraulic connection to Puget Sound. Pumping wells, which commonly cause saltwater intrusion, are not reported to exist in the comingled aquifer west of the site; therefore, only tidally induced mixing between saltwater and freshwater in the immediate vicinity of the intertidal zone currently occurs. Depending on tidal stage and season, the saltwater component of discharge at Large Spring is estimated to range between 36 and 99 %.

The site is also in the Tacoma Smelter Plume area but has soil arsenic concentrations of less than 200 mg/kg. Ecology has determined this soil concentration level as unlikely to pose a threat to groundwater quality.

Water Supply Wells and Springs

The City of DuPont has three water supply wells at its Bell Hill wellfield (located approximately one mile southeast of the South Parcel), with Wells 1 and 3 completed in the Sea Level Aquifer and Well 2 completed in a deeper confined aquifer beneath the Sea Level Aquifer. The City's Hoffman Hill wellfield has two wells located over a mile southwest of the South Parcel which are also completed in the Sea Level Aquifer. The City also has a pending water right application to develop a wellfield sourced from the Sea Level Aquifer in the vicinity of Pond and Grant Lakes near Center Drive. The City's existing and proposed water supply wells produce water either hydraulically upgradient of (Bell Hill and the Pond Lake area) or cross-gradient (Hoffman Hill) to the South Parcel and are completed in confined aquifers which are hydraulically isolated from the Vashon Aquifer.

Prior well inventories in 1991 and 2006 for private residential water supply wells in the site area did not identify any within the Vashon Aquifer in close proximity of the site, nor in the comingled Vashon-Sea Level Aquifer near the active mine site.

As previously mentioned, Sequalitchew Springs provides most of JBLM's water supply.

3.3.2 Impacts of the Alternatives

This sub-section identifies and analyzes the potential for impacts to surface and groundwater resources on and in the vicinity of the site under the EIS Alternatives.

As described in **Chapter 2** of this DEIS, the 2011 Settlement Agreement states that permits for the Pioneer Aggregates South Parcel Project (Proposed Action) shall not be effective until permits for the Sequalitchew Creek Restoration Plan (Restoration Plan)[1], as a separate but related action. The Restoration Plan seeks to restore and enhance streamflow and ecological functions from Sequalitchew Lake through Edmond Marsh into Sequalitchew Creek ravine by sequentially restoring diverted flows back to the creek, improving the sustainability of flows through the system, and restoring aquatic habitat.

Consistent with the 2011 Settlement Agreement, this DEIS assumes that mining and reclamation activities under the Proposed Action would not proceed until permits and funding are in place to implement the Restoration Plan. It is assumed that projects associated with the Restoration Plan would be mitigation for certain environmental impacts identified in this DEIS, and that permits for the restoration Plan would be a condition of any City of DuPont approval of the Proposed Action. However, because the Restoration Plan is considered a separate project that would be subject to separate environmental review and could be funded and implemented independent of the Proposed Action, the general discussion in the Environmental Impacts sub-section of Groundwater only addresses the impacts of the proposed mining/reclamation and does not include implementation of the Restoration Plan. This is intended to help the reader understand the impacts of the proposed

[1] *The Sequalitchew Creek Restoration Plan is sponsored and developed by CalPortland, the Environmental Caucus and the South Puget Sound Salmon Enhancement Group (SPSSEG).*

mining/reclamation, and the need for the Restoration Plan with the proposed project. Proposed mining/reclamation in combination with the Restoration Plan is specifically discussed below in the Cumulative Impacts sub-section.

ALTERNATIVE 1 – PROPOSED ACTION

This sub-section describes impacts to groundwater quality and quantity that could occur due to the proposed mine expansion. The primary project impact to groundwater would be decreased Vashon Aquifer water levels due to dewatering activities needed for mining. Ultimately, the gravel deposits which the Vashon Aquifer is comprised of would be removed from the Re-Mine Area and part of the South Parcel. Drawdown of the Vashon Aquifer is anticipated to affect groundwater and surface water features (streams and wetlands) within a one to two-mile radius from the proposed mine site. The extracted groundwater would be conveyed to a constructed wetland system and ultimately infiltration galleries located at the bottom of the current mine, where the Vashon Aquifer and the Sea Level Aquifer are comingled and permeable Steilacoom Gravels are present. Because local surface waters are closely related to groundwater, changes in the groundwater-surface water relationship at nearby surface water features is also discussed.

As previously described in **Chapter 2**, a dewatering plan to accomplish the Proposed Action has been developed and is comprised of four steps (see **Section 2.5** for details). Briefly, these steps include:

- **Step 1:** 10 "Step 1" dewatering wells shown in **Figure 2-4** would be pumped for 60 days to confirm groundwater model predictions and to adjust the dewatering plan (with respect to well spacing, design, and pumping rate) as necessary prior to additional dewatering. This step will be fully reversible since no gravel will be extracted during this step.
- **Step 2:** The 24 Step 1 and Step 2 dewatering wells shown in **Figure 2-4** would be pumped for approximately six months, serving as a larger scale pumping test to confirm groundwater model predictions and to dewater gravels in preparation of mining. This step will be fully reversible since gravel will not be extracted. For Steps 1 and 2, if model predictions significantly differ from the observed hydraulic response, model refinements and/or adjustments to the subsequent dewatering and mining activity plans would be made.
- **Step 3:** This step represents the active dewatering and mining phase of the Proposed Action. Pumping from an estimated 66 dewatering wells (shown as the Step 1, 2, and 3 wells in **Figure 2-4**) may concurrently occur during the step as mining progresses southward toward Sequalitchew Creek. This step is expected to last between five and eight years, is when active gravel mining would occur, and its duration will be dependent on market conditions and successful achievement of groundwater drawdown thresholds. Potential impacts on aquifer water levels are expected to build slowly over time as wells are added and mining progresses southward. Water level monitoring data would be compared to model predictions, and if more drawdown occurs than predicted, adaptive actions with respect to dewatering and/or mining

would be required to ensure that target drawdown levels are not exceeded. Step 3 could be partially reversible (depending on the extent of gravel extraction that occurs prior to a hypothetical mining moratorium or market downturn).

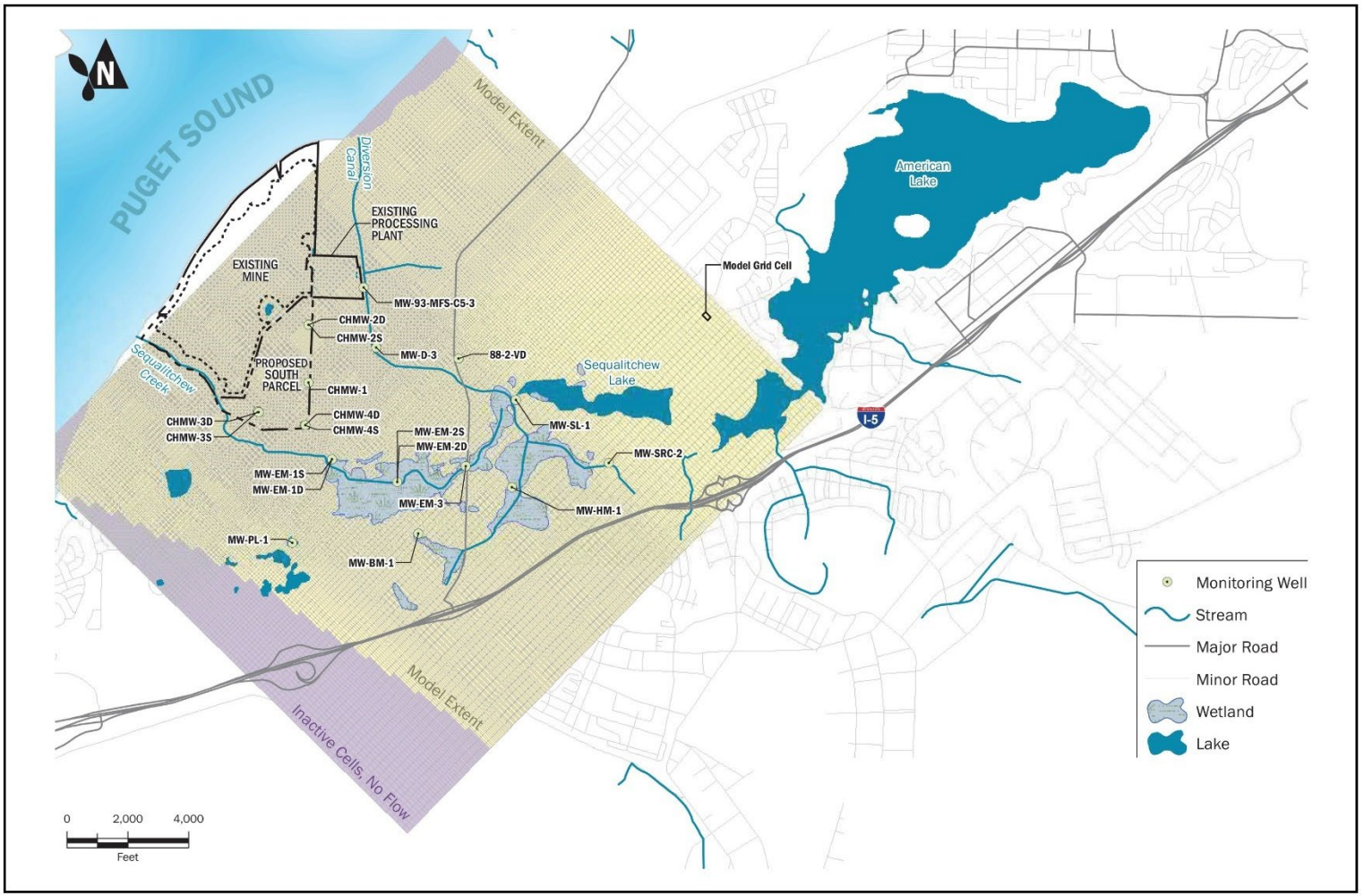
- **Step 4:** This step represents the planned condition for the South Parcel following the completion of active dewatering and would continue in perpetuity. A passive dewatering trough would be constructed at the toe of the eastern mine slope to collect groundwater, and would replace the dewatering wells. Collected groundwater would be conveyed to the mitigation wetland and infiltration facilities at the western margin of the Existing Mine. Gravel mining at locations west of the trough will continue in early phases of Step 4 (following completion of the trough) until all sand and gravel planned for mining has been extracted. Step 4 would be irreversible.

For the following discussion, it is assumed that the Proposed Action would proceed to completion, and therefore Step 3 would be irreversible.

Groundwater Modeling

To estimate likely extraction well pumping rates and groundwater drawdown due to dewatering, a 3-dimensional groundwater flow model of the project area was developed for this EIS. The groundwater model refined and updated previous site groundwater models developed in 2003, 2004, and 2009 to incorporate recent hydrogeologic data and interpretations and was calibrated to recent water level monitoring data. The groundwater model is a set of equations that are inter-related in a way that enables simulation of groundwater levels and flows for the area surrounding the gravel mine (see **Figure 3.3-5** and **Appendix E** for detail). Five different model scenarios were generated:

- An "existing conditions" model was developed to simulate groundwater levels as they currently exist. The existing conditions scenario simulates monthly water levels from 2004 to 2015, using observed surface water body elevations and calculated recharge rates as inputs for each monthly timestep (see **Appendix E** for further detail).
- A "Step 1 future conditions" scenario modified the "existing conditions" scenario by including active pumping from the 10 Step-1 dewatering wells shown in **Figure 2-4** for each monthly timestep. Monthly pumping rates were adjusted to maintain groundwater levels at target elevations that would allow mining to occur.
- A "Step 2 future conditions" model scenario modified the "existing conditions" scenario by including active pumping from the 24 Step-1 and Step-2 dewatering wells (**Figure 2-4**) for each monthly timestep. Monthly pumping rates were adjusted to maintain groundwater levels at target elevations that would allow mining to occur.
- A "Step 3 future conditions" model scenario modified the "existing conditions" scenario by including active pumping from all 66 dewatering wells for Steps 1, 2, and 3 (**Figure 2-4**) for each monthly timestep. Monthly pumping rates were adjusted to maintain



Source: Aspect, 2022.

EA Engineering, Science, and Technology, Inc., PBC

Figure 3.3-5

Existing Monitoring Well Network

groundwater levels at target elevations that would allow mining to occur. The Step 3 model scenario assumes all dewatering wells will actively pump at the same time, while in actuality Step 3 dewatering is planned to occur over five to eight years, with dewatering progressively extending southward as mining activities incrementally extend southward. It is possible that not all Step 3 dewatering wells will pump at the same time as simulated (if possible CalPortland plans to construct a passive dewatering trough in the north part of the site as mining extends southward), however, to evaluate the maximum potential effects of Step 3 pumping, all dewatering wells are simulated as active.

- A "Step 4 future conditions" model scenario modified the "existing conditions" scenario by including a passive dewatering trough to capture groundwater that will emanate from seeps at the base of the finished-grade eastern mine slope of the South Parcel.

The difference between groundwater levels and flows simulated by the different model scenarios are the best available information on groundwater impacts from the proposed dewatering plan. Those impacts are discussed in the sub-sections below. Although all groundwater models are simplified approximations of reality, the model generated in this case is the most comprehensive model developed to date for this area, and therefore the best existing tool for the impacts analysis.

Since groundwater and surface water are generally connected, the model represents these connections quantitatively. Surface water features where groundwater discharge consistently occurs (including Sequalitchew Springs and Sequalitchew Creek and its neighboring seeps in the ravine above the Olympia Beds) are simulated as "drain" cells in the model. Bell, McKay, Hamer, East Edmond, and West Edmond marshes are simulated using "river" cells that allow both groundwater recharge and discharge to occur across low-permeability wetland soils (to reflect the hydraulic connection that exists between surface water and groundwater in the marsh complex). Wetland soil properties were assigned based on field data and through model calibration, and areas where wetland soils have likely been disturbed were simulated with higher permeability than wetland soils that have not been disturbed. Drain cells are also included in marsh areas to simulate surface water outflow from the marshes during the wet season.

Potential aquifer recharge sources not simulated in the model include the Diversion Canal and Sequalitchew Lake.

The groundwater modeling approach and methodology used for the EIS is consistent with industry standard hydrogeologic practices, and reasonably simulates a complex hydrogeologic system. Because all hydrogeologic models are simplifications of reality, their predictions are subject to uncertainty (in a similar manner to how weather forecasts are subject to uncertainty). Identified areas where greater model uncertainty may exist for the site model are described in **Appendix E** and can be summarized as follows:

- Based on the model assumptions discussed above, the predicted amount of aquifer drawdown due to dewatering could be overestimated. This potential bias is considered "conservative" with respect to drawdown because if bias is present, the model most likely will over predict aquifer drawdown.
- The groundwater model was calibrated to Vashon Aquifer water level data alone; therefore, more uncertainty exists for model predictions of Vashon Aquifer discharge to surface water such as in the Sequalitchew Creek ravine.
- Sufficient aquifer water level data from the Sea Level Aquifer were not available for model calibration; therefore, greater uncertainty exists with respect to water level predictions for the Sea Level Aquifer compared to the Vashon Aquifer. However, dewatering activities are not proposed in the Sea Level Aquifer and the Olympia Beds provide relative isolation from the changes in water level in the Vashon Aquifer.

Wetland Water Balance Modeling

The site groundwater model is capable of estimating changes in groundwater level and discharge to springs and Sequalitchew Creek in the upper ravine due to dewatering activities since it simulates the primary physical processes and parameters affecting them. However, the groundwater model cannot predict changes in marsh-complex water levels because surface water inflows to the marshes are not directly simulated in the groundwater model, and monthly marsh surface water levels are input values to the groundwater model. A water balance model was developed for this EIS to predict changes in wetland water levels and flows. The wetland water balance model is discussed briefly here because a groundwater component is simulated by it.

The wetland water balance model first simulated the "existing" condition based on historical water level data and simulation results were improved through model calibration. Changes in groundwater levels (as simulated by the groundwater model) for each dewatering step were then input into the water balance model, and it was used to predict changes in wetland water levels and flows emanating from the wetlands due to changes in the underlying groundwater level. The water balance model was also used to estimate likely effects on the wetlands if the Proposed Action and the Sequalitchew Creek Restoration Plan occur (see the Cumulative Impacts sub-section for details).

The water balance model divided the marsh complex into 1) an upper area consisting of Bell, Hamer, and McKay marshes; 2) a central area comprised of the East Edmond Marsh area; and 3) West Edmond Marsh. Water inflows into each of these areas consisted of precipitation directly on the wetlands, surface water inflows, and groundwater discharge. Outflows consisted of evapotranspiration from open water and vegetation, surface water outflows, and groundwater recharge. Time steps were monthly. Changes in wetland water elevation were calculated by assessing the change in water storage within each wetland group (total water in minus total water out) and spreading that change in volume over the area of the wetland. A qualitative calibration process was performed where existing condition simulated water levels were compared to historically observed wetland water levels.

The groundwater component simulated in the water balance model is significantly simplified compared to the groundwater model; each wetland has a single soil permeability value assigned, a uniform monthly groundwater elevation beneath each wetland is assigned, and a uniform aquifer permeability adjacent to each wetland is assigned. Additionally, groundwater levels beneath each wetland do not change in response to predicted recharge or discharge flow to/from the wetland. Nonetheless, because significant changes to the hydrology of the wetland complex will occur as part of the Sequalitchew Creek Restoration Plan and their likely impacts on the underlying aquifer system are difficult to quantify, output from the wetland water balance model was used in the EIS to make interpretations regarding the likely aquifer system response to changes in surface water elevations and flows caused by the Restoration Plan. It should be noted that groundwater elevation predictions from the groundwater model were used as input for the wetland water balance model; no wetland water balance model outputs were incorporated into the groundwater model.

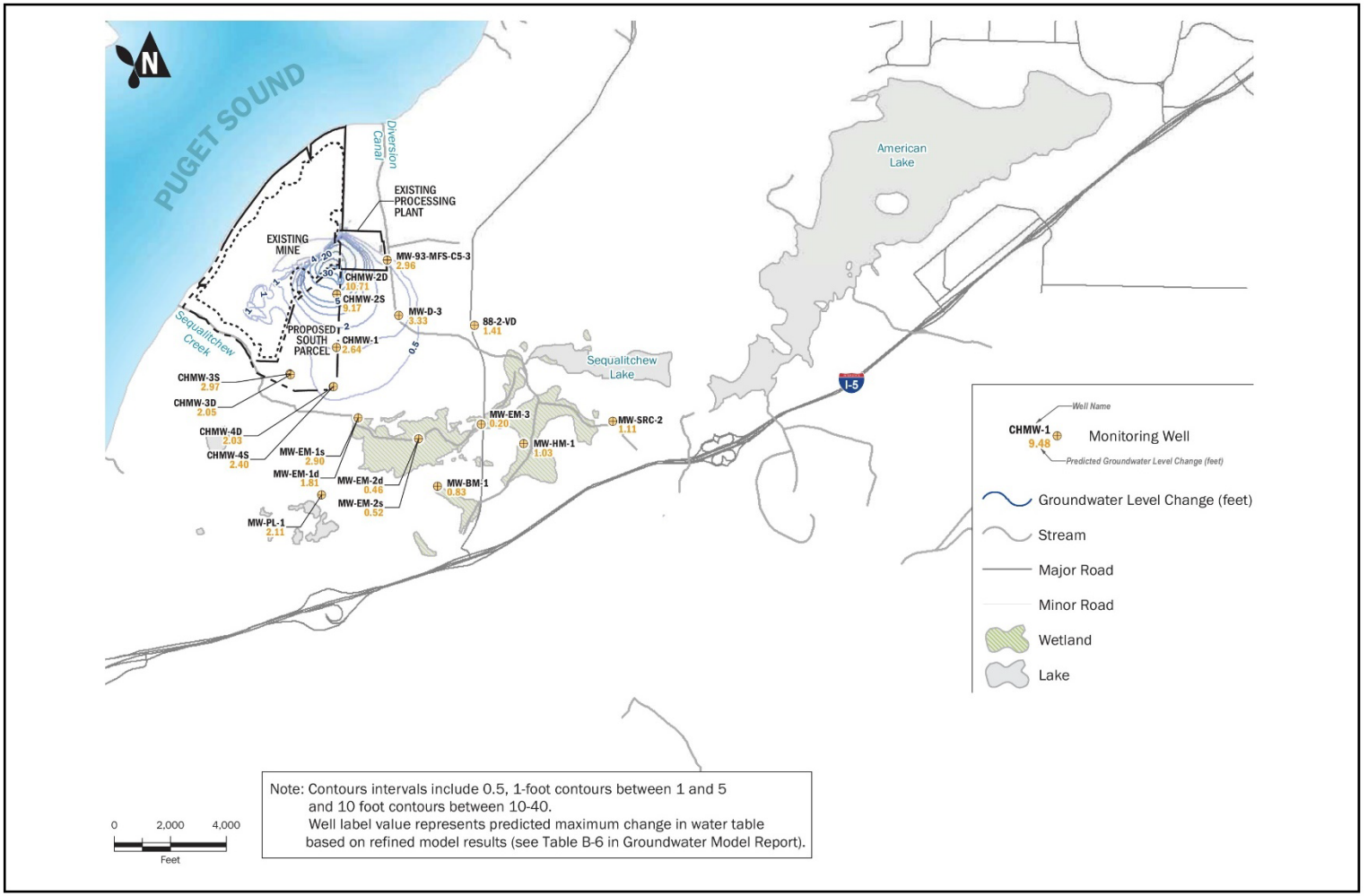
Groundwater Flow and Water Levels

Water levels in the Vashon Aquifer are expected to decline significantly at the project site due to the Proposed Action. Aquifer drawdown is projected to generally decrease with increasing distance from the dewatering area, as discussed in this subsection. As discussed in the Surface Water sub-section, aquifer drawdown would cause surface water level elevations to decrease.

Three types of predicted water levels (and drawdown) based on groundwater model results were calculated and applied in the following ways:

- "Raw" predicted water levels are water levels predicted by the calibrated model, with no additional corrections. Model predicted changes in groundwater recharge and discharge were calculated using "raw" water levels.
- "Refined" predicted water levels are based on "raw" predicted water levels but have been statistically corrected to be more accurate based on field measurements at existing wells. "Refined" water levels are effectively best estimate predictions of expected future water levels near the site, but could only be calculated at site-area monitoring wells where real-world water level measurements exist.
- "Performance threshold" predicted water levels are calculated using "refined" water levels but incorporate additional corrections for model uncertainty relating to seasonal and annual climate variations. "Performance threshold" values represent "worst case scenario" predicted water levels and drawdown. Defined through statistical testing (a 95% lower confidence interval), "performance threshold" water levels are expected to have less than a 5% chance of being exceeded due to random chance.

Raw maximum predicted drawdown contours for each dewatering step are shown in **Figures 3.3-6** through **3.3-9**. Maximum performance threshold predicted drawdown values are listed next to each well in **Figures 3.3-6** to **3.3-9**. The performance threshold maximum drawdown

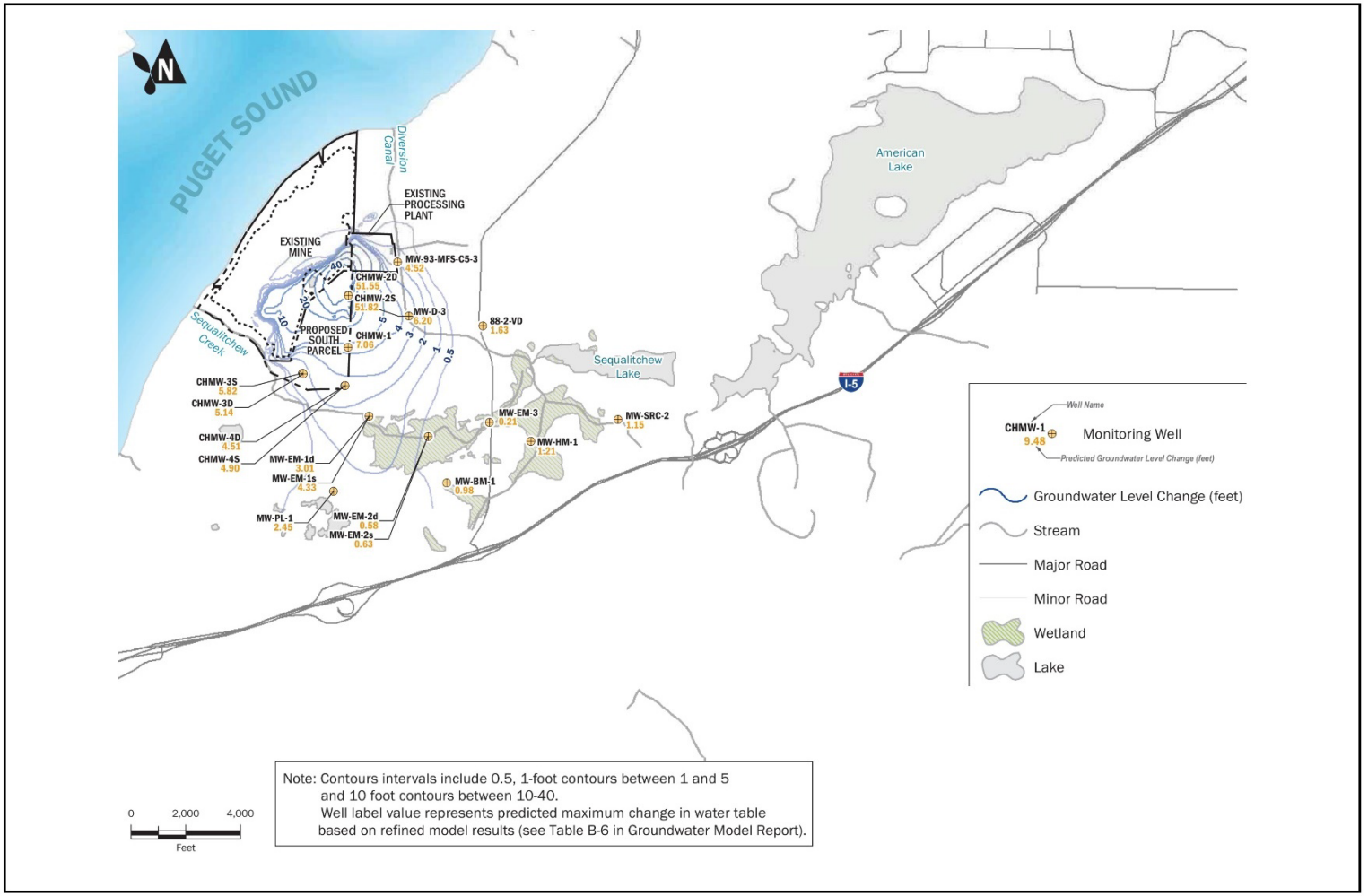


Source: Aspect, 2022.

EA Engineering, Science, and Technology, Inc., PBC

Figure 3.3-6

Maximum Model Calculated Groundwater Level Changes: Step 1

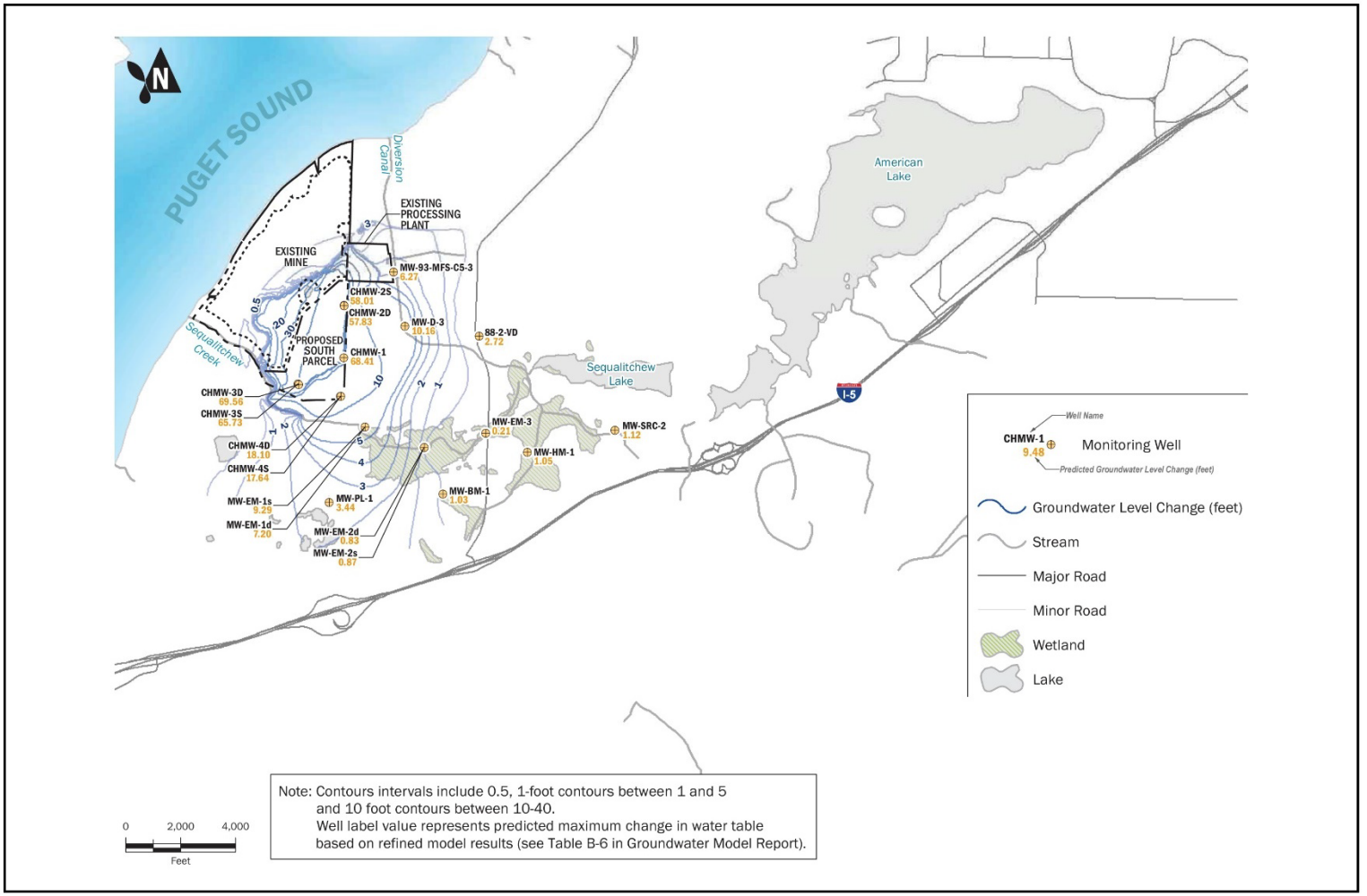


Source: Aspect, 2022.

EA Engineering, Science, and Technology, Inc., PBC

Figure 3.3-7

Maximum Model Calculated Groundwater Level Changes: Step 2

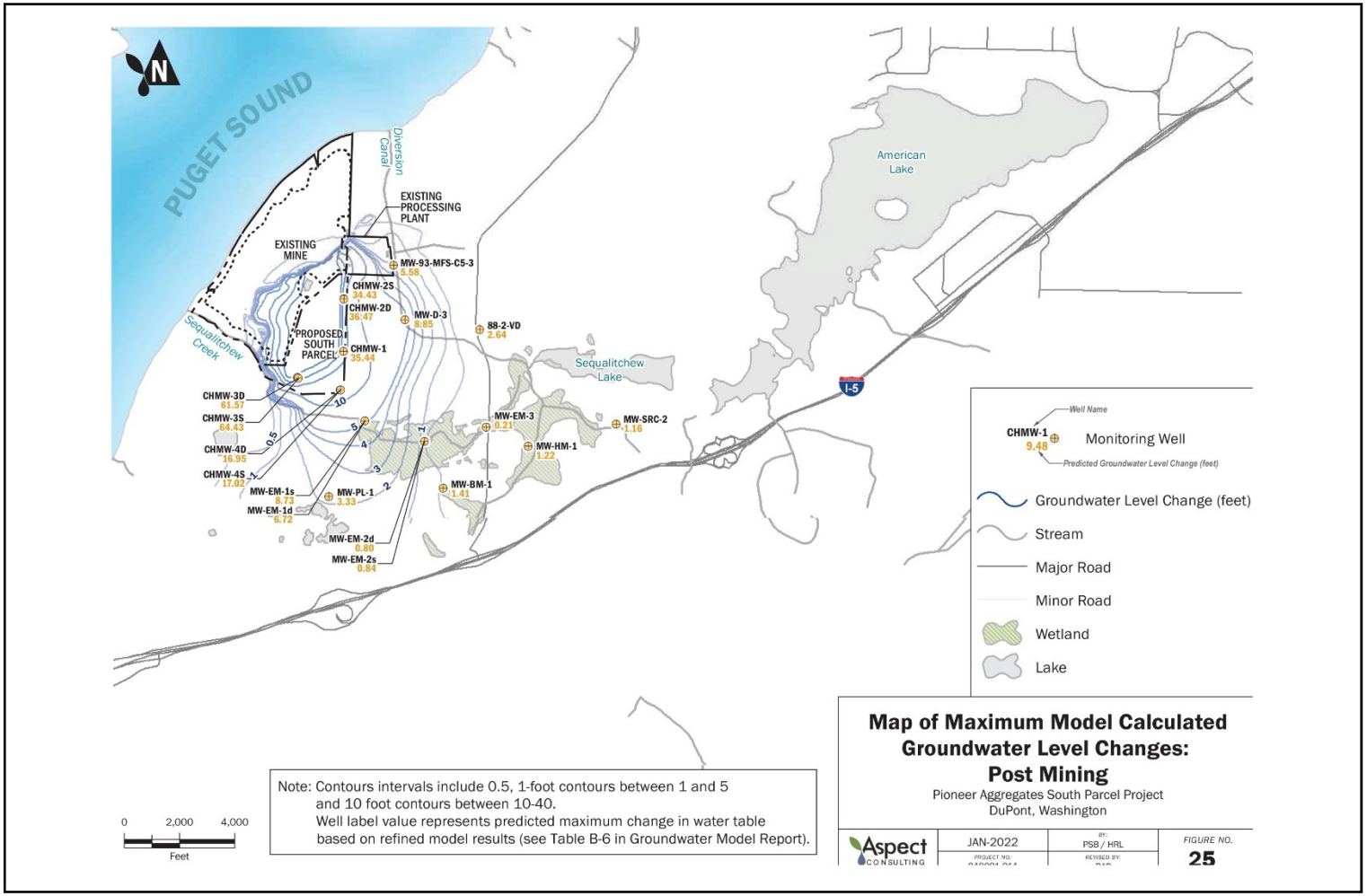


Source: Aspect, 2022.

EA Engineering, Science, and Technology, Inc., PBC

Figure 3.3-8

Maximum Model Calculated Groundwater Level Changes: Step 3



Source: Aspect, 2022.

EA Engineering, Science, and Technology, Inc., PBC

Figure 3.3-9

Maximum Model Calculated Groundwater Level Changes: Post Mining

values are greater than the contoured (raw maximum predicted) drawdown values because model and seasonal predictive uncertainties are added to them.

- Maximum predicted raw and performance threshold drawdown values at the South Parcel and the wetland complex are discussed below for each dewatering step below:
- Step 1 (10 dewatering wells pumping for 60 days in the northeast corner of the South Parcel): The performance threshold maximum predicted drawdown at a site monitoring well is 10.71 feet at CHMW-2D (approximately 450 feet south of the southernmost Step 1 dewatering well), while in the wetland complex area it is 2.90 feet at MW-EM-1S (located at the west end of West Edmond Marsh). Up to 30 feet of raw drawdown is predicted to occur in the vicinity of the active dewatering wells (**Figure 3.3-6**), while less than 0.5 feet of raw drawdown is predicted to occur beneath the wetland complex and Sequalitchew Creek. Because Step 1 will only last for 60 days, it is possible that measurable aquifer drawdown at more distant features (such as the marsh complex) may not occur if Step 1 commences during the wet season when the wetlands are "full" and provide ample recharge to the water table.
- Step 2 (24 dewatering wells pumping for six months in the northeast and east-central portions of the South Parcel): : The performance threshold maximum predicted drawdown is 51.82 feet at CHMW-2S, while in the wetland complex area it is 4.33 feet at MW-EM-1S (at the west end of West Edmond Marsh). A raw maximum predicted drawdown of over 40 feet is predicted for a broad area in the mine vicinity near the active dewatering wells (**Figure 3.3-7**), while less than 0.5 to almost 2 feet of raw drawdown is predicted to occur beneath the wetland complex and Sequalitchew Creek. Similar to Step 1, because Step 2 will only last for six months, aquifer drawdown near the wetlands may be difficult to observe if Step 2 occurs primarily during the wet season when aquifer recharge is higher.
- Step 3 (up to 66 dewatering wells pumping for five to eight years in the eastern and southern sections of the South Parcel): The performance threshold maximum predicted drawdown is 69.56 feet at CHMW-3D (**Figure 3.3-8**) and is up to 9.29 feet beneath the western edge of the marsh complex (at MW-EM-1S). Maximum performance threshold drawdowns farther east in the marsh complex range are approximately one foot or less. Raw maximum predicted drawdown values of greater than 40 feet are predicted across much of the South Parcel, while beneath West Edmond Marsh the raw maximum predicted drawdown ranges from approximately 6 feet to 0.5 feet (and decreases to the east). Between 5 and 10 feet of raw maximum drawdown is predicted beneath Sequalitchew Creek in the upper ravine, while less than 0.5 feet is generally predicted beneath East Edmond, Bell, Hamer, and McKay marshes.
- Step 4 involves passive dewatering via a trough located in the eastern and southern sections of the South Parcel and will be active in perpetuity. The performance threshold maximum predicted drawdown is 64.43 feet at CHMW-3S (**Figure 3.3-9**) and is up to 8.73 feet beneath West Edmond Marsh (at MW-EM-1S). Maximum performance threshold drawdowns farther east in the marsh complex are approximately one foot or less. Relative to Step 3, onsite drawdown will be less with the passive groundwater collection system. Less drawdown is predicted from passive dewatering relative to active dewatering because the excavated mine slope and trough can more efficiently

maintain groundwater elevations at levels beneath the proposed mine floor than pumping wells.

With the Proposed Action, the general groundwater flow direction in the Vashon Aquifer is expected to remain to the northwest. However, in the immediate vicinity of the project site, local groundwater flow paths are expected to change and flow toward the dewatering wells (or the groundwater collection trough in Step 4) rather than flowing toward their existing natural discharge points (i.e., the Olympia Beds Truncation or seeps in the Sequalitchew Creek ravine). Changes in local flow direction would likely be greatest during Steps 1 and 2 and during earlier phases of Step 3 (when dewatering would be focused in the northern part of the South Parcel). During later phases of Step 3 and in Step 4 local groundwater flow paths would be similar to current conditions, though local flow paths that currently discharge from the north to the Sequalitchew Creek ravine may be reversed and instead terminate at a dewatering well or seeps that drain to the Step 4 groundwater collection trough.

Predicted water level changes in the Sea Level Aquifer are expected to be negligible beneath the Olympia Beds because it is hydraulically isolated from the Vashon Aquifer by the Olympia Beds. Therefore, no notable change in its northwest groundwater flow direction is expected.

West of the Olympia Beds Truncation where the combined Vashon and Sea-Level Aquifer exists, groundwater flow would generally remain to the west/northwest toward Puget Sound, though localized groundwater paths near the planned infiltration facility at the far west end of the mine could change due to groundwater mounding beneath it. Because the mine dewatering system intercepts groundwater from the Vashon Aquifer that would otherwise enter the comingled aquifer (via downward groundwater flow at the Olympia Beds truncation), the total volume of water entering the comingled Vashon and Sea Level aquifer should not significantly change during Steps 1 and 2. Groundwater levels would likely be higher near the planned infiltration facilities due the more concentrated and higher rate of infiltration expected to occur at those facilities relative to the existing area where groundwater from the Vashon Aquifer enters and provides recharge to the comingled Vashon-Sea Level Aquifer. During Steps 3 and 4 slightly more water is likely to be infiltrated in the comingled aquifer than currently flows into it from the Vashon Aquifer since some groundwater that naturally discharges to Sequalitchew Creek in the upper ravine (above the Olympia Beds) is expected to be captured by the dewatering system and conveyed to the infiltration facilities.

Though the general direction of groundwater flow is not expected to appreciably change following completion of the Proposed Action, lower groundwater levels in the Vashon Aquifer near the site are expected to result in less groundwater discharge to surface water bodies and more aquifer recharge due to surface water losses. Expected changes in groundwater recharge/discharge relationships and aquifer water levels near these features due to the Proposed Action are discussed below.

Lakes

Because slightly lower aquifer water levels are predicted near Sequalitchew Lake (less than 0.5 feet of raw aquifer drawdown is predicted for all dewatering steps, while performance

threshold maximum drawdown values near Sequalitchew Lake range from 0.21 to 2.72 feet in Step 3), more recharge may occur in its vicinity since the lake typically receives surface water inflows from Sequalitchew Springs.

As mentioned previously, expected changes in surface water levels at kettle lake and wetland features where surface water inflow/outflow does not occur (and therefore groundwater recharge/discharge is not expected) are discussed in the Surface Water sub-section.

Wetlands

Lower aquifer water levels beneath the wetland complex are predicted to cause more surface water inflow to the Vashon Aquifer within the wetlands. Relative to existing conditions, the groundwater model predicts that aquifer recharge from the combined wetland complex would increase by the following average amounts during dewatering:

- Step 1: similar to existing conditions/no significant change
- Step 2: 0.2 cfs greater than existing conditions
- Step 3: 0.6 cfs greater than existing conditions
- Step 4: 0.5 cfs greater than existing conditions

Greater surface water inflow from the wetlands to the aquifer would cause aquifer water levels beneath them to be somewhat buffered and experience less drawdown than would occur in their absence. However, increased groundwater recharge from the wetlands would cause wetland water levels to decrease, as discussed in Section 3.4, **Surface Water**. A brief discussion of predicted changes in aquifer water levels beneath the wetland complex follows.

Bell, McKay, and Hamer Marshes are relatively far from the South Parcel, and less than 0.5 feet of raw aquifer drawdown is predicted beneath all three marshes during all dewatering steps. Performance threshold maximum aquifer drawdown values of approximately one foot are predicted at each marsh for each dewatering step (with a predicted range across all dewatering steps of between 0.83 and 1.41 feet as shown in **Figures 3.3-6** to **3.3-9**). Predicted changes in marsh water level due to aquifer drawdown are discussed in Section 3.4, **Surface Water**, and are less than predicted changes in aquifer water levels primarily because of surface water inflows and the presence of low-permeability marsh sediments (which limit the rate of surface water flow into aquifer).

Beneath East Edmond Marsh, less than 0.5 feet of raw aquifer drawdown is predicted for Step 1, up to 0.5 feet for Step 2, and up to one foot of drawdown for Steps 3 and 4. Performance threshold maximum drawdown during all dewatering steps ranges from 0.20 to 0.87 feet. Smaller decreases in marsh water levels are predicted relative to groundwater levels, as discussed in Section 3.4, **Surface Water**. Though closer to the project site than Bell, McKay, and Hamer Marshes, lower model uncertainty with respect to aquifer water level predictions exists at East Edmond Marsh, causing it to have lower performance threshold drawdown values than Bell, McKay, or Hamer Marshes.

West Edmond Marsh is the closest large wetland to the site and has more raw drawdown predicted than the other wetlands. As previously discussed, during Steps 1 and 2, raw maximum drawdown of 2 feet or less is predicted beneath the wetland, while performance threshold maximum drawdown values of up to 4.33 feet are predicted. During Steps 3 and 4 between approximately 1 and 5 feet of maximum raw drawdown is predicted (depending on location, as shown in **Figures 3.3-8** and **3.3-9**). In Steps 3 and 4, performance threshold maximum drawdown values of up to 9.29 feet of drawdown are predicted at the west end of the marsh (MW-EM-1S), and while only 0.87 feet is predicted at its east end (MW-EM-2S). Higher predicted drawdown values at the west end of West Edmond Marsh are likely due to it being closer to site dewatering features, and because only seasonal hydraulic connection exists between surface water and groundwater (due to the fine-grained marsh sediments which cause surface water to be seasonally disconnected or "perched" above groundwater). Existing summer conditions in the western portion of West Edmond Marsh would result in surface water being either perched above the water table or dry (see **Figure 3.3-3**). Where perched conditions exist aquifer drawdown would not cause surface water inflow (i.e., recharge) to the aquifer to increase, and in the absence of buffering surface water inflows, more aquifer drawdown would occur. With lower aquifer water levels, more surface water in West Edmond Marsh would be seasonally perched and disconnected from groundwater. The effects of increased aquifer drawdown on surface water level elevations and wetland function are discussed in Section 3.4, **Surface Water**, and in Section 3.6, **Plants and Animals**.

Streams

The groundwater model predicts significant reductions in Sequalitchew Creek baseflow through the ravine due to decreases in aquifer water level caused by the Proposed Action. In dewatering Steps 1 and 2, spring and seep discharge within the ravine are not predicted to significantly change because the dewatering steps are relatively short (months in duration) and the pumping wells are relatively far from Sequalitchew Creek (approximately 3000 feet or more, as shown in **Figure 2-4**). In Step 3, groundwater discharge to the ravine is predicted to decrease by 83% on average, with the greatest decreases occurring in the dry season. During Step 4, discharge to the ravine is predicted to be on average 79% less than existing conditions, and similarly the greatest decreases are predicted in the dry season. In Step 4, the average annual baseflow (which is fed by groundwater discharge at seeps and springs) of Sequalitchew Creek is projected to be reduced from approximately 1.6 cfs to approximately 0.34 cfs. Step 4 is predicted to have slightly less impact on Sequalitchew Creek baseflows than Step 3 because the passive dewatering trough will induce slightly less aquifer drawdown than the active dewatering wells.

Groundwater recharge from Lower Sequalitchew Creek where it overlays the combined Vashon-Sea Level Aquifer has not been quantified but is expected to decrease with decreasing upstream baseflows in Sequalitchew Creek. The reduction in recharge from Lower Sequalitchew Creek is likely insignificant relative to other inflows and recharge sources to the combined Vashon-Sea Level Aquifer

Aquifer recharge from and discharge to the Diversion Canal also is not quantified. The reach of the Diversion Canal downstream of Sequalitchew Lake and upstream of DC-1 currently receives

groundwater discharge. Under the Proposed Action, aquifer drawdown may cause less discharge to the canal in that reach. If so, more water would be retained by the aquifer in that area, which would potentially reduce aquifer drawdown in that vicinity.

Springs

Predicted changes in spring discharge for the Sequalitchew Creek ravine are discussed in the Streams sub-section above.

No change in Sequalitchew Springs discharge to Sequalitchew Lake is expected due to the Proposed Action since aquifer drawdown is not predicted to occur there.

Changes in discharge at the Large Spring and other springs adjacent to Puget Sound which receive water from the comingled Vashon-Sea Level Aquifer have been estimated using the groundwater model at approximately a 2% increase due to the Proposed Action. Since dewatering is expected to capture groundwater that would normally discharge to Sequalitchew Creek, slightly more water would be infiltrated into the Vashon-Sea Level Aquifer than currently discharges to it from the Vashon Aquifer. This additional water entering the aquifer may slightly increase local groundwater elevations and spring discharge rates.

Puget Sound

Marine discharge to Puget Sound from the comingled Vashon-Sea Level Aquifer is not likely to change significantly and may slightly increase (predicted to be less than 2%) since mine dewatering is predicted to capture some Sequalitchew Creek base flow, which would then be infiltrated in the comingled aquifer (as discussed above in the Springs sub-section). However, the total volume of water discharging to Puget Sound in the project area (both groundwater and surface water) should not significantly change.

Groundwater Quality

Groundwater quality beneath and in the area of the South Parcel would largely be unaffected by the Proposed Action. Mining permits require best management practices for groundwater and stormwater pollution prevention, defined spill control and cleanup procedures, and operations management to minimize the use of potential pollutants within the mine. The consistent presence of heavy machinery onsite would enable a rapid spill cleanup response, where contaminated soils can quickly be excavated into and removed by a dump truck.

Groundwater with elevated iron and manganese concentrations flowing beneath Fort Lewis Landfill 5 would continue to flow toward the project site and the Olympia Beds Truncation, though dewatering potentially would cause more to flow toward the dewatering features rather than the Olympia Beds Truncation. The ultimate destination of groundwater captured through dewatering or groundwater flowing over the Olympia Beds Truncation would be the same (the comingled Vashon-Sea Level Aquifer), however.

Greater surface water inflows from the wetlands could affect groundwater temperature and water quality in the immediate vicinity of the wetlands, but because aquifer mixing and dilution would occur, notable changes in groundwater quality at the dewatering site are not expected.

Significant saltwater intrusion impacts are not expected due to the Proposed Action, though less flow in Sequalitchew Creek could result in a slight landward shift of the saltwater-freshwater interface near its mouth. Slight increases in recharge to the comingled Vashon-Sea Level aquifer could cause intertidal springs west of the existing mine to have a slightly greater freshwater component.

Drinking water supplies near the South Parcel (Sequalitchew Springs, DuPont's Bell Hill and Hoffman Hill wellfields) are not expected to be impacted by the Proposed Action since they are either significantly upgradient of the project site (Sequalitchew Springs) or completed in deeper aquifers that are separated from the Vashon Aquifer by confining units.

Water Supply Wells and Water Supply Springs

The proposed project would not directly disturb the Olympia Beds or the deeper aquifers, and therefore indirect impacts on deep-aquifer water levels are expected to be minimal. Model results indicate that the change in water level in the Sea Level Aquifer at the edge of the model boundary in the direction of the City wellfield is less than 0.1 feet. Thus, existing and proposed City wellfields are not expected to be impacted by the Proposed Action.

Aquifer drawdown is not predicted to occur at Sequalitchew Springs, and therefore no effects on JBLM's water supply springs are expected.

No water supply wells are known to exist in the site area which tap the Vashon Aquifer, and therefore none would be impacted by the Proposed Action.

CUMULATIVE IMPACTS WITH PROPOSED ACTION AND SEQUALITCHEW CREEK RESTORATION PLAN

Introduction

As indicated in **Chapter 2** of this EIS, the 2011 Settlement Agreement states that permits for the Pioneer Aggregates South Parcel Project shall not be effective until permits for the Sequalitchew Creek Restoration Plan are in place, as a separate but related action. The Sequalitchew Creek Restoration Plan seeks to restore and enhance streamflow and ecological functions from Sequalitchew Lake through Edmond Marsh into Sequalitchew Creek ravine. Restoration of Sequalitchew Creek seeks to address almost two centuries of human manipulation. The principal goals of the Restoration Plan are to restore flows in Sequalitchew Creek, portions of which are now dry. This goal will be achieved by implementing a series of actions in a coordinated and adaptively managed project. The Restoration Plan is intended to sequentially restore diverted flows back to the creek, improve the sustainability of flows

through the system, and restore aquatic habitat by removing flow-related fish passage barriers and increasing the habitat available to aquatic species.

The Restoration Plan is composed of multiple elements and phasing; its general objectives are to achieve year-round surface water flow in Sequalitchew Creek from Sequalitchew Lake to Puget Sound, minimize surface water flow to the Diversion Canal, and improve habitat conditions for native salmonid populations in the Sequalitchew Creek watershed.

Cumulative Impacts

Expected cumulative impacts to the groundwater system with the Proposed Action and Restoration Plan include:

- Lower surface water levels in East Edmond Marsh are predicted to cause the marsh to become a groundwater discharge feature because its planned surface water elevation will be lower than the underlying groundwater elevation. Beneath West Edmond Marsh groundwater recharge is projected to increase due to the increased surface water flow through it. Surface water levels are not expected to significantly change at Bell, McKay, and Hamer Marshes with the restoration plan, and therefore significant changes in their groundwater recharge/discharge relationships are not expected.
- Greater surface water flows through West Edmond Marsh and the Sequalitchew Creek "dry reach" is likely to increase groundwater recharge in its vicinity. Increased recharge in this area potentially will cause spring discharge in the upper Sequalitchew Creek ravine to increase, particularly if concentrated recharge occurs in the western portion of the "dry reach". However, if substantial streamflow losses in the current "dry reach" section of Sequalitchew Creek occur, a possible action identified in the restoration plan is adding a liner of low permeability materials to the creek bed in this vicinity. If this does occur, less groundwater recharge would occur in the "dry reach" area.
- Streamflow loss from Lower Sequalitchew Creek to the combined Vashon-Sea Level Aquifer should increase (as well as nearby aquifer water levels) due to the higher surface water flows through Sequalitchew Creek.
- During dry summers (when Sequalitchew Springs discharge to Sequalitchew Lake is fully consumed by JBLM), no surface water outflow from Sequalitchew Lake to East Edmond Marsh and Sequalitchew Creek will occur. These infrequent dry periods are predicted to last for several weeks to months, and during these periods the hydraulic system would shift closer to the condition simulated by the groundwater model with no Restoration Plan actions. However, because surface water level elevations in East and West Edmond marshes would be lower due to beaver dam removal, the aquifer would likely receive less recharge from the wetlands. Therefore, during drought periods greater aquifer drawdown could develop beneath Edmond Marsh and/or less groundwater discharge may occur in the Upper Sequalitchew Creek ravine with the Restoration Plan.
- Intertidal spring water quality and discharge rates from the combined Vashon-Sea Level Aquifer are not expected to change with the Proposed Action and the Restoration Plan.
- Recharge near the Diversion Canal (if any) would likely decrease since the Restoration Plan aims to minimize surface water flows in the Diversion Canal. Monitoring data and

the groundwater model calibration effort suggest that the Diversion Canal is not a significant source of recharge to the aquifer.

ALTERNATIVE 2 – NO ACTION

The No Action Alternative includes two scenarios: Scenario A – Continuation of Existing Site Conditions; and Scenario B – Site Development under Existing Zoning.

Scenario A

Under No Action Alternative Scenario A, the surface and groundwater conditions would remain as under existing conditions.

Scenario B

If the site were to be developed consistent with existing zoning, clearing and grading associated with construction would increase potential for erosion impacts to surface and groundwater resources; with adherence to applicable regulations during construction, significant impacts to these resources are not anticipated. The increase in impervious surfaces on the site with development consistent with existing zoning would increase stormwater runoff; with adherence to applicable regulations related to stormwater quantity and quality, significant impacts are not anticipated.

As indicated above, development of the site consistent with existing zoning includes the potential for the Sequalitchew Creek Restoration Plan to be implemented without the Proposed Action. However, there are no other known substantial funding sources other than CalPortland.

3.3.3 Mitigation Measures

Proposed Mitigation Measures

The following mitigation measures have been included in the Proposed Action to reduce surface water and groundwater impacts.

- Groundwater and surface water level monitoring for features in the site area that could potentially be affected would be implemented (see **Appendix F** for details). Monitoring data would be reviewed throughout the active dewatering period and used in support of the Proposed Action mitigation measures bulleted below. City review of monitoring data should include retention of a qualified hydrogeologist to provide qualified review of both data and projected impacts.

    - Steps 1 and 2 of the aquifer pumping tests would be completely reversible and would allow for confirmation testing of groundwater model predictions. If observed impacts differ significantly from predicted impacts, updates to the

groundwater model would be pursued to improve its predictive accuracy for subsequent dewatering steps and/or adjustments to the dewatering and mining activity plans would be made.

- The dewatering plan would be phased so that dewatering would start at locations farthest from Sequalitchew Creek and the wetland complex, and gradually would proceed closer to the waterbodies only if observed aquifer water levels do not exceed performance threshold values.

- If performance threshold water levels are exceeded, adaptive management responses (such as adjusting the dewatering operations and/or the boundaries and depth of mining so that performance threshold exceedances do not occur) would be required before additional mining could occur.

- Since dewatering Step 3 would be irreversible, increased monitoring vigilance at different phases of Step 3 as dewatering and mining progress southward could be warranted to ensure that performance threshold water levels are not exceeded.

- Erosion and sediment controls and stormwater treatment, which are intended to protect groundwater quality and the long-term performance of the proposed infiltration facilities, would be implemented (see **Appendix D** and Section 3.1, **Earth**, for details).

Other Possible Contingency Mitigation Measures

- As an element of the approval conditions for the Proposed Action, the City of DuPont could require a Monitoring and Response Plan. The Monitoring and Response Plan could include, among other things, definition of monitoring methodology, establishment of performance thresholds, and identification of contingency response measures to the considered for implementation if monitoring indicates exceedance of a performance threshold. The Monitoring and Response Plan could incorporate elements of the adaptive management processes proposed to be established for the Proposed Action and the Sequalitchew Creek Restoration Plan.

- The Sequalitchew Creek Restoration Plan is a separate but related action that is intended to be implemented in parallel with the Proposed Action. The mine and the stream restoration project each have their own adaptive management process tailored to achieving the goals and objectives of each specific project. The interaction between the two adaptive management processes could include: 1) project schedules that encourage restoration in advance of the potential impacts from mining; 2) development of performance thresholds for mining that support restoration and 3) coordinated monitoring and open sharing of information. The City, as the permitting authority for both projects would have a key role in assuring consistency between the two adaptive management plans. The adaptive management process included in the

Monitoring Plan (see **Appendix F**) includes, but is not limited to, the following potential mitigation actions if the impacts of dewatering on groundwater levels are greater than anticipated including: Installing additional monitoring locations; modifying the dewatering system or approach; revising the mining plan; and providing additional mitigation to impacted surface waters.

- The Sequalitchew Creek Restoration Plan's adaptive management process similarly identifies examples of potential response actions to be implemented if restored flows do not meet the plans objectives that include, but are not limited to: removing beaver obstructions; installing additional beaver exclusion devices; escalating beaver management; installing additional flow paths through the former railroad grade that divides Edmond Marsh; sealing the losing reach; creating connections to Bell and/or McKay marshes; and expediting later elements of the Restoration Plan.

Other groundwater contingency mitigation measures that could be implemented as part of the adaptive management process include:

- Groundwater captured from the mine could be conveyed to the Sequalitchew Creek ravine (either by open channel or micro-tunneling). This approach could provide mitigation for decreased seep discharge within the ravine if the conveyance outfall (or confluence) is located in the vicinity where groundwater discharge currently occurs. However, this mitigation measure could require revisiting conflicting provisions in the 2011 Settlement Agreement and would not augment streamflow between Sequalitchew Lake and the ravine.

- Groundwater captured from the mine could be pumped into Edmond Marsh rather than into the Sequalitchew Creek ravine. Benefits of this mitigation approach would be that cool groundwater (which has a low summer water temperature relative to surface water) would enter the marsh and could enhance Sequalitchew Creek surface water flow and fish habitat. A potential drawback of this mitigation action is that groundwater discharge/infiltration to the comingled Vashon-Sea Level Aquifer would substantially decrease. In addition, it likely would over-mitigate expected dewatering impacts to Sequalitchew Creek if active year-round (as opposed to only during certain dry or low-flow conditions).

- Water could be actively conveyed to Edmond Marsh during dry periods, while during all other periods captured groundwater from the South Parcel could be conveyed to the lower mine area for infiltration (as is planned in the Proposed Action). This could serve as a contingent measure for consideration and/or further study to supplement Sequalitchew Creek flows during dry periods when no outflow from Sequalitchew Lake occurs or if the Restoration Plan provides less environmental benefit than currently expected.

3.3.4 Significant Unavoidable Adverse Impacts

Under the Proposed Action with the Sequalitchew Creek Restoration Plan, unavoidable adverse impacts to the surface water system of the Sequalitchew Creek watershed would likely include:

- The Vashon Aquifer water table would significantly decrease in the vicinity of the South Parcel. Groundwater levels beneath Edmond Marsh, the closest marsh to the site, are predicted to decrease by up to 0.87 feet near its center (at MW-EM-2S) and remain up to 0.84 feet lower following completion of the Proposed Action. At the west end of the marsh (MW-EM-1S), long-term groundwater level declines of up to 8.73 feet could occur.

- Groundwater discharge in the Sequalitchew Creek ravine is expected to significantly decrease (by an annual average of up to 83%) during the Proposed Action and is expected to provide on average 79% less baseflow to Sequalitchew Creek following the Proposed Action. Greater percentage decreases in baseflow are expected during the dry season. Impacts to baseflow quantity could be mitigated by the Sequalitchew Creek Restoration Plan, except during periods when surface water outflow from Sequalitchew Lake does not occur.

- The intent of the proposed mitigation measures described in Sub-section 3.3.3, is to reduce these unavoidable adverse impacts to a non-significant status. If implementation of the proposed mitigation measures fails to mitigate these unavoidable adverse impacts, the City will consider implementing other possible contingency mitigation measures listed in Sub-section 3.3.3 as part of the adaptive management process.

3.4 WATER RESOURCES - SURFACE WATER

This chapter of the DEIS describes surface water features — streams, lakes, the associated marsh system, and artificial channels – on the site and in the site vicinity. Potential impacts associated with the EIS Alternatives are evaluated and mitigation measures identified. This section is based on the *Earth and Water Resources Report* (May 2023), *Stormwater Management Report* (February 2021), *Groundwater Model Update* (June 2017), and *South Parcel Monitoring Plan* (November 2017) all prepared by Aspect Consulting and peer reviewed by Mott MacDonald (see **Appendices B**, **D**, **E**, and **F**).

3.4.1 Affected Environment

Surface Water Hydrology

The surface water systems that are relevant to the site and Proposed Action include: Sequalitchew Lake, Sequalitchew Creek, the related marsh system, the Joint Base Lewis-McChord (JBLM) Stormwater Diversion Canal, on-site stormwater system, and the Kettle Wetland. In the Sequalitchew Creek watershed, the natural flow direction is westward from Sequalitchew Lake, through a portion of the marsh system, and into the Sequalitchew Creek ravine before discharging to Puget Sound. Construction of the Diversion Canal on JBLM created a secondary outlet for the water flowing out of Sequalitchew Lake, resulting in water no longer following the natural course to Sequalitchew Creek. Under current conditions, there is a segment of Sequalitchew Creek between the western margin of the marsh system and the steep ravine of the creek that does not typically have flowing surface water; this segment is referred to as the "dry reach" of Sequalitchew Creek. Relevant surface water bodies are depicted on **Figure 3.4-1**.

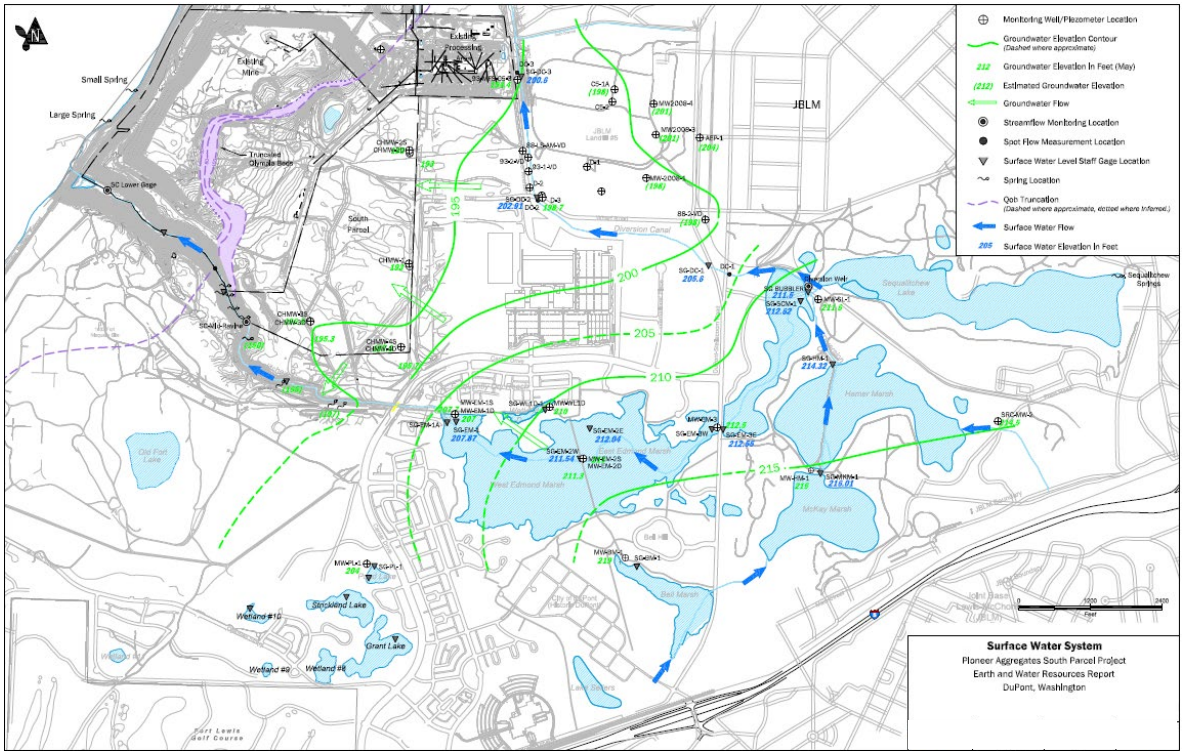
Sequalitchew Lake

Sequalitchew Lake is the headwaters of the Sequalitchew Creek watershed. It is an approximately 85-acre lake located on JBLM. The lake is fed by groundwater springs (Sequalitchew Springs)[1] at the east end of the lake and likely other groundwater discharges and minor surface water inputs. The normal water level of the lake is elevation 211.5 feet (ft) NGVD29.[2] The depth of the lake is approximately 6 ft on average and approximately 11.5 ft at maximum. The outlet of the lake is on the extreme west end of the lake.

[1] *Sequalitchew Springs also provide the primary water supply for JBLM. Sequalitchew Springs represent a discharge from the groundwater system to the surface water system. Groundwater and surface water exchanges are complex and related to water level (or head) differences at any given location. Additional upgradient surface water bodies (e.g., American Lake) likely provide a source of water to the groundwater system that eventually discharges to Sequalitchew Lake.*

[2] *National Geodetic Vertical Datum of 1929.*

Figure 3.4-1
SEQUALITCHEW CREEK WATERSHED AND JBLM STORMWATER SURFACE WATER SYSTEM



Source: Aspect Consulting, 2022, Revised 2023.

Historically, the lake outlet discharged primarily into Sequalitchew Creek and the associated marsh system to the southwest and west, eventually flowing into Puget Sound, though the flows through the marsh system were at times blocked due to beaver activity (i.e., dam-building). Washington Department of Fish and Wildlife (WDFW) operated a salmon rearing facility at the lake from 1976 to approximately 1997. In spring during that period, the fish would migrate out of the lake to Puget Sound via Sequalitchew Creek and the marsh system. To facilitate flows and a migration pathway for the outmigration, WDFW would remove beaver dams and heavy vegetation within the marsh system to create a flowing channel.

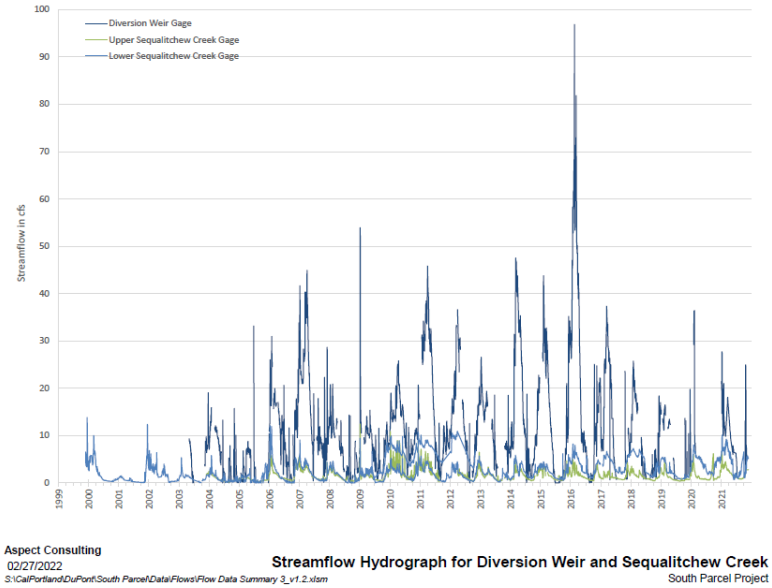
A culvert and weir system at the outlet of the lake was constructed in the 1950s to facilitate both outflow from the lake southwest toward Sequalitchew Creek and stormwater flow from JBLM northwest toward the Diversion Canal. Specifically, four 42-inch-diameter culverts—Sequalitchew Creek Culverts—connect the lake outlet with Sequalitchew Creek and were intended to convey the outflow of the lake southwest to the creek through the marsh system (i.e., to replicate historical conditions). Additionally, an 18-ft-wide concrete structure—Diversion Weir—with wooden stop logs was constructed at the lake outlet just upstream of the Sequalitchew Creek Culverts. The Diversion Weir was intended to control the water level of the lake (to protect JBLM's water supplies from Sequalitchew Springs) by

directing water at high flow conditions to the Diversion Canal. Separately, three 48-inch-diameter culverts—Diversion Canal Culverts—cross under the Sequalitchew Creek Culverts to facilitate the northwest trending flows from Bell, McKay, and Hamer Marshes to the Diversion Canal. The flows from the Diversion Weir join the Diversion Canal just downstream (northwest) of the outlet of the Diversion Canal Culverts. As originally designed, the culvert and weir system would have conveyed the outflow from the lake toward the Sequalitchew Creek and marsh system and the stormwater flow from JBLM (and peak flows from the lake) into the Diversion Canal.

The culvert and weir system are currently in disrepair. Additionally, beaver dam construction within the marsh system increases surface water levels in the marsh to an elevation above the Sequalitchew Lake water level. The current disrepair of the system combined with nearby beaver dam construction within the marsh system results in the majority of outflow from the lake being routed to the JBLM Diversion Canal (i.e., the lake outflow bypasses the Sequalitchew Creek and marsh system). As such, discharges from the lake currently seldom flow into the creek and marsh system. There may be indirect discharges from the lake toward the creek and marsh system via groundwater but that has not been quantified.

Based on data recorded from 2003 to 2021, average monthly flows at the lake outlet weir vary from 2.4 cubic feet per second (cfs) in September to 21.5 cfs in March. During particularly dry years, there are periods during late summer or early fall when no flow is measured over the weir. No (or very low) flows over the diversion weir occur occasionally for limited periods (i.e., short periods in the summers of 2004, 2006, 2008, 2012, 2014, and 2016); extended periods of no-flow conditions occur in particularly dry years (i.e., in later summer and early fall of 2005 and 2015). Peak flows can reach approximately 40 to 50 cfs, with isolated occurrences of even greater flows (i.e., the maximum recorded flow over the diversion weir was approximately 97 cfs in early 2016). A hydrograph of flows measured at the Diversion Weir (representing outflow from Sequalitchew Lake) is shown on **Figure 3.4-2**. Monthly average flow rates recorded at the Diversion Weir from 2003 to 2021 are summarized in **Table 3.4-1**.

Figure 3.4-2
SEQUALITCHEW LAKE OUTFLOW (DIVERSION WEIR) AND SEQUALITCHEW CREEK STREAMFLOW MEASUREMENTS



Source: Aspect Consulting, 2022, Revised 2023.

Table 3.4-1
MONTHLY AVERAGE DIVERSION WEIR (SEQUALITCHEW LAKE OUTLET) AND SEQUALITCHEW CREEK FLOWS

Month	Average Flow in cfs				
	Diversion Weir	Mid-Sequalitchew Creek Ravine	Lower Sequalitchew Creek Ravine		
	2003 to 2021	2004 to 2021	1977 to 1978	1984 to 1987	1999 to 2021
January	15.6	2.5	9.7	5.9	4.0
February	19.6	2.6	12.8	8.5	4.2
March	21.5	2.2	12.2	8.7	3.8
April	19.8	2.0	0.7	9.4	3.2
May	12.7	1.6	1.6	7.8	2.7
June	7.4	1.2	1.5	3.7	1.9
July	3.2	0.9	0.2	1.3	1.3
August	2.8	0.8	0.1	1.0	1.1
September	2.4	0.8	0.1	1.0	1.1
October	3.7	0.8	0.1	1.4	1.4
November	7.1	1.3	2.4	3.7	2.6
December	10.9	1.9	10.5	5.1	3.5
Mean Annual Flow	10.5	1.6	4.3	4.8	2.7

Note: cfs = cubic feet per second

Source: Aspect Consulting, 2022, Revised 2023.

Sequalitchew Marsh System

The Sequalitchew Marsh system includes a complex series of marshes generally located between Sequalitchew Lake and the downstream portion of Sequalitchew Creek. Surface water flow from Bell, McKay, and Hamer Marshes is generally northward eventually draining to the JBLM Diversion Canal and from there into Puget Sound. Surface water flow from the East Edmond Marsh was historically westward to the West Edmond Marsh. At high flow conditions the West Edmond Marsh can discharge to Sequalitchew Creek and from there into Puget Sound. Due to beaver activity (e.g., dam building) in East Edmond Marsh, surface water now typically flows back eastward toward the Diversion Canal (i.e., does not follow its historical course down the creek). In addition, as described in Section 3.3, **Groundwater**, there are complex interactions between the marsh system and underlying groundwater. Namely, groundwater can discharge to surface water when groundwater levels are higher than surface water levels (i.e., in upward gradient conditions).

Conversely, surface water can discharge to groundwater when groundwater levels are lower than surface water levels (i.e., in downward gradient conditions). Indirect flow between the marshes via discharge to and from groundwater—from the south and east (Bell, McKay, Hamer Marshes) toward the west (East and West Edmond Marshes)—is inferred based on groundwater measurement contouring and marsh surface water level measurements. Based on the known surface water flow patterns and inferred groundwater-surface water interactions, Aspect (2022, Revised 2023) developed a spreadsheet-based water balance model of the marsh system, incorporating groundwater and surface water inflows/outflows, precipitation, and evapotranspiration. The water balance model can be used to estimate the hydraulic impact on certain elements of the system (e.g., water levels in the marshes or flows in Sequalitchew Creek) due to changes in other elements (e.g., lowered groundwater levels). The model provides a tool for assessing the interconnectedness of the groundwater and surface water systems and for predicting impacts to the surface water system from the Proposed Action and/or Sequalitchew Creek Restoration Plan.

East and West Edmond Marshes

East and West Edmond Marshes stretch from the outlet of Sequalitchew Lake to the dry reach of Sequalitchew Creek. East Edmond Marsh—including the eastern portion that is colloquially referred to as “Eastern East Edmond Marsh”—covers approximately 87 acres between the Sequalitchew Lake outlet and Robinson Trail (a former railroad grade converted to a public pedestrian trail). On the east end of Eastern East Edmond Marsh (just west of the Sequalitchew Lake outlet), a large beaver dam complex pools water in the marsh above that of the Sequalitchew Lake outlet, resulting in flow from the marsh eastward into the Diversion Canal (i.e., against the general—and historical—westward flow of water in the watershed). Eastern East Edmond Marsh is connected to East Edmond Marsh via a box culvert beneath DuPont-Steilacoom Road; water can flow east or west through the box culvert, depending on water levels in Eastern East and East Edmond

Marshes. Eastern East Edmond Marsh also receives some surface water flow from Hamer Marsh via a 12-inch culvert and likely shallow subsurface flows indirectly from Hamer Marsh via groundwater. According to the water balance model, East Edmond Marsh receives approximately 0.28 cfs, on average, as surface water inflows from Hamer Marsh and approximately 0.3 cfs, on average, from shallow groundwater inflow. East Edmond Marsh also loses water to groundwater outflow from other areas of the marsh at an estimated average rate of 0.5 cfs. The average water level in Eastern East Edmond Marsh is approximately 212.4 ft NGVD29 (or about 1 ft higher than the average Sequalitchew Lake level) and the average water level in East Edmond Marsh is approximately 212.2 to 212.4 ft NGVD29, indicating a slight westward gradient, on average. There is an open channel through East Edmond Marsh, which is likely the historical channel but may also have been excavated previously to facilitate flow (i.e., perhaps by WDFW for hatchery fish migration).

West Edmond Marsh covers approximately 80 acres between Robinson Trail and the dry reach of Sequalitchew Creek. West Edmond Marsh is hydraulically connected to East Edmond Marsh via a submerged culvert beneath Robinson Trail and likely subsurface flow beneath the trail. According to the water balance model, West Edmond Marsh receives approximately 0.17 cfs, on average, as surface water inflows from East Edmond Marsh (i.e., via the submerged culvert) and loses approximately 0.24 cfs, on average to groundwater outflow. Water levels in West Edmond Marsh vary and are controlled by several beaver dams. In the eastern portion of West Edmond Marsh, the average water level is approximately 211.4 ft NGVD29; in the western portion of West Edmond Marsh, the average water level is approximately 207.9 ft NGVD29. Sequalitchew Creek forms a channel along the northern margin of West Edmond Marsh. The western-most portion of West Edmond Marsh becomes dry in the summer of most years.

Bell, McKay, and Hamer Marshes

Bell, McKay, and Hamer Marshes cover approximately 18, 37, and 69 acres, respectively. While natural surface water bodies, they have been impacted by the construction of the Diversion Canal to facilitate drainage of stormwater from JBLM. The three marshes are in series, with surface water flows going from Bell to McKay to Hamer Marsh, facilitated by the Diversion Canal. The average water level in Bell Marsh is approximately 218.6 ft NGVD29. The average water level in McKay Marsh is approximately 215.4 ft NGVD29. The average water level in Hamer Marsh is approximately 214.0 ft NGVD29. The water levels in these three marshes are typically higher than those of East and West Edmond Marshes. As such, a portion of the water (estimated by the water balance model to be approximately 0.3 cfs on average) from Bell, McKay, and Hamer Marshes may infiltrate to ground and flow as groundwater to discharge to East and West Edmond Marshes. In addition, some surface water (estimated by the water balance model to be approximately 0.28 cfs on average) flows directly from Hamer Marsh to Eastern East Edmond Marsh via the 12-inch culvert connecting those two bodies.

Sequalitchew Creek

Sequalitchew Creek is approximately 3.3 miles long, starting from the eastern end of East Edmond Marsh, continuing as a channel through East and West Edmond Marshes as described above, exiting the marsh system on the western end of West Edmond Marsh into the dry reach of the creek between West Edmond Marsh and the steep creek ravine, then through the ravine section to discharge into Puget Sound. Historically, the creek began at Sequalitchew Lake; however, the construction of the Diversion Weir at the outlet of the lake and the beaver dams in the marsh system have largely restricted the direct surface water connection between the lake and the creek. Within East and West Edmond Marshes, the creek is low-gradient/low-velocity and appears as a channel of open water or a channel of less dense vegetation. Within the dry reach of the creek, flows exiting West Edmond Marsh typically infiltrate into ground, leaving the dry reach, including the portion of the creek that passes underneath Center Drive, grassy and without flow most of the time. West of the dry reach, the creek grade steepens into an approximately 1.3-mile-long ravine, where groundwater springs—discharging from the Steilacoom Gravel Member subunit of the Vashon Recessional Outwash aquifer—restore surface water flows to the creek. The creek continues westward through the incised ravine section, gaining flow from additional groundwater springs in the upper portion of the ravine. As the creek continues past the location of the Olympia Beds Truncation, about midway through the ravine section of the creek, west of which the aquitard is no longer present and groundwater levels are lower, additional observable groundwater spring discharges to the creek appear to cease. As the creek nears Puget Sound, the ravine section widens, and the gradient lessens. The creek discharges to Puget Sound via a 5-ft by 5-ft box culvert beneath an active railroad grade. The railroad grade culvert appears to limit the connection between the creek and Puget Sound, resulting in a brackish marsh immediately upstream of the culvert.

Average annual streamflow measured (for the period from 2004 to 2021) at a gaging station located approximately 3,900 ft upstream from Puget Sound is approximately 1.6 cfs (with peak flows typically between 5 and 8 cfs and with low flows of approximately 1 cfs or less). Average annual streamflow measured (for the same period) at a separate gaging station located approximately 700 ft upstream of Puget Sound just upstream of the brackish marsh at the mouth of the creek (the lower gage) is approximately 2.8 cfs (with peak flows typically between 5 and 10 cfs and with low flows of approximately 2 cfs or less).[3] Baseflow in the ravine section of the creek appears to vary from approximately 0.5 cfs in late summer to approximately 2.5 cfs in winter. Annual peak daily flow is typically between 5 and 10 cfs, with the maximum peak daily flow recorded as 13.8 cfs (in December 1999 at the lower gage). Hydrograph timeseries of Sequalitchew Creek flows are summarized in **Appendix E**.

[3] *The increase in streamflow from the mid-ravine gaging station to the lower gage can be attributed to groundwater inflows from springs and seeps between the mid-ravine station and the Olympia Beds Truncation, additional surface water inflows, and possibly other groundwater discharges adding flow to that section of the creek, potentially directly to the creek bed, which would be difficult to observe.*

Sequalitchew Creek and all tributaries (including Sequalitchew Lake) are closed to further consumptive appropriations (i.e., water right permitted diversions) by the Washington State Department of Ecology (Ecology), according to the instream flow rule of Chapter 173-512 Washington Administrative Code (WAC).

On-Site Stormwater

Due to the high permeability of site soils, precipitation falling on the site generally infiltrates at or near where it falls or is conveyed by ditches to small infiltration facilities distributed throughout the existing mine. Infiltration of stormwater on-site is facilitated by a combination of relatively permeable surficial soils (outwash material) remaining within the mined area as well as a depth to groundwater of approximately 10 to 14 ft below ground surface, which allows for a vertical gradient and downward flow. As such, on-site stormwater is contained within the existing mine. Furthermore, there are no documented streams or natural drainage channels conveying surface water to or from the site.

Kettle Wetland

The Kettle Wetland is an existing 1.78-acre natural wetland located in the Expansion Area of the site. The wetland is an example of a kettle lake, a common continental glacier feature that forms from a large block of isolated glacial ice that becomes surrounded by outwash sediments. When the ice melts, a topographic depression forms where water can collect. Based on the elevation of its bottom, the Kettle Wetland appears to be in direct hydraulic connection with the Vashon Aquifer (Steilacoom Gravel Member and/or Outwash).

Other Surface Water Features

There are numerous other surface water features in the vicinity of, but not directly connected by surface water flow to, Sequalitchew Creek. An example of other surface water features is Wetland 1-D, a small (2.1-acre) wetland immediately north of West Edmond Marsh. While Wetland 1-D is not connected to other wetlands or Sequalitchew Creek by surface water, it likely exchanges flow indirectly via groundwater.

Other isolated kettle wetland/lake formations include Pond, Strickland, Grant, and Old Fort Lakes, as well as Wetlands #8, #9, #10, and #11, all of which are located south of Sequalitchew Creek. The kettle wetland/lake formations are not directly connected to Sequalitchew Creek or marsh system by surface water and experience water level fluctuations similar to those of the groundwater system that exists south of Sequalitchew Creek.

Surface Water Quality

This section summarizes the known water quality information related to relevant surface water bodies onsite and within the Sequalitchew Creek watershed.

On-Site Kettle Wetland

Water quality data for the Kettle Wetland is not available. However, because the Kettle Wetland is likely in direct hydraulic connection with—and likely a reflection of—the Vashon Aquifer, the surface water quality of the wetland is likely similar to that of the groundwater.

Sequalitchew Creek Watershed

The relevant water quality standards for the Sequalitchew Creek watershed—including Sequalitchew Lake, East and West Edmond Marshes, and Sequalitchew Creek—are described in Chapter 173-201A WAC. Sequalitchew Lake and Sequalitchew Creek each have a designated aquatic life use of core summer salmonid habitat because they are tributary to Puget Sound, which is designated as an extraordinary aquatic life marine water, per WAC 173-201A-600(1)(a)(iv) and 173-201A-612. The current freshwater quality standards for core summer salmonid habitat, in accordance with WAC 173-201A-200, are summarized in **Table 3.4-2.**

Table 3.4-2
FRESH WATER QUALITY CRITERIA FOR CORE SUMMER SALMOND HABITAT

Parameter	Criterion	Allowable Change
Temperature (7-DADMax)	16.0°C	0.3°C when T ≥ 16.0°C or 28/(T+7) when T < 16.0°C
Dissolved Oxygen (1-Day Minimum)	10.0 mg/L or 95% Saturation	0.2 mg/L
Turbidity	N/A	5 NTU over background when ≤ 50 NTU; 10% increase when > 50 NTU
Total Dissolved Gas	110% of Saturation	--
pH	6.5 to 8.5 Standard Units	<0.2 Standard Units

Source: Chapter 173-201A WAC.
Notes:
°C = degrees Celsius
T = background temperature unaffected by project
mg/L = milligrams per liter
7-DADMax = 7-day average of daily maximum temperatures
NTU = nephelometric turbidity units

Sequalitchew Lake

The water quality in Sequalitchew Lake is generally good. Temperature varies seasonally from above 20 degrees Celsius (°C) in summer to below 6°C in winter. Dissolved oxygen

concentrations are typically greater than 9 milligrams per liter (mg/L), pH is neutral, and turbidity is generally low.

Marsh System

The water quality of the marsh system is representative of a more stagnant, aquatic plant-rich environment. Temperatures in the marsh system vary more than in the lake, with summertime temperatures approximately 22°C (72°F) and wintertime temperatures approximately 3°C (37°F). Dissolved oxygen concentrations are relatively low, typically less than 4 mg/L, and pH is slightly acidic (median value of 6.5 Standard Units). Turbidity is relatively low, or less than 10 nephelometric turbidity units (NTU). Measured iron concentrations are relatively elevated (above 1 mg/L) in East and West Edmond Marshes, particularly near Robinson Trail (an old railroad grade) where groundwater seeps enter the marshes. Concentrations of other metals commonly associated with stormwater runoff (e.g., copper and zinc) are low in the marshes.

Sequalitchew Creek

The water quality of the ravine section of Sequalitchew Creek (west of the marshes and dry reach of the creek) is very good and relatively consistent, likely related to the primary source of surface water flow in the creek being the groundwater seeps. Temperatures in the creek are generally cool, less than 15°C (59°F). Dissolved oxygen concentrations are relatively high, typically greater than 9 mg/L. Turbidity is low, or less than 15 NTU. Metals concentrations in the creek are consistently low.

3.4.2 Impacts of the Alternatives

This section describes the anticipated impacts to the surface water system of the site and the Sequalitchew Creek watershed resulting from the two alternatives.

ALTERNATIVE 1 – PROPOSED ACTION

Under Alternative 1—the Proposed South Parcel Project (Proposed Action)—there would likely be impacts to surface water features both onsite and within the larger Sequalitchew Creek watershed. The impacts to surface water features would be primarily a result of the permanently lowered groundwater levels in the vicinity of the site due to long-term pumping and groundwater drainage at the site.

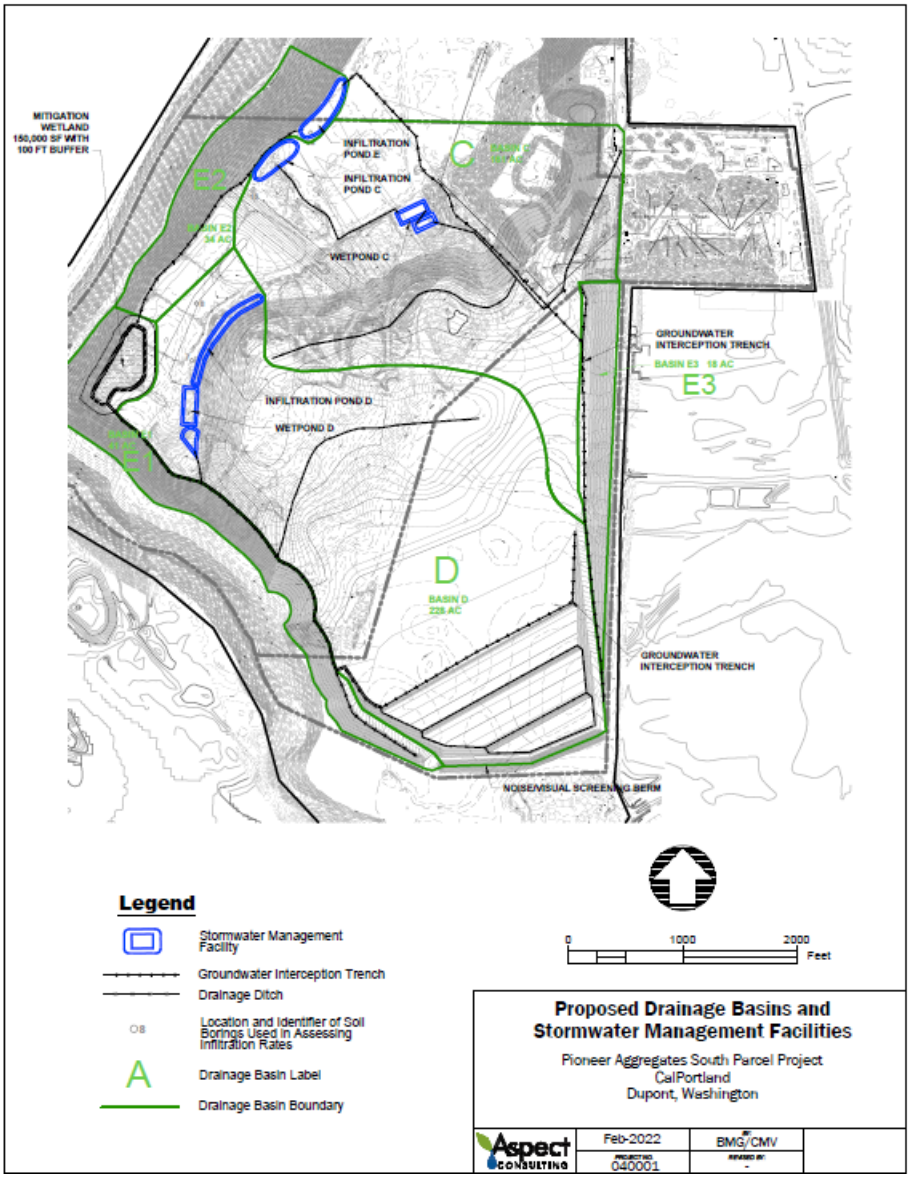
On an overall basis, changes in site grading would affect stormwater flows, but not the overall stormwater balance within the site. Primarily, changes in groundwater levels beneath the site resulting from proposed groundwater lowering are expected to affect flow in Sequalitchew Creek and surface water levels in the marsh system.

Stormwater Management

Under the Proposed Action, stormwater would continue to be managed and infiltrated on-site. As mining activities remove the permeable outwash materials and expose the underlying relatively impermeable Olympia Beds material, conveyance channels would be excavated to direct stormwater flows – and a significant amount of intercepted groundwater flows from the eastern slopes of the expanded mining area – toward three infiltration facilities in the lower (western) portion of the existing mine area of the site. For stormwater management planning purposes, the site has been divided into five contributing areas (or basins). Basins C and D would include 390 acres of the existing mine and expansion area. Basins E1, E2, and E3 would include a total of approximately 92.6 acres of the side slopes of the mined area (existing and expanded). All basins would contribute stormwater flows to be conveyed and infiltrated on-site. Flows from Basin E3 would also include the extracted groundwater from dewatering activities (while active dewatering is taking place) and intercepted groundwater (following active dewatering and mining activities) emanating from the eastern slope of the expanded mining area. A site water balance model was developed by Aspect (2022, Revised 2023) to quantify estimated stormwater and groundwater inflows and outflows from each basin.

Stormwater flows from Basins C and D would pass through one of two pairs of water quality treatment cells to reduce solids content in the water prior to entering the infiltration ponds designated for those basins (i.e., Infiltration Ponds C and D, respectively). Flows from Basin E1 would be conveyed to a constructed mitigation wetland (described below in the Mitigation Measures section and more fully in Section 3.6, **Plants and Animals**, and eventually to the third infiltration facility, Infiltration Pond E, which would also receive direct stormwater flows from Basins E2 and E3. The proposed stormwater basins and water quality and infiltration facilities are shown on **Figure 3.4-3.**

Figure 3.4-3
PROPOSED STORMWATER MANAGEMENT BASINS, WATER QUALITY TREATMENT, AND INFILTRATION FACILITIES



Source: Aspect Consulting, 2022, Revised 2023.

The water quality treatment and infiltration facilities would require performance monitoring and maintenance in order to retain their function. The project Stormwater Management Report (Aspect 2021) does not provide details regarding operation and maintenance (O&M) of the facilities; however, proper operation and maintenance (O&M) of the facilities would be a required element of the Sand and Gravel Permit coverage for the facility and an O&M plan would be developed during the permitting process.

Failure to maintain water quality treatment facilities, particularly for the interception of fine particles could result in particulates reducing the infiltration capacity of the system.

Reduced infiltration capacity of the system, if significant enough, could result in ponding of water in the lower portions of the reclaimed mine under severe storm events. Infiltration capacity could be restored through maintenance of the infiltration facilities or, in the worst case, establishing new infiltration facilities in the permeable gravels that remain on the floor of the existing mine.

Sequalitchew Creek Watershed Impacts

While no direct surface water diversions are proposed as part of the project, indirect impacts to surface waters will likely occur from the permanently lowered groundwater levels caused by dewatering, excavation, and groundwater seepage and stormwater diversion. Groundwater is in direct hydraulic connection with portions of the watershed surface water system; therefore, impacts to groundwater may also affect surface waters. The impact to surface waters will be more severe for those water bodies closer to the site.

Sequalitchew Lake

Sequalitchew Lake is located east of the area anticipated to be impacted by appreciable (i.e., greater than 0.5 ft) groundwater drawdown due to proposed dewatering. The primary water source to the lake is groundwater (spring) discharge at the far eastern end of the lake. The eastern end of the lake is relatively far removed from the anticipated appreciable groundwater drawdown area. In addition, the lake level is controlled artificially by the Diversion Weir. For these reasons, water levels in Sequalitchew Lake are not anticipated to be significantly impacted by the Proposed Action.

Marsh System

The anticipated impacts to water levels within the marsh system—including Bell-McKay-Hamer and East and West Edmond Marshes—were estimated using a spreadsheet-based water balance model of the marsh system (described above in the Sequalitchew Marsh System section of Affected Environment). The marsh water balance model is described in more detail by Aspect (2022, Revised 2023).

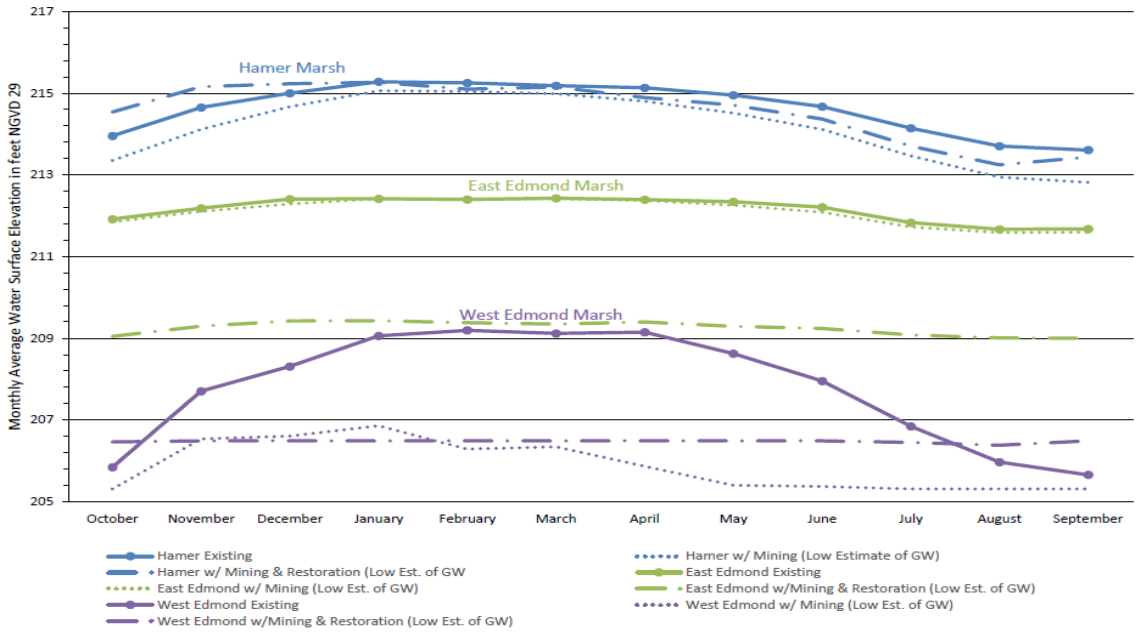
The calibrated marsh water balance model was used to predict the anticipated impact on average monthly marsh water levels due to proposed groundwater-level lowering at the site. The primary driver for the anticipated impacts to surface waters are estimated lowered groundwater levels beneath the marshes (as simulated by the groundwater model, described in Section 3.3, **Groundwater**, which would lead to increased groundwater recharge (or outflow) from the marshes. The results of the marsh water balance model indicate that water levels in the marsh would be expected to be lowered, compared to observed water levels during the simulated period, due to the proposed groundwater lowering. The effect on marsh water levels is anticipated to vary seasonally as well.
In West Edmond Marsh, located closest to the site, the decrease in water levels may vary between 0.35 ft (in late summer, when West Edmond Marsh is often dry under existing

conditions) and 3.0 ft (in spring). The average decline was calculated as 1.9 ft. Without mitigation, the projected lower water levels in West Edmond Marsh would likely result in reduced potential for outflows from the marsh system into the ravine section of Sequalitchew Creek; however, outflows from West Edmond Marsh do not commonly reach the ravine section of Sequalitchew Creek under existing conditions.

In East Edmond Marsh, the decrease in water levels may vary between 0.005 ft (in winter) and 0.13 ft (in early summer). The average decline was calculated as 0.1 ft. These projected lower water levels in East Edmond Marsh are small and would likely not have a significant impact on the potential for surface water outflows from the marsh system to the ravine section of Sequalitchew Creek.

In Bell-McKay-Hamer Marshes, the decrease in water levels may vary between 0.2 ft (in spring) and 0.8 ft (in late summer). The average decline was calculated as 0.3 ft. These projected lower water levels in Bell-McKay-Hamer Marshes would likely lead to less flow – groundwater and surface water – from those marshes to East Edmond Marsh. Hydrographs showing observed (solid line with circular symbols) and predicted (under Proposed Action only conditions; dotted line) monthly average water levels in the marsh system are presented on **Figure 3.4-4**. The dashed-dotted line showing predicted flows under Proposed Action and Streamflow Restoration alternative is discussed below in the Mitigation Measures section.

Figure 3.4-4
OBSERVED AND PREDICTED MONTHLY AVERAGE MARSH WATER LEVELS



Aspect Consulting
11/1/2022
S:\CalPortland\DuPont\South Parcel\Water Balance Analyses\Water Balance -2022 - Mining&Restoration.xlsm

Predicted Marsh Hydrographs with Mining and Restoration
Pioneer Aggregates South Parcel Project

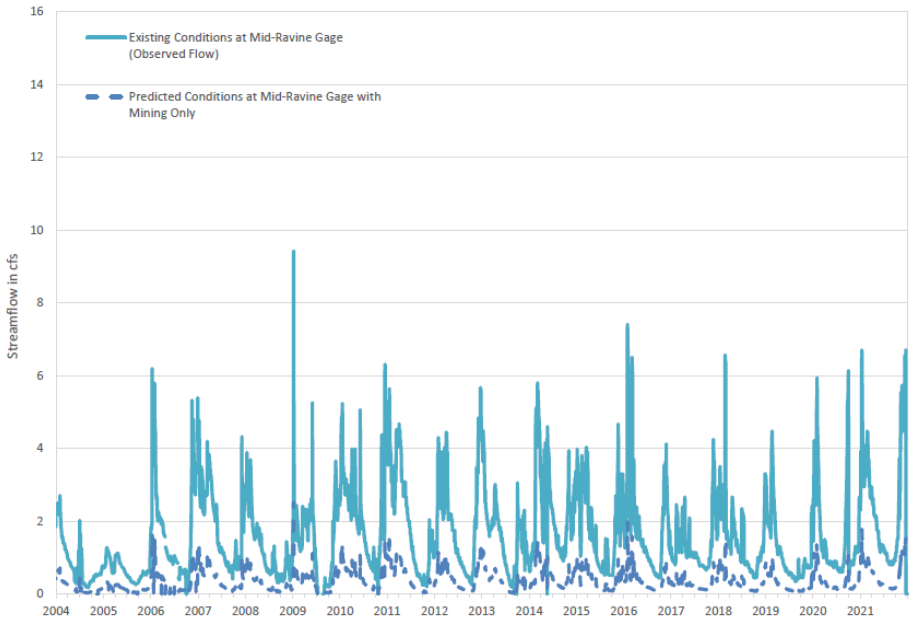
Source: Aspect Consulting, 2022, Revised 2023.

Sequalitchew Creek

The Proposed Action and associated groundwater-level lowering will decrease the number and flow rate of groundwater seeps and springs feeding Sequalitchew Creek within the ravine section. The impact to the groundwater springs and resulting Sequalitchew Creek flows was estimated using the numerical groundwater flow model, as described in Section **3.3, Groundwater**. Under long-term future proposed conditions (i.e., Step 4 of dewatering), reductions in spring flows leading to the creek are anticipated to occur throughout the entire year and to range from 76% (in January) to 86% (in summer). Base flow and peak flow in the creek are accordingly expected to be reduced. The annual average flow in Sequalitchew Creek is anticipated to be reduced from approximately 1.6 cfs to approximately 0.34 cfs. Hydrographs showing the observed and predicted flows in Sequalitchew Creek based on 2003 to 2021 data are shown on **Figure 3.4-5**.

While the Proposed Action is anticipated to negatively impact flows in Sequalitchew Creek, which is closed to further consumptive appropriations by the instream flow rule of Chapter 173-512 WAC, the Proposed Action does not require a water right from Ecology, as the pumped groundwater will not be withdrawn for the purpose of putting it to beneficial use.

Figure 3.4-5
OBSERVED AND PREDICTED SEQUALITCHEW CREEK FLOW HYDROGRAPHS



Aspect Consulting
10/30/2022
S:\CalPortland\DuPont\South Parcel\Report Drafts\Earth and Water Resources Report 2021\Analysis\Exceedance Flows-rev7.xlsm

Predicted Streamflow Hydrograph for Sequalitchew Creek with Mining Only
Earth and Water Resources Report
DuPont, WA

Source: Aspect Consulting, 2022, Revised 2023.

Other Surface Water Features

Other surface water bodies—including Wetland 1-D; Pond, Strickland, Grant, and Old Fort Lakes; and Wetlands #8, #9, #10, and #11—may be impacted by the proposed groundwater lowering , based on numerical groundwater flow model results. The magnitude of the impact is dependent on proximity to the proposed groundwater lowering activities at the site. Wetland 1-D water levels are anticipated to be reduced by approximately 3 ft, a relatively large impact, owing to its closer proximity to the site. Water levels in Pond Lake may be reduced by approximately 2 ft, resulting in the pond going dry earlier in the year (it typically goes dry currently in spring to mid-summer). Water levels in Wetlands #8, #9, #10, and #11 are anticipated to be reduced by approximately 1 ft. Old Fort Lake water levels may be reduced by approximately 0.5 ft. These water features and potential impacts to them are described in more detail in Section 3.5, **Fisheries**.

Kettle Wetland - The Kettle Wetland and its buffer would be cleared under the Proposed Action, and the entire wetland would be eliminated. The Kettle Wetland relies on groundwater to sustain wetland vegetation so even if the Kettle Wetland were to be left in place within the site, the change in groundwater levels would eventually alter the hydrology of the Kettle Wetland, converting the wetland vegetation to upland plant species. Proposed mitigation for these wetland impacts includes creation of a new wetland, as discussed in Sub-Section 3.5.3.

CUMULATIVE IMPACTS WITH PROPOSED ACTION AND SEQUALITCHEW CREEK RESTORATION PLAN

As described in Chapter 2 of this DEIS, the 2011 Settlement Agreement states permits for the Pioneer Aggregates South Parcel Project (Proposed Action) shall not be effective until permits for the Sequalitchew Creek Restoration Plan (Restoration Plan) are in place. The Restoration Plan will be evaluated as a separate but related action. The Restoration Plan seeks to restore and enhance streamflow and ecological functions from Sequalitchew Lake through Edmond Marsh into Sequalitchew Creek ravine by sequentially restoring diverted flows back to the creek, improving the sustainability of flows through the system, and restoring aquatic habitat.

It is assumed that CalPortland funding/implementation of projects associated with the Restoration Plan would be mitigation for certain environmental impacts identified in this DEIS and would be a condition of any City of DuPont approval of the Proposed Action.

The primary components of the Restoration Plan include:

- Improve hydraulic gradients so water discharges from Hamer and Bell Marshes flow into Edmond Marsh rather than into the Diversion Canal.

- Improve Sequalitchew Lake outlet and the Diversion Weir structure to allow significant flows from the lake into the Edmond Marsh complex to support a functional creek ecosystem and provide for the passage of migratory fish in the Sequalitchew Creek system.
- Rehabilitate East and West Edmond Marshes by removal of sufficient fill and other flow impediments to provide hydraulic gradients and capacity necessary to achieve and maintain adequate flows through the marsh system.
- Rehabilitate Sequalitchew Creek below West Edmond Marsh (i.e., the dry reach) to reduce seepage, improve fish habitat, and help restore year-round flows.
- Actively manage beaver activities (e.g., on-going beaver dam removal, installation and maintenance of beaver exclusion devices, etc.) to maintain hydraulic gradients that provide flows through Hamer, Bell, and Edmond Marshes.

The effectiveness of these elements depends on the independent modification of the diversion structure within JBLM which is proceeding as a separate federal project. JBLM entered a Memorandum of Agreement (MOA) with the Environmental Caucus, the South Puget Sound Salmon Enhancement Group and CalPortland describing the commitments each party is making to enhance flows down the creek. This includes substantial water utility repair and maintenance of the structures on JBLM. Congress has also indicated to the Army that the work on JBLM is a priority by including the following language in the Congressional Committee Report attached to the National Defense Authorization Act:

> "*The committee commends the Army for its work thus far in accomplishing needed environmental restoration projects related to Sequalitchew Creek and its associated canals. The committee notes that the Army made an important first step in this process by executing a memorandum of agreement with stakeholders. The committee encourages the Army to continue its work by following up with agreed-upon water utility repair and developing a maintenance plan per the memorandum of agreement.*"

The Settlement Agreement states that permits for the Restoration Plan must be in place before permits for the Proposed Action are effective. The plan identifies specific objectives and establishes performance thresholds and aspirational goals to be accomplished for each objective, along with an adaptive management plan to adapt to changing conditions and observations during plan implementation. Monitoring during mining is presumed to ensure that groundwater levels remain within the expected range. If groundwater levels are not maintained within the expected range it is specified that corrective actions will be implemented in accordance with the adaptive management plan for mining.

The anticipated combined effect on surface waters of the Proposed Action and the Restoration Plan is summarized in this section.

Marsh System

Water Levels

Water levels in the marsh system under the Proposed Action and Restoration Plan implementation were assessed with the marsh water balance model. The objectives and performance thresholds of the Restoration Plan were designed to improve flows and habitat to compensate for the impacts to the marsh system from drawdown of groundwater levels and subsequent effects on marsh water levels. Parameters established for the marsh system model to replicate combined effects of the Proposed Action and Restoration Plan included:

- Groundwater levels were lowered in accordance with a conservatively low estimate of simulated long-term groundwater conditions due to proposed groundwater dewatering and mining activity.
- Marsh surface level control structures in East and West Edmond Marshes and Hamer Marsh were assumed functional and effective with modification of the JBLM diversion and beaver management (e.g., selective removal of beaver dam structures and installation and maintenance of beaver exclusion devices). The target water levels were set to ensure east to west movement of water through the marsh system:
    - Eastern East Edmond Marsh: 210.5 ft NGVD29 (compared to the current average of 212.4 ft NGVD29)
    - East Edmond Marsh: 209 ft NGVD29 (compared to the current average of 212.2 to 212.4 ft NGVD29)
    - West Edmond Marsh: 206.5 ft NGVD29 (compared to the current average of 207.9 ft NGVD29 in the western portion of the marsh).
- Flows from Sequalitchew Lake were to be routed to Sequalitchew Creek via Eastern East Edmond Marsh (i.e., not diverted to the Diversion Canal).
- The dry reach of Sequalitchew Creek was assumed to be lined to prevent surface water flows leaving West Edmond Marsh from infiltrating to ground and, rather, continuing as surface water flows into the ravine section of the creek.

The results of the modeling indicate that the target water levels (which are significantly lower than they currently are) in the East and West Edmond Marshes could generally be achieved, resulting in continuous surface water flow from Sequalitchew Lake through to Sequalitchew Creek. The anticipated gradient across the marsh system from the Sequalitchew Lake outlet to the west end of West Edmond Marsh would be approximately 0.0006 feet per foot, or 0.06 feet per 100 feet. The East and West Edmond Marshes water levels are anticipated to be relatively consistent throughout the year. The predicted marsh system water levels under the Proposed Action and Restoration Plan scenario are shown earlier on **Figure 3.3-4.**

Table 3.4-3 provides a monthly summary of predicted flows from the lake to the marsh system, flows from the marsh system to the creek, and gain or loss from the marshes from or to groundwater, precipitation, and evapotranspiration. For comparison, monthly average flows from Sequalitchew Lake (to the Diversion Canal) based on existing observed data are also shown in **Table 3.4-3**.

Water Quality

In general, the water quality within East and West Edmond Marshes would be expected to be improved under the Proposed Action and Restoration Plan scenario, due to increased and consistent surface water inflows from Sequalitchew Lake and flushing out through Sequalitchew Creek. In particular, dissolved oxygen would likely increase and pH would likely become more neutral. Increased flows through the marsh system may also result in lower iron concentrations near Robinson Trail due to increased flushing.

Table 3.4-3
PREDICTED SURFACE WATER FLOWS TO AND FROM THE MARSH SYSTEM

	Existing Conditions	Predicted Conditions for Sequalitchew Marsh System			
				Gain (+) or Loss (-)	
Month	Average Outflow from Sequalitchew Lake (cfs)	Average Inflow from Sequalitchew Lake (cfs)	Average Outflow to Sequalitchew Creek (cfs)	Flow (cfs)	Percent (%)
January	15.6	15.8	18.5	2.7	17%
February	19.6	19.8	22.0	2.2	11%
March	21.5	22.2	24.3	2.1	9%
April	19.8	20.4	21.9	1.5	7%
May	12.7	13.4	14.6	1.2	9%
June	7.4	7.7	8.5	0.8	10%
July	3.2	3.4	3.5	0.1	3%
August	2.8	2.5	2.4	-0.1	-4%
September	2.4	2.2	2.4	0.2	9%
October	3.7	3.7	4.7	1.0	27%
November	7.1	7.1	8.8	1.7	24%
December	10.9	11.0	13.2	2.2	20%
Average:	**10.6**	**10.8**	**12.1**	**1.3**	**12%**

Note: cfs = cubic feet per second

Source: Adapted from Aspect Consulting, 2022, Revised 2023.

Sequalitchew Creek

Creek Flows

Under the Proposed Action and Restoration Plan scenario, flow rates and volumes delivered to – and flowing through – the dry reach segment of Sequalitchew Creek between West Edmond Marsh and the ravine section of the creek are generally expected to increase. Under this scenario, the predicted flows for the dry reach vary by month, from 2.4 cfs in August/September to 24.3 cfs in March, with an average annual flow of 12.1 cfs. Peak flows may reach as high as 65 cfs. Even with the Restoration Plan implemented, there may still be periods of dry, no-flow conditions in the dry reach of the creek, namely during dry periods when flow from Sequalitchew Lake through the Diversion Weir may not occur (i.e., in conditions similar to the low- or no-flow conditions, described in Section 3.3B.1, of the relatively dry years of 2004, 2005, 2006, 2008, 2012, 2014, 2015, and 2016).

Flows in the ravine section of Sequalitchew Creek were predicted based on the sum of predicted dry reach flows under the Proposed Action and Restoration Plan scenario and remaining groundwater discharges in the ravine.[4] The average monthly flows in the ravine section of the creek are predicted to range from 2.5 cfs in August to 26.3 cfs in March, with an average annual flow of 12.9 cfs (compared to the current 1.6 cfs average observed at the mid-ravine gage). Similar to predictions for the dry reach, there may be periods with reduced—or zero—flow in Sequalitchew Creek at the mid-ravine gage despite the Restoration Plan because of no outlet flows from Sequalitchew Lake. Flows in the creek may be lower than under existing conditions approximately 10% of the time. The number of no-flow days at the mid-ravine gage would be expected to increase under the Proposed Action and Restoration Plan scenario compared to existing conditions because of reduced or eliminated groundwater seepage to the ravine section of the creek that would no longer be present to add flows to the creek under low- or no-flow conditions upstream from Sequalitchew Lake. Periods with lower predicted flows in the creek compared to existing conditions are anticipated to occur typically in the period from July through October. The number of no-flow days at the mid-ravine gage also would be expected to increase under the Proposed Action and Restoration Plan scenario compared to existing conditions because of reduced or eliminated groundwater seepage to the ravine section of the creek that would no longer be present to add flows to the creek under low- or no-flow conditions upstream from Sequalitchew Lake. However, no flow days are rare under existing conditions (occurring approximately 0.13% of the time) and would remain rare (0.46% of the time) with the Proposed Action and Restoration Plan.

Potential impacts on fisheries resources are discussed in Section 3.6, **Plants and Animals**.

[4] *The two components summed for this analysis represent: (a) the predicted surface water flows to Sequalitchew Creek from discharges from West Edmond Marsh as a result of the Restoration Plan implementation and (b) the predicted additional contributions to Sequalitchew Creek from remaining groundwater springs and seeps following the Proposed Action.*

Water Quality

The water quality effects in the ravine section of Sequalitchew Creek from the combined Proposed Project and Restoration Plan scenario would be primarily related to temperature. Flows in the creek, currently supplied primarily by consistently cool groundwater discharges, would instead be largely supplied by surface water flows originating in Sequalitchew Lake (which is relatively warm in summer and cold in winter) under this scenario. Temperatures in the creek in the winter are expected to fall to 5 or 6°C (41°F to 43°F). Creek temperatures in the summer—particularly June through August—are expected to rise to 21°C. Exceedances of the 16°C (61°F) 7-day average of daily maximums criterion of Chapter 173-201A WAC could be expected from May through September. These seasonal fluctuations in surface water temperatures in Sequalitchew Creek, however, may be more analogous to historical conditions in the creek prior to the construction of the Diversion Weir and Canal and re-routing of most of the Sequalitchew Lake outflows away from the creek and marsh system into the Diversion Canal. However, temperatures in the creek would be slightly higher than they were historically because of the reduction of groundwater seeps and springs providing groundwater flow to the ravine section of the creek resulting from the Proposed Action.

Other Surface Water Features

Because the other nearby surface water bodies—including Wetland 1-D; Pond, Strickland, Grant, and Old Fort Lakes; and Wetlands #8, #9, #10, and #11—would not benefit directly from the Restoration Plan implementation, they would be expected to be impacted by the proposed groundwater lowering in a similar manner as under the Proposed Action, as discussed above.

Stormwater Management

Because on-site stormwater flows and management would not be affected by implementation of the Restoration Plan, stormwater management would be performed in a similar manner as proposed under the Proposed Action, as discussed above.

ALTERNATIVE 2 - NO ACTION

Under Alternative 2, the No Action Alternative—either Scenario A Continuation of Existing Site Conditions or Scenario B Site Development under Existing Zoning—no significant impacts to surface water are expected. In either scenario, on-site stormwater would continue to be collected, conveyed, and infiltrated onsite (though onsite stormwater flow may increase due to increased impervious land coverage). The Kettle Wetland would remain intact. Flows and water quality in Sequalitchew Creek and surface water levels and water quality in the marsh system and Sequalitchew Lake would be expected to remain unaffected compared to current conditions.

Separate actions related to the Sequalitchew Creek Restoration Plan and JBLM Diversion Canal may or may not proceed without the Proposed South Parcel Project and CalPortland involvement.

3.4.3 Mitigation Measures

This section describes the measures that CalPortland has proposed to mitigate the impacts to surface water features resulting from the Proposed Action.

Proposed On-Site Impacts Mitigation

- Mitigation for the elimination of the Kettle Wetland will be accomplished by the creation of a new 3.4-acre constructed wetland in the southwest portion of the existing mine's bottom. The constructed wetland will be designed, constructed, maintained, and monitored in accordance with a detailed wetland mitigation plan (Anchor QEA, 2021). This is discussed in further detail in Section 3.6, **Plants and Animals**.

- On-site stormwater flow and groundwater seepage and the associated potential for increased erosion will be managed in accordance with a series of Mine Best Management Practices, as described in the *Preliminary Stormwater Management Report* (2021) and the *Earth and Water Resources Report* (Aspect 2022, Revised 2023).

Proposed Mitigation for Off-Site Resources

As described in **Chapter 2** of this DEIS, the 2011 Settlement Agreement states that permits for the Pioneer Aggregates South Parcel Project (Proposed Action) shall not be effective until permits for the Sequalitchew Creek Restoration Plan (Restoration Plan) are in place. The Restoration Plan will be evaluated as a separate but related action. The Restoration Plan seeks to restore and enhance streamflow and ecological functions from Sequalitchew Lake through Edmond Marsh into Sequalitchew Creek ravine by sequentially restoring diverted flows back to the creek, improving the sustainability of flows through the system, and restoring aquatic habitat.

The impacts of this mitigation measure are the same as described above in the subsection Cumulative Impacts with Proposed Action and Sequalitchew Creek Restoration Plan.

Other Possible Contingency Mitigation Measures

As an element of the approval conditions for the Proposed Action, the City of DuPont could require a Monitoring and Response Plan. The Monitoring and Response Plan could include, among other things, definition of monitoring methodology, establishment of performance

thresholds, and identification of contingency response measures to the considered for implementation if monitoring indicates exceedance of a performance threshold. The Monitoring and Response Plan could incorporate elements of the adaptive management processes proposed to be established for the Proposed Action and the Sequalitchew Creek Restoration Plan.

The Sequalitchew Creek Restoration Plan is a separate but related action that is intended to be implemented in parallel with the Proposed Action. The mine and the stream restoration project each have their own adaptive management process tailored to achieving the goals and objectives of each specific project. The interaction between the two adaptive management processes could include: 1) project schedules that encourage restoration in advance of the potential impacts from mining; 2) development of performance thresholds for mining that support restoration and 3) coordinated monitoring and open sharing of information. The City, as the permitting authority for both projects would have a key role in assuring consistency between the two adaptive management plans.

The adaptive management process included in the Monitoring Plan (Aspect Consulting, 2017) includes, but is not limited to, the following potential mitigation actions if the impacts of dewatering on groundwater levels are greater than anticipated including: Installing additional monitoring locations; modifying the dewatering system or approach; revising the mining plan; and providing additional mitigation to impacted surface waters.

The Sequalitchew Creek Restoration Plan's adaptive management process similarly identifies examples of potential response actions to be implemented if restored flows do not meet the plans objectives that include, but are not limited to: removing beaver obstructions; installing additional beaver exclusion devices; escalating beaver management; installing additional flow paths through the former railroad grade that divides Edmond Marsh; sealing the losing reach; creating connections to Bell and/or McKay marshes; and expediting later elements of the Restoration Plan.

Other surface water contingency mitigation measures that could be implemented as part of the adaptive management process include:

- As described in Section 3.3, **Groundwater**, a possible contingency mitigation measure not considered in recent CalPortland documents – but discussed in the 2010 Final Feasibility Study (Anchor QEA 2010) – is to convey at least some of the intercepted groundwater seepage from the eastern slopes of the proposed mine expansion area to discharge to the ravine section of Sequalitchew Creek or West Edmond Marsh. Such mitigation has the potential to provide surface water flows in Sequalitchew Creek to offset the reduced groundwater seepage to the creek due to the Proposed Action and/or to make up for low- or no-flow periods in the creek and marsh system due to low or no flow discharges from Sequalitchew Lake under implementation of the Restoration Plan. If coupled with the Restoration Plan (including lining the dry reach section of the creek), the diversion of the groundwater seepage from the proposed expansion area to

West Edmond Marsh would provide flows to the dry reach as well as the ravine section of Sequalitchew Creek, while diversion to the ravine section of the creek would only provide flows to the ravine section (not the dry reach). Such mitigation could be adaptively managed, based on flow and temperature conditions in Sequalitchew Creek, and in such a way as to allow for some groundwater seepage from the proposed expansion area to be retained on-site and infiltrated to the Vashon-Sea Level Aquifer via the planned infiltration facilities in order to reduce negative impacts to the intertidal springs. Conveying groundwater from the mine expansion area to the ravine may require resolving conflicting provisions in the 2011 Settlement Agreement (see Chapter 2).

- Another possible additional mitigation measure that was considered in the 2010 Final Feasibility Study (Anchor QEA 2010) is raising the level of Sequalitchew Lake to increase the hydraulic gradient of Sequalitchew Creek through the East and West Edmond Marshes in order to better facilitate flows through the marsh system. With Restoration Plan implementation, the anticipated hydraulic gradient across the marsh system is approximately 0.0006 ft/ft. According to the 2010 Final Feasibility Study, the primary limitation to raising the lake level to induce a higher gradient is the protection of the Sequalitchew Springs located on the east end of Sequalitchew Lake. The Sequalitchew Springs are the drinking water source for JBLM and are protected behind a back-flow prevention weir. Reportedly, the lake level could potentially be raised (by modifying the outlet structure at the west end of the lake) by 0.56 ft with a moderate level of effort for modifications to the back-flow prevention weir at the springs. Raising the lake level higher than that is possible but would reportedly require a significant reconstruction of the facilities at the spring.

3.4.4 Significant Unavoidable Adverse Impacts

Under the Proposed Action with the Sequalitchew Creek Restoration Plan, unavoidable adverse impacts to the surface water system of the Sequalitchew Creek watershed would likely include:

- Increasing the surface water gradient between Sequalitchew Lake and the top of the ravine to restore the natural flow regime to the Sequalitchew Creek watershed, in combination with lower groundwater levels resulting from mining, would result in water levels in East and West Edmond Marshes being lowered by up to approximately 3 ft compared to existing conditions.

- Water levels in isolated lakes and kettle wetlands not directly connected by surface water to the Sequalitchew Creek system would be lowered due to lowered groundwater levels from the Proposed Action. The anticipated decrease in water levels would be approximately 3 ft for Wetland 1D; 2 ft for Pond Lake; 1 ft for Wetlands, #8, #9, #10, and #11; and 0.5 ft for Old Fort Lake. Implementation of the

Restoration Plan would likely not mitigate these impacts. These isolated wetlands have significant seasonal variability in water levels and are often dry during the summer. For these reasons, changes that result from changes in groundwater level may be difficult to observe.

Flows in the ravine section of Sequalitchew Creek would likely be lower than under existing conditions an estimated 10% of the time due to a reduction in groundwater seeps and spring discharges to the creek following groundwater lowering.

- Water temperatures in Sequalitchew Creek from April through September would likely be warmer than under existing conditions and could be expected to exceed 16°C (the 7-day average of daily maximum temperatures water quality criterion provided in WAC 173-201A-200) from May to September.

- The intent of the proposed mitigation measures described in 3.3B3, is to reduce these unavoidable adverse impacts to a non-significant status. If implementation of the proposed mitigation measures fails to mitigate these unavoidable adverse impacts, the City will consider implementing other possible contingency mitigation measures listed in 3.3.B3 as part of the adaptive management process.

If the contingency mitigation measure of conveying the intercepted groundwater from the eastern slopes of the proposed expansion area to Sequalitchew Creek and/or West Edmond Marsh is feasible and implemented as part of the adaptive management process for the Proposed Action and Restoration Plan Alternative, the flow and temperature impacts to Sequalitchew Creek would likely be at least partially reduced, if not eliminated, and may result in greater overall improvement of conditions within the creek.

Flows in the JBLM Diversion Canal would be reduced with the redirection of Sequalitchew Lake outlet flows to the historically natural drainage course through Sequalitchew Creek. Because the Diversion Canal was originally constructed to convey stormwater flows from JBLM and provide a watercourse for Sequalitchew Lake outlet flows, the reduced flows in the Diversion Canal are not considered an adverse impact.

Because on-site stormwater flows will be managed in a similar manner as existing conditions (i.e., on-site collection, conveyance, and infiltration) and because the removal of the Kettle Wetland will be mitigated by a new constructed wetland, no significant unavoidable adverse impacts to on-site surface waters are anticipated under the Proposed Action and Restoration Plan scenario.

3.5 FISHERIES

This section of the DEIS describes the existing fisheries conditions in the site vicinity (including the area associated with the Sequalitchew Creek restoration). Potential impacts associated with the EIS Alternatives are evaluated and mitigation measures identified. This section is based on the *Fisheries Technical Report* (February 2023) prepared by Anchor QEA and peer review by Raedeke Associates (see **Appendix G**).

3.5.1 Affected Environment

There are no fisheries resources on the site. Accordingly, the affected environment discussion for fisheries is focused on the lower 1.4 miles of Sequalitchew Creek, and the estuary and brackish marsh near the mouth of the creek. Other affected environments addressed in this analysis include the Puget Sound nearshore north of the Nisqually flats to Tatsolo Point and potential fish habitat in the Edmond Marsh complex. These areas are all outside the site but are subject to potential indirect effects from Proposed Action-related changes to the Vashon Aquifer and the off-site Sequalitchew Creek Restoration Plan.

Sequalitchew Creek

A description of the Sequalitchew Creek watershed and the fisheries habitat characteristics of Sequalitchew Creek is presented below. Refer to Section 3.3, **Groundwater**, and Section 3.4 **Surface Water**, for additional detail on Sequalitchew Creek physical habitat characteristics.

In general, Sequalitchew Creek has undergone a series of alterations over the last approximately 180 years from urban, military, and private development that has reduced fish access and habitat conditions.

Sequalitchew Creek Watershed

Sequalitchew Creek (Water Resource Inventory Area 12-0019) drains a watershed covering approximately 38.4 square miles that discharges into Puget Sound. **Figure 3.5-1** illustrates the characteristics of the Sequalitchew Creek drainage basin (see **Appendix G** for detail on the Sequalitchew Creek basin).

Physical Habitat of Upper Sequalitchew Creek

Upper Sequalitchew Creek is largely an artificial channel from its source at the Lake Sequalitchew weir to the west end of West Edmond Marsh. This channel is excavated within the existing wetland complex and has extremely low velocity where it flows in a culvert under DuPont Steilacoom Road. Except under extreme high flow conditions, all flow that

Source: Anchor QEA, 2022.

EA Engineering, Science, and Technology, Inc., PBC

Figure 3.5-1

Existing Aquatic Resources

passes through that culvert either infiltrates or evaporates within the Edmond Marsh Complex (see **Appendix G**, Plants and Animals Technical Report for additional detail).

Physical Habitat of Lower Sequalitchew Creek

Sequalitchew Creek above river mile 1.0 and below Edmond Marsh is typically dry. Only rarely is there a surface water connection between Edmond Marsh and lower Sequalitchew Creek. Most instances of surface water connection appear related to storm events, but some are from humans removing or altering the beaver dam at the west end of Edmond Marsh. The source of water in the lower mile of the creek is groundwater discharged from the Vashon Aquifer as springs in the Sequalitchew Creek ravine. In general, water flows in Sequalitchew Creek are not sufficient to allow fish use throughout much of the year (see **Appendix G** for detail on the physical characteristics of Sequalitchew Creek and fish use).

Biological Habitat of Sequalitchew Creek

The Sequalitchew Creek drainage basin contains both anadromous and resident fish that occur at different times of the year and use different portions of the creek. Documented anadromous fish use is reported for Sequalitchew Creek in the site vicinity, including by coho salmon (*Oncorhynchus kisutch*), chum salmon (*O. keta*), and cutthroat trout (*O. clarkii*) (see Figure 4 of **Appendix G**). The U.S. Fish and Wildlife Service also identifies bull trout (*Salvelinus confluentus*), a threatened species, as occurring in the site vicinity. Native bull trout populations are known to be present in the Nisqually River, whose mouth is located approximately one mile south of Sequalitchew Creek. Although suitable habitat for bull trout does not exist within Lower Sequalitchew Creek, it is likely that this species is present in the nearshore habitat and could enter Lower Sequalitchew Creek estuary to forage during salmon smolt out-migration.

Resident fish reported or expected to occur in Sequalitchew Creek within the site vicinity include cutthroat trout (*O. clarki*), rainbow trout (*O. mykiss*), sculpins (*Cottus* sp.), and western brook lamprey (*Lampetra richardsonii*). Other resident fish reported to occur in the Sequalitchew Creek drainage basin, but outside the site vicinity, include kokanee salmon (*O. nerka*) and spiny ray fish in American Lake and Sequalitchew Lake. Chum salmon have been reported to spawn in the lower 650 feet of Sequalitchew Creek in the past.

Historical Augmentation of the Fishery

WDFW augmented the fishery of Sequalitchew Creek intermittently from 1980 to 2001. Coho salmon smolts were released into Sequalitchew Creek from 1980 to 1994 and again in 2001. The annual number of coho salmon smolts (young salmon that are moving from freshwater to the ocean) released ranged from 2,280 to 987,480 with an average annual release of 238,477. Fall Chinook salmon (O. *tshawytscha*) smolts were also released into Sequalitchew Creek in 1990 and 1991. The annual number of Chinook smolts release ranged from 19,800 to 42,800 with an average annual release of 27,533. Coho salmon,

chum salmon, and cutthroat trout are currently reported to utilize Sequalitchew Creek according to the most recent information from WDFW and the *WRIA 12 Salmonid Habitat Limiting Factors Report*.

Coho salmon spawning survey records for Sequalitchew Creek indicate sporadic observations have been made by WDFW in 1962, and between 1982 and 1985. These surveys conducted in the winter (November 6 to December 27) extended from the mouth to RM 1.6. These data indicate that the annual number of adult coho salmon observed ranged from 0 to 145 with an annual average of 22. These surveys occurred during the period when smolts were released in the watershed, and flows were maintained by cutting a channel through Edmond Marsh.

The time of year when anadromous fish are reported to occur in Sequalitchew Creek within the site vicinity is as follows: Coho salmon smolts out-migrate from March to May, while returning adults spawn from late November to early January. Chum salmon spawn between December and February, and the fry (the stage where they begin the process of adapting to salt water) out-migrate immediately after emerging from the gravels, which is usually between March and June. Resident and sea-run cutthroat trout reside in Sequalitchew Creek throughout the entire year. Adults typically spawn in the spring and summer (February to August) and the fry emerge in late summer. Adult bull trout can potentially be present in the lowest portions of Sequalitchew Creek at any time of the year but are most likely to enter the stream to forage on out-migrating salmon smolts between March and June. Bull trout are not expected to use Sequalitchew Creek for spawning purposes due to the limited known distribution in the vicinity and the lack of spawning conditions that bull trout require.

Fish Habitat under Existing Flows

The analysis of salmonid spawning and passage in Sequalitchew Creek prepared for this EIS is based on water depth and flow, and considers conditions for coho salmon, chum salmon, and cutthroat trout (see **Appendix G** for detail on the methodology utilized for water depth and flow).

The analysis indicates that optimal flows for both spawning and rearing in Sequalitchew Creek are higher than provided by current flows in Sequalitchew Creek; i.e. existing low flows in the creek are not considered suitable for spawning and rearing of coho and chum salmon. Cutthroat trout habitat is also severely limited due to low flows, especially during drier-than-average years. Also note that a 2013 study found that "adult capacity and abundance in Sequalitchew Creek is essentially zero" (see to **Appendix G** for additional detail).

Marine Shoreline

Fish habitat along the marine shoreline at the mouth of Sequalitchew Creek and the barge-loading facility is described below.

Physical Habitat Characteristics of the Marine Shoreline

Mouth of Sequalitchew Creek

The Puget Sound shoreline at the mouth of Sequalitchew Creek is characterized by an armored slope above a gravel beach with minimal estuarine habitat. Farther offshore, a shallow soft sediment bench extends from the Nisqually River delta to just north of the mouth of Sequalitchew Creek. The BNSF railroad tracks paralleling the shoreline in this area are perched on a steep riprap berm. On the Nisqually Reach side of the railroad there are gravel deposits on either side of the mouth of Sequalitchew Creek that extend above the high tide line. These create more complete nearshore habitats, with beach grasses, drift logs, and low angle beaches extending into the subtidal zone. The railroad berm bisects the mouth of Sequalitchew Creek and influences tidal currents, wave action, and sediment deposition along the marine shoreline. There is a brackish marsh associated with Sequalitchew Creek on the upstream side of the railroad berm. Wind waves and tidal flows in the marsh are limited by a culvert under the railroad berm. The culvert draining Sequalitchew Creek through this railroad berm influences tidal exchanges, deltaic sediment deposition, and fish passage. There is limited rearing habitat in the brackish marsh on the upstream side of the railroad berm because this berm does not allow the channel to meander and otherwise naturally braid into multiple tidal channels. The loss of these natural processes limits the quantity and quality of fish habitat in this estuary.

Marine Shoreline West of the Existing Mine

The shoreline on the Puget Sound side of the railroad berm also has limited fish habitat due to steep slope influences on wave action, sediment deposition, and estuarine vegetation. Waves formed by the predominant wind direction (from the southwest) break on the riprap-lined slope during high tides and do not allow for the deposition of fine-grained substrate in most areas. Substrate along the shoreline that is influenced by high-energy waves and wave reflection scouring is dominated by cobbles and gravel. In addition, the steep riprap embankment does not allow estuarine vegetation to grow above the high tide line. This limits the organic export of nutrients and benthic invertebrates (small bottom-dwelling aquatic animals with no backbone) that juvenile salmonids need during their acclimation to estuarine conditions. Within approximately 0.25 mile on either side of the mouth of Sequalitchew Creek, there is a sand bar at the shoreline. This sandbar reduces wave energy and scour. The sandier substrate off shore of the bar supports patches of eelgrass. The bottom substrate farther offshore that is not influenced by wave scouring consists of fine-grained sediment overlying cobbles.

Barge Loading Facility

The Puget Sound shoreline at the Pioneer Aggregates barge loading facility near Tatsolo Point is located where the BNSF railroad tracks also parallel the shoreline. The railroad tracks are perched on a steep berm composed of riprap that occupies the intertidal zone to

nearly mean lower low water (MLLW), meaning there is little intertidal beach present. This railroad berm influences tidal currents, wave action, and sediment deposition along the marine shoreline. Although there is a gravel beach adjacent to the railroad berm approximately 200 feet north of the dock, the area has minimal nearshore habitat value. The shoreline on the Puget Sound side of the railroad berm has limited fish habitat because the steep slope influences wave action, sediment deposition, and estuarine vegetation. Waves formed by the predominant wind direction (from the southwest) break on the riprap-lined slope and do not allow for the deposition or effective transport of fine-grained substrate (see **Appendix G** for additional detail)

Biological Habitat Characteristics of the Marine Shoreline

The Nisqually Reach west of the existing mine and the nearshore from the mouth of Sequalitchew Creek provide habitat for numerous species of fish and marine invertebrates. WDFW Priority Habitats and Species mapping documents the presence of key habitats for cutthroat trout, coho salmon, and chum salmon migration and rearing; and Pacific sand lance (*Ammodytes hexapterus*) and surf smelt (*Hypomesus pretiosus*) breeding. The reach is used by Dungeness crab (*Cancer magister*) and various types of shrimp. Kelp and algae beds are present in the shallow subtidal; there have been limited observations of eelgrass in the vicinity (eelgrass is critical fish habitat).

Mouth of Sequalitchew Creek

Although fish habitat along the marine shoreline at the mouth of Sequalitchew Creek is influenced by the railroad berm, this area is used by a variety of species. These include plants and invertebrates in the intertidal and subtidal zones, as well as the marine and fish species described below.

Prior studies indicate that 75 plant species were found growing on the bottom substrate in the intertidal area (0 to 9 feet above MLLW). Of these intertidal plants, more than half were red algae (Rhodophytes) and green algae (Chlorophytes). The majority of the subtidal plants were found between 0 and -16 feet below MLLW. Small patches of eelgrass in sparse densities were observed near the mouth of Sequalitchew Creek (see **Appendix G** for detail). Prior studies also identified 270 species of invertebrates in the intertidal area, with the majority of these species occurring near 0 feet MLLW. Several species of limpets, barnacles, and periwinkles were the dominant molluscan groups. The most productive area was the lower intertidal area near the mouth of Sequalitchew Creek. Subtidal invertebrates found in this area include snails (gastropods), worms (polychaetes), sea stars, and amphipod crustaceans.

Marine fish observed along the shoreline in this area include 31 species of bottomfish, 26 species of bottom-dwelling fish, and 11 water-column species. The predominant bottomfish include English sole (*Parophrys vetulus*), rock sole (*Lepidosetta bilineata*), and starry flounder (*Platichthys stellatus*). The dominant bottom-dwelling fish include buffalo sculpin

(*Enophrys bison*), Pacific tomcod (*Microgadus proximus*), staghorn sculpin (*Leptocottus armatus*), rockfish species (*Sebastes* spp.), cabezon (*Scorpaenichthys marmoratus*), painted greenling (*Oxylebius pictus*), and pipefish (*Syngnathus griseolineatus*). The water-column fish are represented by shiner perch (*Cymatogaster aggregate*), surfperches (Embiotocidae), and tubesnout (*Aulorhynchus flavidus*).

Salmonid species observed along the marine shoreline include coho, chum, Chinook, and pink salmon. Adult coho salmon were found along the shoreline at the Sequalitchew Creek mouth in September and October, but most of these fish were returning to spawn in the Chambers Creek, McAllister Creek, and Nisqually River watersheds. Returning chum salmon are found along the shoreline at the Sequalitchew Creek mouth in December and January, but most of these fish spawn in the Nisqually River. Chinook and pink salmon observed along the marine shoreline are mainly migrating to the Nisqually River system. Juvenile salmonids are found along the shoreline at the Sequalitchew Creek mouth during the spring out-migration, but many of these fish originate in the Nisqually River. Juvenile coho salmon are typically found between May and June. The peak migration of juvenile chum salmon occurred between mid-February and late July. Juvenile Chinook salmon were observed migrating from late May to July.

As noted previously, a native population of bull trout is known to inhabit the Nisqually River system. Fish from this population may utilize the nearshore environment near the mouth of Sequalitchew Creek and may also enter the lowest portion of the creek to forage on juvenile salmonids.

Barge Loading Facility

Similar to the area described at the mouth of Sequalitchew Creek, the barge loading area is influenced by the railroad berm. However, the barge loading dock area has less diversity than the mouth of Sequalitchew Creek. The following summarizes the plants and invertebrates in the intertidal and subtidal zones; marine fish; and salmonids found in this area.

An intertidal flora and fauna survey conducted approximately 200 yards south of the barge loading dock in 1978 found little macroalgae above +6 feet MLLW. Only rockweed (*Fucus gardneri*) was present at +6 feet MLLW. At lower elevations, several species of red and green algae were common, and at 0 feet MLLW, several species of kelp dominated. Subtidal plants are distributed at various depths and include macroalgae and kelp at around -8 feet MLLW. A narrow band of bull kelp (*Nereocystis leutkeana*) extends along the shoreline in both directions from the barge loading dock. Algae species are restricted to the area above -20 to -30 feet MLLW, and the most prevalent algae species was sea lettuce (*Ulva lactuca*). Ribbon kelp (*Laminaria saccharina*) was the second most common algae in this area. A variety of filamentous and foliose red algae species are present; the most common is *Sarcodiotheca gaucichaudii*. The cumulative percent cover of these algae ranged

from 100% in the shallow subtidal zone to less than 5% at -20 to -30 feet MLLW. No eelgrass beds were observed in the vicinity of the dock.

Subtidal animals living within (infauna) and on top (epifauna) of the sea bed are present at various depths. The most common infauna group is polychaete worms, while the epifauna is dominated by shrimp and crab species. Larger animals included cockles (*Clinocardium nuttallii*), sea cucumbers (*Parastichopus californicus*), several species of sea stars, Dungeness crab (*Cancer magister*), rock crab (*Cancer productus*), and geoducks (*Panope abrupta*).

Marine fish observed along the shoreline in this area include shiner perch, Pacific herring (*Clupea harengus pallasi*), sand dab (*Citharichthys sordidus*), English sole, and starry flounder. Four salmon species (coho, chum, chinook, and pink) are expected to occur in this area. However, this area is less productive for juvenile salmon rearing and adult migration than the mouth of Sequalitchew Creek due to its greater distance from the Nisqually River. As noted previously, a native population of bull trout is known to inhabit the Nisqually River system. Fish from this population may utilize the nearshore environment in the vicinity of Sequalitchew Creek, including the barge loading facility.

3.5.2 Impacts of the Alternatives

This section identifies and analyzes the potential for impacts to fisheries in the vicinity of the site under the EIS Alternatives.

As described in **Chapter 2** of this DEIS, the 2011 Settlement Agreement indicates that any approval of proposed mining under the Pioneer Aggregates South Parcel Project (Proposed Action) shall not be effective until permits and approvals needed for implementation of the Sequalitchew Creek Restoration Plan (Restoration Plan)[1], as a separate but related action. The Restoration Plan seeks to restore and enhance streamflow and ecological functions from Sequalitchew Lake through Edmond Marsh into Sequalitchew Creek ravine by sequentially restoring diverted flows back to the creek, improving the sustainability of flows through the system, and restoring aquatic habitat.

Consistent with the 2011 Settlement Agreement, this DEIS assumes that mining and reclamation activities under the Proposed Action would require implementation of the Restoration Plan. It is assumed that CalPortland funding/implementation of projects associated with the Restoration Plan would be mitigation for certain environmental impacts identified in this DEIS and would be a condition of any City of DuPont approval of the Proposed Action. However, because the Restoration Plan is considered a separate project that could be funded and implemented independent of the Proposed Action, the general discussion in the Environmental Impacts sub-section of Fisheries only addresses the impacts

[1] *The Sequalitchew Creek Restoration Plan is sponsored and developed by CalPortland, the Environmental Caucus and the South Puget Sound Salmon Enhancement Group (SPSSEG).*

of the proposed mining/reclamation and does not include implementation of the Restoration Plan. This is intended to help the reader understand the impacts of the proposed mining/reclamation, and the need for the Restoration Plan with the proposed project. Proposed mining/reclamation in combination with the Restoration Plan is specifically discussed under Cumulative Impacts.

ALTERNATIVE 1 – PROPOSED ACTION

Direct Impacts

Potential fisheries impacts to the marine shoreline include direct and indirect effects from the spillage of sand and gravel from the conveyor, overturning of barges during loading, accidental spills of pollutants, shading, and lighting, and are summarized as follows:

- Sand and gravel, if spilled in sufficient quantities, could smother the benthic community where the spill occurs.
- Accidental spills of petroleum products (diesel) and other pollutants (hydraulic oil) could potentially occur during barge loading and maintenance activities.
- Extending the life of the conveyor and barge loading dock by about 14 years would extend any impacts to areas directly beneath the dock by shading the shallow water, as well as impacts associated with dock lighting. These impacts would occur until the dock is eventually removed.

As indicated in Sub-section 3.4.1, periodic surveys to date have not detected substantial material spills. Also, Ecology maintains a record of all reported oil spills of 1 gallon or more since 2015; there were no recorded spills in the vicinity during that time.

Indirect Impacts

The Proposed Action would not directly affect Sequalitchew Creek, but the drawdown of the Vashon Aquifer would indirectly reduce flow in Lower Sequalitchew Creek. Lower Sequalitchew Creek is entirely spring fed. Groundwater discharge to Sequalitchew Creek during active dewatering under the Proposed Action is predicted to be 79% less than baseline conditions, on average, resulting in a decrease in average flow in Sequalitchew Creek from 1.6 cfs to 0.34 cfs at the mid-ravine gage. The greatest decrease would occur during the wet season.

Without the Sequalitchew Creek Restoration, these indirect impacts would reduce flows during the spawning life stage of chum salmon and the spawning and rearing life stages of coho salmon and cutthroat trout. Impacts during the spawning season would limit the amount of habitat for resident cutthroat trout and eliminate spawning habitat for anadromous species. This would reduce the spatial extent of habitat available and reduce the portion of the year when fish habitat is accessible.

CUMULATIVE IMPACTS WITH PROPOSED ACTION AND SEQUALITCHEW CREEK RESTORATION PLAN

Introduction

As indicated in **Chapter 2** (Description of proposed Action and Alternatives) of this EIS, the 2011 Settlement Agreement indicates that any approval for mining under the Pioneer Aggregates South Parcel Project shall not be effective until permits and approvals needed for implementation of the Sequalitchew Creek Restoration Plan developed by CalPortland and the Environmental Caucus are in place. The Restoration Plan will be evaluated as a separate but related action. The Sequalitchew Creek Restoration Plan seeks to restore and enhance streamflow and ecological functions from Sequalitchew Lake through Edmond Marsh into Sequalitchew Creek ravine. Restoration of Sequalitchew Creek seeks to address almost two centuries of human manipulation. The principal goals of the Restoration Plan are to restore flows in Sequalitchew Creek, portions of which are now dry. This goal will be achieved by implementing a series of actions in a coordinated and adaptively managed project. The Restoration Plan is intended to sequentially restore diverted flows back to the creek, improve the sustainability of flows through the system, and restore aquatic habitat by removing flow-related fish passage barriers and increasing the habitat available to aquatic species.

The Sequalitchew Creek Restoration Project would also restore fish passage from Sequalitchew Creek to East and West Edmond Marshes. Two fish barrier culverts would be replaced by fish-passable structures, which in combination with increased flows would allow migratory access above the ravine springs and into Edmond Marsh. Restoration would affect the conditions sufficiently to allow establishment of emergent vegetation in the western extent of the complex where inundation would persist through more of the growing season, providing excellent rearing habitat for juvenile coho salmon and cutthroat trout. These effects would increase the size, diversity, and complexity of available fish habitat types.

The increased flow through Edmond Marsh would also improve water quality conditions by increasing dissolved oxygen concentrations and diluting and flushing an area of elevated iron concentrations in the center of the marsh. Improved water quality would improve fish habitat.

Cumulative Conditions

The combined impacts of mining under the Proposed Action together with implementation of the Sequalitchew Creek Restoration (the ‘cumulative condition’) on stream habitat would include a re-establishment of flow from Sequalitchew Lake to flow through the marshes and into Sequalitchew Creek ravine, and re-establishing ecosystem processes, specifically, the movement of water, sediment, nutrients, biota, and dissolved gases through the watershed

from the headwater springs on Sequalitchew Lake to Puget Sound. The increase in hydrology and stream energy would increase aquatic ecosystem productivity and create and maintain habitat diversity, particularly for target species such as chum salmon and cutthroat trout in the system, as described below (see **Appendix G** for details).

Water Quality

The mining under the Proposed Action and Sequalitchew Creek Restoration Plan projects would introduce surface water from the upper watershed to Sequalitchew Creek. Water currently passing through Edmond Marsh has low levels of turbidity and pollutants. The cumulative condition would impact stream temperature in the Sequalitchew Creek ravine by restoring the flow of surface water in the system at a different temperature. The effects would vary seasonally as the volume of water from Sequalitchew Lake and its associated temperature vary. In summer, the outflow from Sequalitchew Lake is warmer than Sequalitchew Creek; in winter, it is colder.

Sequalitchew Creek would experience warm temperatures in June, July, and August, with temperatures reaching up to 21°C (70°F) and cool temperatures in winter, down to 5°C to 6°C (41°F to 43°F) (see **Appendix G** Figure 6). The predicted stream temperatures would be considerably warmer than the current spring discharge in the creek for most of the year. The surface water quality criterion for temperature applicable to Sequalitchew Creek is 16°C for the 7-day average of daily maximums. This threshold may be exceeded from May to September.

This temperature increase could alter habitat for juvenile fish. Increased stream temperatures have been shown to decrease time to emergence in several salmonid species, including coho salmon. Cutthroat trout, which spawn and rear later in the season, have been shown to hatch earlier as temperatures increase. Although sublethal, this temperature increase could impact growth and survival, with juveniles potentially competing for resources earlier in the year.

The dissolved oxygen levels in Lake Sequalitchew and Lower Sequalitchew Creek are currently high (>9 milligrams per liter [mg/L]). Water quality in the marshes is more typical of stagnant waterbodies exposed to the life cycle of aquatic plants.

Water Quantity

Streamflow was evaluated and streamflows were predicted at two locations under the cumulative condition. These locations are the dry reach near Center Drive, and at the mid-ravine of Sequalitchew Creek.

Flows in the Dry Reach - Under existing conditions, the dry reach experiences no consistent flow passing through the entire reach. The bottom of the dry reach is above the current groundwater levels, so ground infiltration in the dry reach would not be impacted by lowering of groundwater with mining under the Proposed Action.

The cumulative condition is predicted to result in an average flow of 12.9 cfs in the dry reach. The flow would vary seasonally (see Figure 5 of **Appendix G**). Peak flows could be as high as 60 cfs if all water is routed through the wetlands during peak flow events. To avoid flooding during peak flows, the highest flows would be directed to the Diversion Canal or detained in the marshes.

Modeling conducted for this EIS analysis (see **Appendix G**) indicates there would be periods when there would be no outflow from West Edmond Marsh, and thus no flow in the dry reach portion of Sequalitchew Creek in the cumulative condition. The occurrence of dry periods in this reach of Sequalitchew Creek would be reduced or eliminated if beaver management structures are built to store water and release it slowly and consistently during periods when there is no flow from Sequalitchew Lake. Should flow be disrupted, it would temporarily disrupt the habitat and fish migratory functions of the stream reach between the Sequalitchew ravine springs and Edmond Marsh.

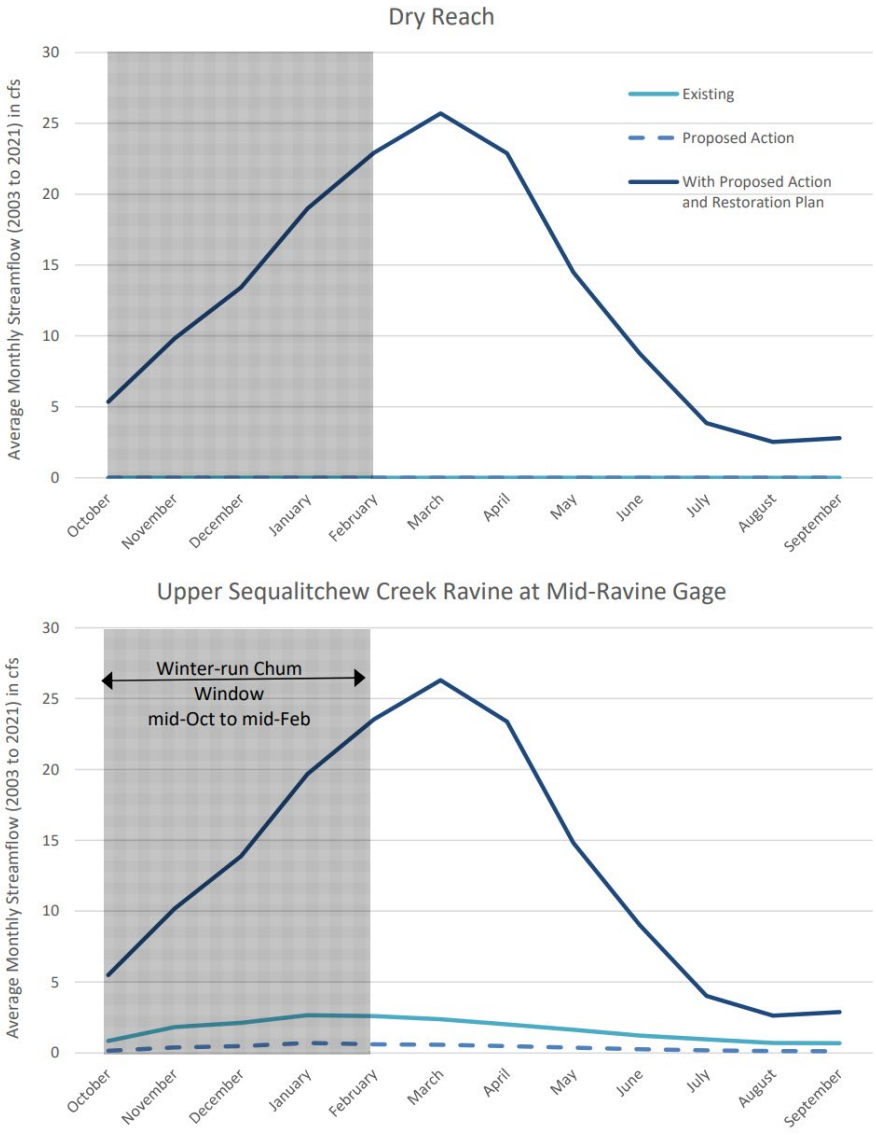
Flows at Mid-Ravine - After passing through the dry reach, streamflows would enter the Sequalitchew Creek ravine under the cumulative condition. The vast majority of flow would originate from Sequalitchew Lake, but there would be contribution from springs within the ravine, although the contribution from these springs with mining under the Proposed Action and Sequalitchew Creek Restoration Plan would be lower than it is under existing conditions.

On average, flow in Sequalitchew Creek at the mid-ravine gage would generally be similar to but slightly higher than the flows in the dry reach (i.e., 0.4 cfs greater), reflecting the input of spring flow. Peak flows would be generally the same magnitude (approximately 60 cfs) as in the dry reach.

There would be periods when the cumulative condition would result in a reduction in flows at the mid-ravine gage compared with the existing condition; flows are anticipated to be lower approximately 10.5% of the time. These effects would be mitigated in part or in whole by implementation of the beaver management actions called for in the Restoration Plan. On an overall basis, implementation of the Sequalitchew Creek Restoration Plan would increase the level of fisheries habitat in Sequalitchew Creek compared to existing conditions.

Low flows are the limiting factor for coho and chum salmon and cutthroat trout spawning and rearing in the ravine. Separate studies (Anchor Environmental 2004, and ICF 2013) show that under flow conditions similar to those predicted with mining and restoration would result in increased capacity of the stream to support spawning and rearing of coho and chum salmon

Flows during the spawning season of winter-run chum (October – February) would be increased providing passage to more of the creek and conditions suitable for spawning in the ravine. Coho salmon spawn in the Nisqually during the earlier part of the same period.



Edmond Marsh

A goal of the Sequalitchew Creek Restoration Plan is to reintroduce a sustainable population of coho salmon. If re-stocking of coho salmon is successful, the aquatic area of West Edmond Marsh would provide rearing habitat for juveniles. Juvenile coho salmon typically stay in freshwater wetlands and small streams for two years or more after spawning.

Nearshore Habitat

Under the cumulative condition, the additional flow in Sequalitchew Creek would transport more nutrients and fine sediment to the nearshore. The mouth of the creek is near the south end of a drift cell[2] with net transport to the north. The additional sediment would benefit the nearshore by replacing some of the sediment that would naturally come from the exposed bluffs above the railroad. Currently this sediment cannot cross the tracks, and the lower shoreline is heavily armored, preventing erosive forces from recruiting sediment below the railroad. Additional nutrients and sediment would also increase biotic productivity on the Puget Sound shoreline at the mouth of the creek, increasing prey resources for fish. Conditions in the brackish marsh are expected to remain stable. Although salinity at the surface could drop, the saltwater that enters the marsh at high tide is anticipated to still cover the entire vegetated surface of the marsh

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ALTERNATIVE 2 – NO ACTION

The No Action Alternative includes two scenarios: Scenario A – Continuation of Existing Site Conditions; and Scenario B – Site Development under Existing Zoning.

Scenario A

Under No Action Alternative Scenario A, the condition of the Sequalitchew Creek fish populations and fish habitat would remain as under existing conditions. Suitable and accessible habitat for all species of fish currently and historically present would continue to be a fraction of what they were a few decades ago. Surface flows from Edmond Marsh into Lower Sequalitchew Creek would continue to occur during extreme precipitation events and would not contribute meaningfully to habitat. The creek would continue be unused or used very little by chum and coho salmon and cutthroat trout.

No-Action Alternative Scenario A includes the potential for the Sequalitchew Creek Restoration Plan to be implemented without the Proposed Action. Funding for alterations to the diversion system is currently programmed by JBLM. For the portions of the plan outside JBLM, other funding sources (e.g., grants) would be required to implement the plan. These alternate funds may or may not be provided, and if provided may or may not be at the same level of funding and/or on the same timeline as under the Proposed Action.

Scenario B

If the site were to be developed consistent with existing zoning, clearing and grading associated with construction would increase potential for erosion impacts to area fisheries resources; with adherence to applicable regulations during construction, significant impacts to these resources are not anticipated. The increase in impervious surfaces on the site with

[2] *Section of shoreline in which sand and gravel naturally move to create beaches.*

development consistent with existing zoning would increase surface water runoff; with adherence to applicable regulations related to stormwater quantity and quality, significant impacts are not anticipated.

As indicated above, development of the site consistent with existing zoning includes the potential for the Sequalitchew Creek Restoration Plan to be implemented without the Proposed Action. However, there are no known likely funding sources other than CalPortland at this time.

3.5.3 Mitigation Measures

The following mitigation measures have been included in the Proposed Action to reduce fisheries resources impacts, including impacts to on-site resources and indirect impacts to off-site resources due to changes in groundwater hydrology. Note that specific mitigation measures associated with dewatering and other aspects of the mining project are discussed in Section 3.3, **Groundwater**, of this EIS.

Proposed On-Site Mitigation

- Existing mitigation measures at the barge loading facility at Tatsolo Point that minimize the potential for impacts on fisheries resources would continue. These include:
    - The facility is designed in accordance with adopted federal, state, and local regulations and guidelines to reduce the likelihood of spills of lubricants, fuels, and chemicals employed in the processing and manufacturing proposed for the site;
    - The overwater portion of the conveyor is enclosed to prevent spillage of gravel; and
    - The dock is not used for the delivery of supplies, or chemical or other materials by water; a spill plan has been prepared for all elements and operations of the facility (marine and upland). Appropriate oil spill containment equipment is available at the dock site.

- Mining operations would continue to manage fugitive dust, and forested buffers around Sequalitchew Creek would remain to protect water quality and its support of healthy fisheries resources.

- Site water and stormwater would continue to be recycled and/or infiltrated in the mine, eliminating turbid runoff and its potential to impact fisheries resources.

- During construction of the mitigation wetland and other excavation of soils, construction best management practices would be used to prevent erosion of soils and sedimentation of water resources that support fisheries resources.

Proposed Mitigation for Off-Site Resources

- Implementation of the Sequalitchew Creek Restoration Plan would mitigate for potential impacts to aquatic resources and vegetation resulting from changes to groundwater levels. The Sequalitchew Restoration Plan will be permitted and implemented contemporaneously with mining of the South Parcel. Among other things, the Restoration Plan would mitigate for the impacts of the mine. Monitoring and mitigation measures, including specific timeframes for monitoring and mitigation efforts, are defined in the Restoration Plan. The goal of the Restoration Plan is to offset potential impacts to aquatic resources within the area subject to changes in groundwater level.

- The Sequalitchew Creek Restoration Plan and proposed mining both include monitoring and adaptive management programs aimed at ensuring the projects achieve their objectives (e.g., to maintain and enhance fisheries resources). A main purpose of ongoing monitoring and adaptive management is to look for detrimental cumulative effects and, if identified, adaptively respond to minimize them.

Other Possible Contingency Mitigation Measures

- As an element of the approval conditions for the Proposed Action, the City of DuPont could require a Monitoring and Response Plan. The Monitoring and Response Plan could include, among other things, definition of monitoring methodology, establishment of performance thresholds, and identification of contingency response measures to the considered for implementation if monitoring indicates exceedance of a performance threshold. The Monitoring and Response Plan could incorporate elements of the adaptive management processes proposed to be established for the Proposed Action and the Sequalitchew Creek Restoration Plan.

  The Sequalitchew Creek Restoration Plan is a separate but related action that is intended to be implemented in parallel with the Proposed Action. The mine and the stream restoration project each have their own adaptive management process tailored to achieving the goals and objectives of each specific project. The interaction between the two adaptive management processes could include: 1) project schedules that encourage restoration in advance of the potential impacts from mining; 2) development of performance thresholds for mining that support restoration and 3) coordinated monitoring and open sharing of information. The City, as the permitting authority for both projects would have a key role in assuring consistency between the two adaptive management plans. The adaptive management process included in the Monitoring Plan (Aspect Consulting, 2017) includes, but is not limited to, the following potential mitigation actions if the impacts of dewatering on groundwater levels are greater than anticipated including: Installing additional monitoring locations; modifying the dewatering system or approach; revising the mining plan; and providing additional

mitigation to impacted surface waters.

Other groundwater contingency mitigation measures that could be implemented as part of the adaptive management process include:

- Groundwater captured from the mine could be conveyed to the Sequalitchew Creek ravine (either by open channel or micro-tunneling). This approach could provide mitigation for decreased seep discharge within the ravine if the conveyance outfall (or confluence) is located in the vicinity where groundwater discharge currently occurs. However, this previously considered mitigation measure would require revisiting conflicting provisions in the 2011 Settlement Agreement and would not augment streamflow between Sequalitchew Lake and the ravine.

- Groundwater captured from the mine could be pumped into Edmond Marsh rather than into the Sequalitchew Creek ravine. Benefits of this mitigation approach would be that cool groundwater (which has a low summer water temperature relative to surface water) would enter the marsh and could enhance Sequalitchew Creek surface water flow and fish habitat. A potential drawback of this mitigation action is that it is, at best, a temporary action because pumping in perpetuity is not feasible, and groundwater discharge/infiltration to the comingled Vashon-Sea Level Aquifer would substantially decrease. In addition, it likely would over-mitigate expected dewatering impacts to Sequalitchew Creek if active year-round (as opposed to only during certain dry or low-flow conditions).

- Water could be actively conveyed to Edmond Marsh during dry periods, while during all other periods captured groundwater from the South Parcel could be conveyed to the lower mine area for infiltration (as is planned in the Proposed Action). This could serve as a contingent measure for consideration and/or further study to supplement Sequalitchew Creek flows during dry periods when no outflow from Sequalitchew Lake occurs or if the Restoration Plan provides less environmental benefit than currently expected. However, this mitigation measure is also likely at best, a temporary action because pumping in perpetuity is not feasible.

3.5.4 Significant Unavoidable Adverse Impacts

The cumulative impacts of the Proposed Action and Sequalitchew Creek Restoration Plan (the cumulative condition) would generally improve all aspects of the freshwater fish habitat in the Sequalitchew Creek watershed compared to current conditions.
The existing low flows do not currently support a fish population. The flows in the ravine section of Sequalitchew Creek under the Proposed Action would likely be lower than under

existing conditions an estimated 10% of the time (during drought years) with the reduction in groundwater discharge to the creek.

Increased water temperature in the Sequalitchew Creek system is anticipated to occur in late summer when only resident fish are present. Fish movement and growth could be limited during the period when water temperature peaks in late summer until temperatures reduce in fall.

Considering the overall increase in freshwater fish habitat conditions in the cumulative condition, in combination with the proposed and potential measures identified in Section 3.5.3, significant unavoidable adverse impacts are not anticipated.

3.6 PLANTS AND ANIMALS

This section of the DEIS describes the existing plants and animals conditions (including wetlands) on the site (including the approximately 188-acre Expansion Area and approximately 125-acre Re-Mine Area), and in the site vicinity (including the area associated with the Sequalitchew Creek Restoration). Potential impacts associated with the EIS Alternatives are evaluated and mitigation measures identified. This section is based on the *Plants and Animals Report* (June 2023), *Landmark Tree Inventory Report* (August 2021), and *Floodplain Habitat Assessment and Mitigation Report* (November 2022) all prepared by Anchor QEA and peer review by Raedeke Associates (see **Appendices H**, **I**, and **J**).

3.6.1 Affected Environment

Plants and Habitat

Dominant plant communities and habitats within the site, the off-site Sequalitchew Creek Restoration Area, and the areas subject to changes in groundwater levels (i.e., the aquatic resources of Sequalitchew Creek and the four wetland systems within the Sequalitchew Creek Restoration Area: East Edmond Marsh, West Edmond Marsh, and the Sequalitchew Creek Riparian Wetlands) with proposed mining operations include coniferous forests, shrublands, grassland, and aquatic resources (streams and wetlands), as described below. Rare plants and plant communities are also described.

Conifer Forests

Conifer forests cover most of the Expansion Area portion of the site, including approximately 135 acres of the approximately 188 acres that would be cleared for mining (see **Figure 2-2** of Chapter 2 of this Draft E). Second-growth conifer forests are interspersed with young regenerating stands as a result of previous timber harvest practices. Douglas-fir (*Pseudotsuga menziesii*) dominates the canopy and regeneration in most areas. Western red cedar (*Thuja plicata*) and Oregon white oak (*Quercus garryana*) also occur in smaller numbers within the conifer forest.

Common understory shrub species include beaked hazelnut (*Corylus cornuta*), snowberry (*Symphoricarpos albus*), trailing blackberry (*Rubus ursinus*), Scot's broom, and salal (*Gaultheria shallon*). Other species include twin flower (*Linnea borealis*), low Oregon grape (*Mahonia nervosa*), sword fern (*Polystichum munitum*), bald-hip rose (*Rosa gymnocarpa*), red huckleberry (*Vaccinium parvifolium*), ocean spray (*Holodiscus discolor*), black-cap raspberry (*Rubus leucodermis*), kinnikinnick (*Arctostaphylos uva-ursi*), bracken fern (*Pteridium aquilinum*), St. John's wort (*Hypericum perforatum*), western and hairy honeysuckles (*Lonicera ciliosa* and *L. hispidula*, respectively), wild strawberry (*Fragaria vesca*), yarrow (*Achillea millefolium*), yerba Buena (*Satureja douglasii*), wood rush (*Luzula parviflora*), velvet grass (*Holcus lanatus*), and colonial bentgrass (*Agrostis capillaris*).

The Re-Mine Area portion of the site is an active mining area dominated with grassland, with patches of shrubland and young stands of red alder (*Alnus rubra*). An approximately 5-acre patch of conifer forest is located at the south end of the Re-Mine Area with similar species composition as the Expansion Area (see **Figure 2-2** of **Chapter 2** of this Draft EIS). Forest vegetation within the off-site Sequalitchew Creek Restoration Area includes riparian habitat associated with Sequalitchew Creek and wetland buffer habitat of wetlands within the Restoration Area. These forested areas are a mixture of coniferous and deciduous trees with a diverse shrub and herbaceous understory. Sequalitchew Creek, wetlands within the Restoration Area, and nearby wetlands are described under *Aquatic Resources* later in this section.

Landmark Trees

A landmark tree survey was performed for the site consistent with DMC Critical Area Chapter 25.10.120.005 criteria. The DMC defines a "landmark tree" as "an existing healthy, well formed tree which poses no safety hazard due to potential collapse, and that meets minimum diameter measurements. Five species and a total of 116 landmark trees were identified during the survey. Landmark tree species include Douglas-fir, Oregon white oak, Pacific madrone, (*Arbutus menziesii*), Pacific yew (*Taxus brevifolia*), and western red cedar. The species and number of landmark trees within the Expansion Area and Re-Mine Area are shown in **Table 3.6-1**. See **Appendix I** for additional detail on landmark trees on the site.

Table 3.6-1
LANDMARK TREES ON THE SITE

Common Name	Scientific Name	Expansion Area Total Trees[1]	Re-Mine Area Total Trees
Douglas-fir	*Pseudotsuga menziesii*	81	1
Oregon white oak	*Quercus garryana*	17	2
Pacific madrone	*Arbutus menziesii*	2	0
Pacific yew	*Taxus brevifolia*	2	0
Western red cedar	*Thuja plicata*	10	1
Total		**112**	**4**

[1] Includes adjacent buffer.
Source: Anchor QEA, 2021.

Shrublands

Shrublands within the Expansion Area portion of the site are dominated by the non-native invasive species Scot's broom. This non-native invasive plant community covers approximately 42 acres of the Expansion Area. Plant coverage beneath this layer is restricted to mosses and small patches of colonial bentgrass. Native shrub species are mostly absent and are present in only a few areas adjacent to patches of native tree species. The native herbaceous species include Idaho fescue (*Festuca idahoensis*), chocolate

lily (*Fritillaria lanceolata*), early blue violet (*Viola adunca*), and Pacific sanicle (*Sanicula crassicaulis*).

As mentioned previously, the Re-Mine Area portion of the site is an active mining area dominated with grassland areas that were hydroseeded during reclamation. The presence of the non-native invasive species Scot's broom and the native species red alder are controlled as part of the reclamation process of the mining.

Shrublands associated with the off-site Sequalitchew Creek Restoration Area (and associated with the nearby wetlands) include wetland buffer habitat that is a mixture of native and nonnative shrub species. Sequalitchew Creek, wetlands within the Restoration Area, and nearby wetlands are described under *Aquatic Resources* below.

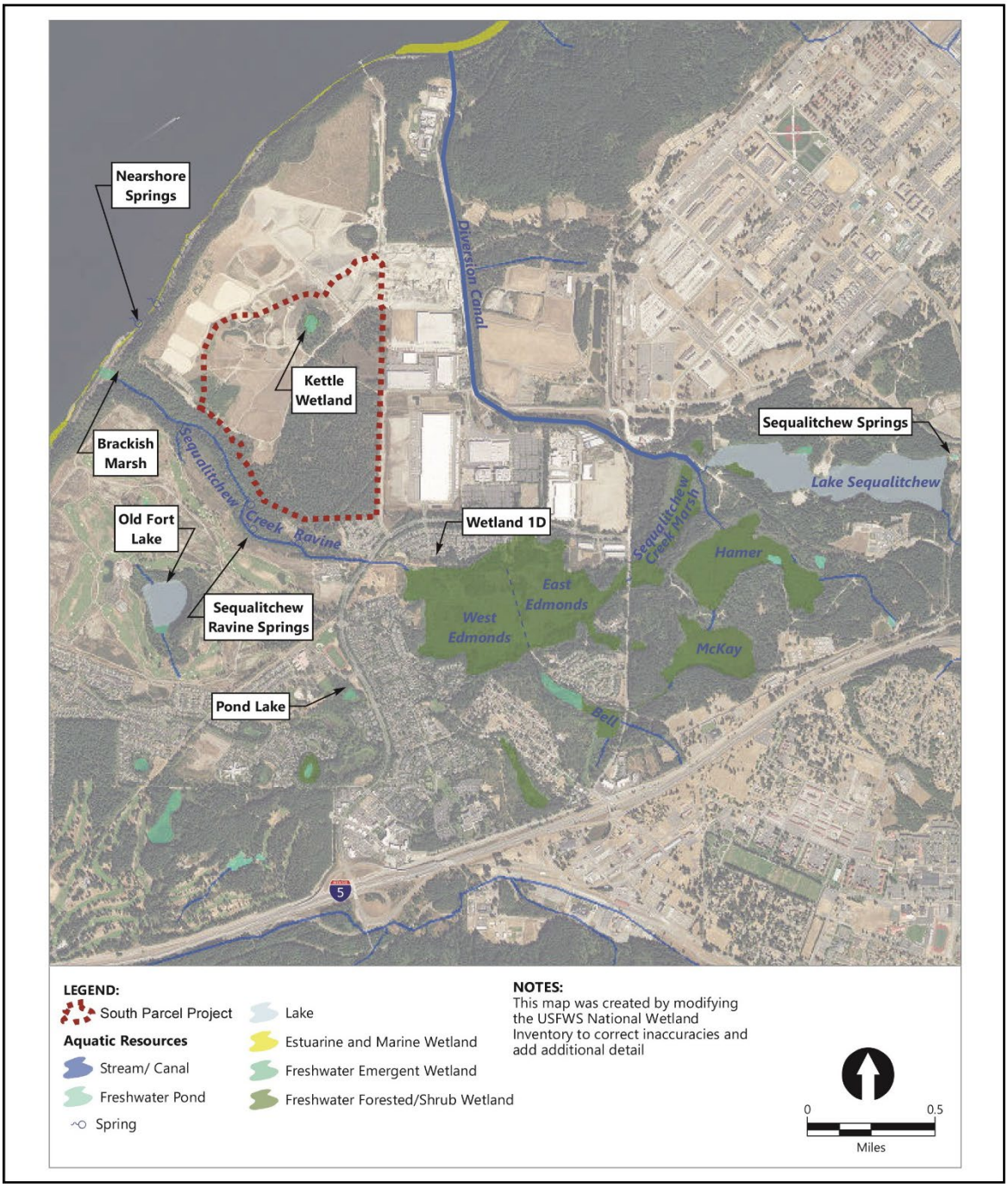
Aquatic Resources

Aquatic resources on the site and in the site vicinity include Sequalitchew Creek, Puget Sound shoreline nearshore springs, and eight wetland communities. No aquatic resources are located within the Re-Mine Area portion of the site. One aquatic resource, the Kettle Wetland, is located within the Expansion Area portion of the site. Sequalitchew Creek and the East Edmond Marsh, West Edmond Marsh, Sequalitchew Creek Riparian Wetlands, and the Brackish Marsh wetland systems are located offsite but within the Sequalitchew Creek Restoration Area and within the area where changes in groundwater levels could occur. Three nearby wetlands are Sequalitchew Creek Ravine Seep Wetlands, Pond Lake, and Wetland 1D (see **Figure 3.6-1**).

Expansion Area Portion of Site Wetlands

Kettle Wetland

The Kettle Wetland is an approximately 1.78-acre, Category III wetland, with a 75-foot required buffer (Per MDC 25.105.050(1)(b)(C). This wetland is located within the Expansion Area portion of the site (see **Figure 3.6-1**). This wetland contains persistent emergent, non-persistent emergent, aquatic bed, and scrub-shrub wetland communities. The dominant hydrologic source for the wetland is the aquifer system. Water levels within the wetland are determined by the seasonal fluctuation in the elevation of the Vashon Aquifer.



Source: Anchor QEA, 2022.

EA Engineering, Science, and Technology, Inc., PBC

Figure 3.6-1

Existing Aquatic Resources

The emergent communities within this wetland consist of common mare's tail (*Hippuris vulgaris*), creeping spike rush (*Eleocharis palustris*), giant bur-reed (*Sparganium eurycarpum*), water parsnip (*Sium suave*), reed canarygrass (*Phalaris arundinacea*), water ladysthumb (*Polygonum amphibium*), mild waterpepper (*Polygonum hydropiperoides*), skunk cabbage (*Lysichiton americanus*), inflated sedge (*Carex vesicaria*), and northern bugleweed (*Lycopus uniflorus*). Aquatic species observed during site visits include pondweed (*Potamogeton* sp.), lesser duckweed (*Lemna minor*), arrowleaf bur-reed (*Sparganium angustifolium*), and floating-leaved pondweed (*Potamogeton natans*). Along the wetland boundary, the scrub-shrub community consists of Pacific willow (*Salix lasiandra*), Scouler's willow (*Salix scouleriana*), sitka willow (*Salix sitchensis*), red-osier dogwood (*Cornus sericea*), and hardhack (*Spiraea douglasii*). Other vegetation along the wetland boundary consists of stinging nettle (*Urtica dioica*), blue elderberry (*Sambucus caerulea*), beaked hazelnut, and Henderson sedge (*Carex hendersonii*).

Buffer vegetation bordering the Kettle Wetland includes tree, shrub, grass, and herbaceous species. Dominant tree species include big-leaf maple (*Acer macrophyla*), red alder, black cottonwood (*Populus trichocarpa*), western red cedar, bitter cherry (*Prunus emarginata*), Douglas hawthorne (*Crataegus Douglasii*), blue elderberry, and Pacific madrone. Dominant shrub species include trailing blackberry, salal, snowberry, Scot's broom, Oregon grape, bald-hip rose, ocean spray, sword fern, Saskatoon serviceberry (*Amelanchier alnifolia*), red huckleberry, and bracken fern. Herbaceous species include velvet grass, western wild-rye (*Elymus glaucus*), and colonial bentgrass (*Agrostis capillaris*). Vine species include manroot (*Marah oreganus*).

Off-Site Wetlands (Sequalitchew Creek Restoration Area)

The below describes off-site wetlands resources in the site vicinity; off-site wetland resources are located within the Sequalitchew Creek Restoration Area. The following describes wetlands in the Restoration Area offsite.

West Edmond Marsh

West Edmond Marsh is an approximately 80-acre, Category II wetland, with a 100- foot required buffer (per DMC 25.105.050(1)(b)(B). West Edmond Marsh is the portion of Edmond Marsh located west of Robinson Trail, a former railroad grade that bisects Edmond Marsh and east of Center Drive (see **Figure 3.6-1**). It has a hydrologic regime dominated by surface water inputs entering East Edmond Marsh to the east and smaller inputs from stormwater infiltration ponds along the north and south. Sequalitchew Creek follows a relatively straight path near the northern boundary of the marsh that results from historical efforts to drain and channelize the marsh.

Water levels in West Edmond Marsh are controlled by multiple beaver dams, the most substantial of which is a large beaver dam at the western boundary just upstream of the normally dry reach of Sequalitchew Creek under Center Drive.

Seasonal high water levels in West Edmond Marsh range from approximately 210 feet elevation in the westernmost portion to 211.8 feet elevation just downstream of Robinson Trail. The westernmost portion has seasonal variation in water levels of 4 to 5 feet and typically dries up in summer. The portion near Robinson Trail retains water year-round and typically experiences a seasonal range in water levels of 1 to 1.5 feet.

Over time, the hydrology of West Edmond Marsh has been affected by various efforts to maintain an open water channel through dense scrub-shrub wetland. The construction and periodic maintenance of this channel through the marsh maintained water levels that were lower than currently exist. Subsequent impoundment of water by beaver dams across this channel and elsewhere in the marsh has resulted in water levels of the marsh steadily increasing in recent decades, as is evidenced by the drowning of some mature upland trees. Vegetative communities include scrub-shrub, emergent, and aquatic bed wetland types. The eastern portion of the marsh is shallow to deeply inundated, due to impoundment by beaver dams. Dominant vegetation includes black cottonwood, willows (*Salix* sp.), spiraea (*Spirea douglasii*), water parsley (*Oenanthe sarmentosa*), yellow pond lily (*Nuphar luteum* var. *polysepala*), pond weed (*Lemna minor*), cattails (*Typha latifolia*), and reed canarygrass (*Phalaris arundinacea*). The area includes upland islands that are forested with mature Douglas-fir, black cottonwood, and other native species. The dense, layered vegetation within the marsh, upland islands, and patches of open water provide high-quality wildlife habitat and offer a substantial habitat base for native wetland plant and animal species.

East Edmond Marsh

East Edmond Marsh is an approximately 55-acre, Category II wetland, with a 100- foot required buffer. This wetland is located between the Robinson Trail on the west and DuPont-Steilacoom Road on the east (see **Figure 3.6-1**). East Edmond Marsh continues to the east of DuPont- Steilacoom on Joint Base Lewis-McChord.[1]

Historically, the primary source of water to East Edmond Marsh was the surface water of Sequalitchew Creek flowing out of Sequalitchew Lake. The Creek followed a meandering channel through the marsh that has been excavated and cleared by human activity. However, beaver activity has resulted in water levels in East Edmond Marsh that are higher than in Sequalitchew Lake, and now the hydrology of East Edmond Marsh is dominated by groundwater inflows from multiple sources including regional groundwater, shallow subsurface flow from nearby Bell, Hamer, and McKay marshes, and stormwater from nearby infiltration ponds.

The water level in East Edmond Marsh is controlled by a large beaver dam located just upstream of the primary culvert under Robinson Trail and is relatively uniform throughout the marsh segment. Seasonal high water levels are typically about 212.5 to 213 ft NGVD 29.

[1] *This segment of the Marsh is not evaluated for this EIS but will be evaluated as part of separate environmental review prepared by others required for the Sequalitchew Creek Restoration Plan.*

East Edmond Marsh retains water year-round, with a typical water level fluctuation of 1 to 1.5 feet seasonally.

Vegetative communities include forested, scrub-shrub, emergent, and aquatic bed wetland types. Dominant vegetation includes black cottonwood, red alder, Oregon ash (*Fraxinus latifolia*), willows, red-osier dogwood, spiraea, sedges (*Carex* spp.), bulrushes (*Scirpus* spp.), water smartweed (*Polygonum amphibium*), water parsley, cattails, and reed canarygrass. Floodwater storage, sediment sequestering, nutrient filtration, and biological support are strong functions of East Edmond Marsh. The area includes upland islands that are forested with mature Douglas-fir, black cottonwood, and other native species. The dense, layered vegetation within the marsh, upland islands, and patches of open water provide high-quality wildlife habitat and offer a habitat base for native wetland plant and animal species.

Sequalitchew Creek Ravine Riparian Wetlands

Sequalitchew Creek Ravine Riparian Wetlands are an approximately 0.5- acre, Category II wetland complex, with a 100- foot required buffer. These wetlands border Sequalitchew Creek west of Center Drive (see **Figure 3.6-1**) and includes many areas of braided flow and side-channels, flood terraces, and well-established forested riparian wetland vegetation communities. The canopy species include red alder, big-leaf maple, and western red cedar. Common shrub species include vine maple (*Acer circinatum*), salmonberry (*Rubus spectabilis*), red elderberry (*Sambucus acemose*), black gooseberry (*Ribes lacustre*), and cascara (*Rhamnus purshiana*). Common herbaceous species include mannagrass (*Glyceria elata*), giant horsetail (*Equisetum telmatiea*), American brooklime (*Veronica americana*), slough sedge (*Carex obnupta*), stinging nettle, Cooley's hedge-nettle (*Stachys coolyeii*), and water parsley.

Brackish Marsh

The Brackish Marsh is an approximately 0.5-acre, Category II wetland, with a 100- foot required buffer. Near its mouth, Sequalitchew Creek passes through a concrete box culvert (5 feet wide by 5 feet high and 240 feet long) under the BNSF Railway Company rail line before discharging into Puget Sound. Upstream of this culvert is the brackish marsh (see **Figure 3.6-1**). The Brackish Marsh occupies a series of terraces dissected by dendritic channels. Common plant species in the marsh include Lyngby's sedge (*Carex lyngbeyi*), seacoast bulrush (*Scirpus maritimus*), seashore saltgrass (*Distichlis spicata*), marsh cinquefoil (*Potentilla anserina*), and gumweed (*Grindelia integrifolia*). Significant patches of colonial bentgrass occur along the margins of the Brackish Marsh.

Nearby Wetlands

Sequalitchew Creek Ravine Seep Wetlands

The Sequalitchew Creek Ravine Seep Wetlands are an approximately 0.13-acre, Category IV wetland complex, with a 50-foot required buffer (DMC 25.105.050.(1)(b)_(D). The wetland complex, consisting of two long, very narrow, and non-contiguous wetlands, is located just above the trail along Sequalitchew Creek at about river mile 0.75 to 0.85. The ravine containing Sequalitchew Creek contains seeps and springs that surface from mid-slope to the toe of slope. These seeps and springs provide base flow to Sequalitchew Creek and contribute to species diversity within the area by supporting plant species that require more moisture than is available in surrounding upland areas. The wetland hydrology emanates from seep heads just above the trail and is dominated by groundwater. Dominant vegetation species include willow herb (*Epilobium ciliatum*) and lady fern (*Athyrium filix-femina*). These forested Seep Wetlands are classified as Category IV wetlands.

Wetland 1D

Wetland 1D is an approximately 2.1-acre, Category II wetland, with a 100-foot required buffer. This wetland is located immediately north of West Edmond Marsh and south of Center Drive (see **Figure 3.6-1**). Wetland 1D is shallow and permanently inundated. Water levels in Wetland 1D range seasonally from 208.6 to 211 feet and track closely with nearby groundwater levels. The wetland is dominated by scrub-shrub vegetation including Pacific willow, spiraea, western crabapple *(Malus fusca*), and red-osier dogwood.

Pond Lake

Pond Lake is an approximately 1.8-acre Category II wetland, with a 100-foot required buffer. This wetland is located approximately 0.5 mile south of the Expansion Area portion of the site (see **Figure 3.6-1**). The water level in Pond Lake typically exhibits a seasonal range of about 4 feet and tracks closely with nearby groundwater levels. It is a shallow pond dominated by herbaceous species, with a forested upland edge dominated by red alder and big-leaf maple. The dominant species in the wetland is reed canarygrass. Small pockets of native species including sedges and water-plantain (*Alisma plantago-aquatica*) occur in the wetland.

Nearshore Springs

Nearshore springs located along the shore immediately west of the Existing Mine and north of the mouth of Sequalitchew Creek of Puget Sound, flow directly into Puget Sound (see **Figure 3.6-1**). These springs express from the rip rap protected shore and there is no surface flow associated with these features within the site.

Rare Plants and Plant Communities

Washington Department of Fish and Wildlife Plants and Priority Habitats

No rare plants are identified by Washington Department of Fish and Wildlife (WDFW) in locations where mining could occur in the site or within the areas subject to changes in groundwater levels. No populations of white-topped aster (*Sericocarpus rigidus*), a state sensitive species, have been documented within the limits of the site, although populations do occur in Pierce County and in oak forests elsewhere in the area.

A patch of forested habitat at the south end of the Re-Mine Area where mining is proposed is mapped by WDFW as priority habitat biodiversity areas and corridor, but the physical characteristics within the small portion where mining is planned do not meet WDFW's stated criteria. Specifically, this area is flat, developable land and is not part of the steep, undevelopable ravine side slope. The forested riparian habitat of Sequalitchew Creek and the forested hillside of Puget Sound near where mining is proposed are also mapped as priority habitat biodiversity areas and corridor. The habitat of East and West Edmond Marsh are mapped by WDFW as waterfowl concentration areas. The Priority Habitats and Species (PHS) database does not include any white oak woodlands in or around the site, or within the City of DuPont. Where white oak exist within the site, they are interspersed in a primarily coniferous forest within the Expansion Area and account for less than 5% of the canopy. WDFW defines priority Oregon white oak woodlands as stands of pure oak or oak/conifer associations where canopy coverage of the oak component of the stand is 25%; or where total canopy coverage of the stand is less than 25%, but oak accounts for at least 50% of the canopy coverage present. The latter is often referred to as an oak savanna. In non-urbanized areas west of the Cascades, priority oak habitat consists of stands one acre in size. Therefore, the interspersed oaks on the site does not meet WDFW criteria for priority habitat.

Important habitats in the larger vicinity of the site include the Nisqually Delta, located approximately two miles from the site. This delta is a large, high-quality wetland complex with regionally rare intact estuarine functions and native plant populations, abundant wildlife habitat, and high utilization by wildlife.

U.S. Fish and Wildlife Service Threatened and Endangered Plants

The U.S. Fish and Wildlife Service (USFWS) identifies Endangered Species Act (ESA)-listed plant species and critical habitats under USFWS jurisdiction that occur or may occur within a specific location where a project is proposed on the agency's website. The status of federally listed plant species and critical habitats protected under the ESA that occur or may occur where mining is proposed on the site or within the area subject to changes in groundwater levels is presented in Table 5 of **Appendix H**. The site and site vicinity does not contain any potential habitat for the ESA plant species golden paintbrush (*Castilleja levisecta*) and marsh sandwort (*Arenaria paludicola*).

Animals

Animal species are described below based on the animal types: birds, mammals, and amphibians. Several federally- and state-listed species occur within the site vicinity. Their status and use of the site vicinity are described.

Birds

The site and off-site Sequalitchew Creek Restoration Area provides a range of habitat features that can provide breeding, foraging, resting, and overwintering habitat to support a wide range of bird species. Forested habitats provide foraging and nesting habitat for a wide variety of songbird species such as song sparrow (*Melospiza melodia*), bushtit (*Psaltriparus minimus*), Bewick's wren (*Thryomanes bewickii*), Steller's jay (*Cyanocitta stelleri*), spotted towhee (*Pipilo erythrophthalmus*), Swainson's thrush (*Catharus ustulatus*), winter wren (*Troglodytes hiemalis*), varied thrush (*Ixoreus naevius*), black-capped chickadee (*Parus atricapillus*), dark-eyed junco (*Junco hyemalis*), chestnut-backed chickadee (*Parus rufescens*), golden-crowned kinglet (*Regulus satrapa*), and red-breasted nuthatch (*Sitta canadensis*).

Upland shrublands and herbaceous habitats are used by species like barn swallow (*Hirundo rustica*), tree swallow (*Tachycineta bicolor*) and white-crowned sparrow (*Zonotrichia leucophrys*). Predatory birds like red-tailed hawk (*Buteo jamaicensis*) commonly hunt in these habitat types. Other raptors such as northern harrier (*Circus cyaneus*) and bald eagle (*Haliaeetus leucocephalus*) occur in forested areas near waterbodies. Snags and downed trees in forested habitat and along the forest edges also provide perch sites for these species. Snags in forested habitats also provide potential nest sites for cavity-nesting birds such as great horned owl (*Bubo virginianus*), and species of woodpeckers including downy woodpecker (*Picoides pubescens*), northern flicker (*Colaptes auratus*), and pileated woodpecker (*Dryocopus pileatus*).

Aquatic habitats and wetland habitats provide a variety of habitat for terrestrial birds, waterbirds, and waterfowl. Open water sections of wetlands can be expected to provide habitat for belted kingfisher (*Megaceryle alcyon*) and wintering and migratory waterfowl, including gadwall (*Anas strepera*), American widgeon (*Mareca americana*), mallard (*Anas platyrhynchos*), ring-necked duck (*Aythya collaris*), and American coot (*Fulica americana*). Wetland areas with grass and herbaceous vegetation provide habitat for red-winged blackbird (*Agelaius phoeniceus*), song sparrow, and marsh wren (*Cistothorus palustris*), among other species including waterfowl. Forested and scrub-shrub wetlands are commonly used by similar species as well as wood duck (*Aix sponsa*). Waterbird species such as great blue heron (*Ardea herodias*) also use many of these habitats.

Mammals

Small mammal species associated with forested habitats include shrew mole (*Neurotrichus gibbsii*), Townsend's vole (*Microtus townsendii*), masked shrew (*Sorex cinereus*), and striped skunk (*Mephitis mephitis*). Larger mammals such as black-tailed deer (*Odocoileus hemionus columbianus*) and coyote (*Canis latrans*) also occur throughout the site.

Wetlands and riparian areas provide habitat for North American beaver (*Castor canadensis*), water shrew (*Sorex palustris*), and raccoon (*Procyon lotor*). Beavers are well documented in the wetland habitats of East and West Edmond Marsh. The non-native species Virginia opossum (*Didelphis virginiana*) also occurs in these habitat types. These and similar species depend on water for foraging, breeding, and sometimes, overwintering habitats.

Amphibians

Wetlands and streams provide habitat for amphibian species such as northern red-legged frog (*Rana aurora*), northwestern salamander (*Ambystoma gracile*), Pacific treefrog (*Pseudacris regilla*), roughskin newt (*Taricha granulosa*), and western red-backed salamander (*Plethodon vehiculum*).

Washington Department of Fish and Wildlife Priority Species

Three priority species are mapped by WDFW as occurring or their habitat present within the site: big brown bat (*Eptesicus fuscus*), little brown bat (*Myotis lucifugus*), and Yuma myotis bat (*Myotis yumanensis*). These bat species occur in forested habitats, typically occupying mature trees. They are not state or federally listed.

Western gray squirrel (*Sciurus griseus*), a state threatened species, is documented within the site vicinity but is not currently identified by WDFW as occurring within the site and surrounding area. This species favors Garry oak (*Quercus garryana*) woodlands as prime habitat. This habitat occurs within areas adjacent to the site, in patches throughout the City of DuPont, and also within the Fort Lewis Military Reservation. This species also forages within coniferous forests that occur near Garry oak woodlands.

The Western gray squirrel was listed as threatened in Washington State in 1993 (WAC 323.12.011). There are three known populations in Washington: the southern Puget Trough, north-central Washington, and south-central Washington. Typical Western gray squirrel habitat in the Puget Trough includes a Douglas-fir-Oregon white oak woodland with an understory dominated by snowberry (*Symphoricarpos albus*), California hazelnut (*Corylus cornuta* var. *californica*), Indian plum (*Oemleria cerasiformis*), and sword fern (*Polystichum munitum*). The typical characteristics of oak woodlands that are important to Western gray squirrels consist of a mix of Douglas-fir (53% on average) with oaks comprising 34% on average. These characteristics were not observed within the site (see **Appendix H** for detail).

One of the primary limiting factors in Western gray squirrel success in the Puget Trough is the lack of genetic diversity through habitat fragmentation. The South Parcel is separated from the primary Western gray squirrel population at Joint Base Lewis-McChord (JBLM) by Interstate 5, as well as several other heavily used roadways. While a small amount of canopy connectivity to JBLM property exists across the Puget Sound Bluff and up Sequalitchew Creek ravine, the lack of connectivity to confirmed squirrel-populated sites contributes to the overall lack of habitat potential on the site for gray squirrels. Accordingly, the site (including Expansion Area) does not provide primary (nesting, breeding) habitat for Western gray squirrel. While the site does possess marginal characteristics of secondary squirrel habitat (e.g., conifer-dominated, moderate canopy and shrub coverage), the factors identified above make the possibility of use of the site by Western gray squirrel remote.

U.S. Fish and Wildlife Service Threatened and Endangered Species

No USFW-listed ESA fish or wildlife species or critical habitats have been identified to be present within the site or vicinity (see **Appendix H** for detail).

3.6.2 Impacts of the Alternatives

This section identifies and analyzes impacts to plants and animals and their habitat on and in the vicinity of the site with proposed clearing, mining (including dewatering), and reclamation under the Proposed Action. Conditions under the No Action Alternative are also identified.

As described in **Chapter 2** of this DEIS, the 2011 Settlement Agreement states that permits for the Pioneer Aggregates South Parcel Project (Proposed Action) shall not be effective until permits for the Sequalitchew Creek Restoration Plan (Restoration Plan) are in place, as a separate but related action. The Restoration Plan seeks to restore and enhance streamflow and ecological functions from Sequalitchew Lake through Edmond Marsh into Sequalitchew Creek ravine by sequentially restoring diverted flows back to the creek, improving the sustainability of flows through the system, and restoring aquatic habitat. Consistent with the 2011 Settlement Agreement, this DEIS assumes that mining and reclamation activities under the Proposed Action would not proceed until the permits are in place to implement the Restoration Plan. It is assumed that projects associated with the Restoration Plan would be mitigation for certain environmental impacts identified in this DEIS, and that permits for the Restoration Plan would be a condition of any City of DuPont approval of the Proposed Action. However, because the Restoration Plan is considered a separate project that would be subject to separate environmental review and could be funded and implemented independent of the Proposed Action, the general discussion in the Environmental Impacts sub-section of Plants & Animals only addresses the impacts of the proposed mining/reclamation and does not include implementation of the Restoration Plan. This is intended to help the reader understand the impacts of the proposed

mining/reclamation, and the need for the Restoration Plan with the proposed project. Proposed mining/reclamation in combination with the Restoration Plan is specifically discussed under Cumulative Impacts.

ALTERNATIVE 1 – PROPOSED ACTION

Direct Plants and Habitat Impacts

Conifer Forests

The majority of coniferous forests within the site would be logged prior to initiating mining. The total area of coniferous forest proposed for clearing within the Re-Mine Area portion of the site is approximately 15 acres, and the conifer forest proposed for clearing in the Expansion Area portion of the site is approximately 135 acres. Revegetation would occur throughout the site consistent with the reclamation plan developed for both the existing and proposed mining areas. Reclamation would include the establishment of mixed species, including Oregon white oak, and conifer-dominant forests along the slopes of the mine.

Landmark Trees

Ninety landmark trees would be removed under the Proposed Action including Douglas-fir (74), Oregon white oak (13), Pacific madrone (1), Pacific yew (1), and western red cedar (1). All of these landmark trees are within the Mineral Resource Overlay designated under the City's Comprehensive Plan. Replacement of landmark trees would be provided, consistent with City of DuPont replacement ratio guidance.

Shrublands and Grasslands

The majority of the shrublands and grasslands within the site would be cleared in conjunction with proposed logging activities. The total area of shrublands and grasslands within the Re-Mine Area portion of the site is approximately 60 acres, with most of that area comprised of grassland habitat associated with hydroseeding during reclamation activities. The total area of shrublands and grasslands within the Expansion Area portion of the site is approximately 42 acres. The dominant shrublands species is the non-native invasive species Scot's broom. Scot's broom has been controlled in the Re-Mine Area during reclamation activities and would also be controlled throughout the site during mining and reclamation. This control of invasive species would benefit the existing adjacent native habitats and the riparian corridor of North Sequalitchew Creek by reducing invasive species pressure. Grassland and shrublands would be created on the site with proposed reclamation, similar to reclamation associated with portions of the Existing Mine.

Aquatic Resources

The 1.8-acre Kettle Wetland is the only aquatic resource located within the site and the only aquatic resource that would be directly impacted by the Proposed Action.

Kettle Wetland - The Kettle Wetland and its buffer would be cleared under the Proposed Action, and the entire wetland would be eliminated. The Kettle Wetland relies on groundwater to sustain wetland vegetation so even if the Kettle Wetland were to be left in place within the site, the change in groundwater levels would eventually alter the hydrology of the Kettle Wetland, converting the wetland vegetation to upland plant species. Proposed mitigation for these wetland impacts includes creation of a new wetland, as discussed in Sub-Section 3.6.3.

Rare Plants and Plant Communities

The Proposed Action would not directly impact rare plants or rare plant communities.

Indirect Plant and Habitat Impacts (Offsite)

Conifer Forests

No indirect impacts to coniferous forest habitats (i.e. loss of forest area) outside the site associated with the Proposed Action are anticipated.

Shrublands and Grasslands

No indirect impacts to shrublands and grasslands habitats (i.e. loss of shrublands or grasslands) outside the site associated with the Proposed Action are anticipated.

Aquatic Resources

The aquatic resources of Sequalitchew Creek and the four wetland systems within the Sequalitchew Creek Restoration Area: East Edmond Marsh, West Edmond Marsh, and the Sequalitchew Creek Riparian Wetlands are within the area where wetland hydrology could be affected by changes in groundwater levels under the Proposed Action. The wetland hydrology of aquatic resources identified as nearby wetlands, except for the Seep Wetlands (Sequalitchew Creek Ravine, Pond Lake, and Wetland 1D) could also be affected by changes in groundwater levels, but any effects are anticipated to be minor. The indirect effects of the Proposed Action on the Seep Wetlands are anticipated to have a greater potential for impact. Groundwater seeps that support the hydrology of these wetlands would be reduced, resulting in a reduction or loss of wetland hydrology. The Brackish Marsh is not anticipated to be affected by changes in groundwater levels due the dominance of tidal hydrology on that resource. The potential hydrologic impacts on these wetlands are described in greater detail below.

West Edmond Marsh and Wetland 1D - West Edmond Marsh and Wetland 1D are the two resources that are most likely to be affected by the proposed groundwater drawdown without implementation of the Sequalitchew Creek Restoration Plan (see Section 3.3, **Groundwater**, and Section 3.4, **Surface Water**). Earlier drying of saturated and inundated areas could have detrimental effects on the existing plant community. Wetland plant communities (and soils) are shaped by saturated and inundated conditions during the growing season (averages from March 1 to October 31). Exotic plant invasion (particularly reed canarygrass) favors this type of alteration when winter saturation and inundation are not sufficient to maintain existing plant communities or preclude noxious weed invasion.

It is likely that a slow conversion of wetland habitats would occur; the changes could result in some conversion of aquatic wetland habitat to emergent wetland habitat and emergent wetland habitat to shrub-scrub wetland habitat (see **Appendix H** for detail).

East Edmond Marsh - Under the Proposed Action the drawdown effects on East Edmond Marsh would result in an average decrease in water level of 1.2 inches (see Section 3.3, **Groundwater**, and Section 3.4 **Surface Water**). The decrease would be greatest in June at about 1.5 inches and lowest in February at less than 0.1 inch. East Edmond Marsh would continue to follow the same seasonal pattern of fluctuation with the highest water levels in January through March and seasonal lows in August and September. It is not anticipated that this change would have any measurable effect on the wetland given that this decrease would occur within a seasonal fluctuation in water level of more than 20 inches. Ultimately, continued beaver activity would be anticipated to have a greater impact on water levels in the marsh.

Pond Lake - Pond Lake is an isolated water body, hydrologically connected to groundwater with little surface water inflow and no outflows. With the Proposed Action, the surface water level in Pond Lake is conservatively projected to decrease by about two feet, based on the amount of groundwater drawdown estimated in its vicinity. The surface water level in Pond Lake currently varies seasonally by up to eight feet but more typically around four feet. Pond Lake goes dry in summer. With the Proposed Action, the seasonal variation would be two feet, and the lake would go dry a month earlier and rewet slightly later. Herbaceous vegetation in Pond Lake varies from year to year depending on when the water levels recede. With the Proposed Action, the conditions observed during driest years would become common, with more emergent vegetation and less aquatic vegetation establishing. A sustained reduction in peak water levels could allow establishment of scrub-shrub wetland species along the wetland boundary and greater cover of reed canary grass within the higher parts of the wetland. The relatively steep slopes around the wetland would prevent the wetland size from substantially changing.

Sequalitchew Creek and Riparian Forest Wetlands - Without restoration, Sequalitchew Creek west of Center Drive would experience reduced base flows as a result of reduction in seep and spring discharge caused by the drawdown of the Vashon Aquifer. A reduction of aquatic life would be expected to occur in the upper ravine without implementation of the Sequalitchew Creek Restoration Plan activities (see Section 3.5, **Fisheries**, for additional detail).

Without implementation of the Restoration Plan, the change in groundwater levels would eliminate the hydrologic support provided to the Sequalitchew Creek riparian forest wetlands and some loss of the existing wetland vegetation would occur.

Sequalitchew Creek Ravine Seep Wetlands - Dewatering of the aquifer under the Proposed Action is likely to indirectly impact the Seep Wetlands along the Sequalitchew Creek trail by disrupting the hydrology of these wetlands. These indirect impacts would result in the loss of wetland vegetation and function of the wetlands. The resulting loss in wetland area could be up to 0.13 acre of wetland habitat being converted to upland habitat due to insufficient saturation during the growing season.
Indirect impacts from changes in the aquifer would also affect the springs in the Sequalitchew Creek bed.

Brackish Marsh - The reduction in flows in Sequalitchew Creek resulting from dewatering of the Vashon Aquifer without implementation of the Sequalitchew Creek Restoration Plan are estimated at 1.3 cfs. While this is a substantial fraction of the freshwater in the marsh, it is anticipated to have little impact to the Brackish Marsh. The reduction in freshwater input would result in only a negligible increase in salinity in the marsh during high tides. No effect on the existing wetland is anticipated as a result of salinity alterations (see **Appendix H** for detail).

Nearshore Springs - The springs that flow directly into Puget Sound express from the shore near the toe of slope at the beach and there is no surface flow associated with these features within the site. No measurable change in groundwater flow from these springs is expected, and no impacts to these springs are expected as a result of the Proposed Action.

Direct Impacts to Animals

Birds

The Proposed Action would reduce and degrade existing foraging and breeding habitat for some bird species that use habitats within the site. The clearing of vegetation would increase the fragmentation and isolation of remaining habitats. The components of the Proposed Action with the greatest potential to impact bird habitats are the clearing of vegetation which would eliminate the existing foraging and breeding habitats for birds.

Reclamation of the mine slopes would continue to progress. After mining activities are completed, the Proposed Action would increase the acreage of reclaimed and reforested areas on the mine slopes, and their associated potential habitat for birds, by approximately 177 acres.

The removal of the Kettle Wetland could disrupt bird habitat and reduce breeding, wintering, and migration habitat for bird species until habitat in the mitigation wetland is fully functional. Although different from wetland buffer habitat, restored forests on reclaimed slopes are currently maturing and would continue to provide new habitat to offset this impact.

Mammals

The Proposed Action would alter habitat for mammal species within the site for reasons similar to those described for above for birds. The majority of individual mammals would disperse into adjoining habitats; however, some of the individual mammals could perish. The proximity of the site area to similar intact habitats would provide dispersal routes as proposed clearing begins. Clearing would occur segmentally which may provide small mammals opportunity to relocate and disperse into newly reclaimed areas.

Amphibians and Reptiles

Within the Kettle Wetland, any existing amphibians would perish during the clearing of the surface vegetation and soils. New habitat with similar hydrology would be created in the mitigation wetland to compensate for these impacts; see Sub-section 3.6.3 for detail.

Washington Department of Fish and Wildlife Priority Species

Removal of mature trees in the coniferous forest could reduce habitat for big brown bat, little brown bat, and Yuma myotis bat priority species. Clearing of forested areas within the site would reduce habitat that is thought to have once been within the historical range of gray squirrels but is unlikely to be occupied by the current population.

U.S. Fish and Wildlife Service Threatened and Endangered Species

No ESA-listed animals species habitat would be altered directly as a result of the Proposed Action. Refer to Section 3.4, **Fisheries**, of this EIS for analysis of the potential effects on fish species.

Indirect Impacts to Animals

Birds

The alteration of wetland systems within the off-site area with the changes in groundwater level without Sequalitchew Creek Restoration, particularly East and West Edmond Marsh,

could disrupt bird habitat and reduce breeding, wintering, and migration habitat for bird species. These areas are documented to regularly attract concentrations of waterfowl. However, the potential impacts to wetland area associated with changes in groundwater level is anticipated to be minor relative to the size of the wetland systems, particularly in combination with the Sequalitchew Creek Restoration Plan activities (see *Cumulative Impacts* below for detail).

Mammals

The alteration of Edmond Marsh and other wetland systems that could be modified by the changes in groundwater without mitigation could disrupt the existing wetland mammal habitat by removing existing water and food sources and sheltering vegetation, thereby reducing the available breeding and foraging habitat for aquatic habitat dependent mammal species (e.g., beaver). However, the potential reduction in wetland areas due to changes in groundwater level are expected to be minor relative to the size of the wetland systems, particularly in combination with the Sequalitchew Creek Restoration Plan activities (see *Cumulative Impacts* below for detail). Use of the Seep Wetlands by mammals is unlikely, and a reduction in the size or the loss of the Seep Wetlands would have minimal impacts due to the proximity of the much larger Sequalitchew Creek and its associated riparian areas, which provide mammalian habitat.

Amphibians and Reptiles

Loss of wetland area, alterations to seasonal inundation patterns, and subsequent changes in plant communities would reduce the area of habitat that support amphibians. These changes could indirectly disrupt amphibian habitat and reduce breeding, wintering, and foraging habitat for amphibian species.

The early drying of normally inundated areas could adversely affect amphibian breeding by lowering surface water levels during the breeding and rearing seasons. This could result in the loss of available habitat, leading to exposure of egg masses and rearing juveniles from reduced water levels. Tadpoles, juveniles, and adults may disperse to areas that remain inundated during early drying periods. However, the existing amphibian population likely uses all available habitats. Thus, unoccupied amphibian habitats are likely to be unavailable to individuals dispersing from drying portions of the wetlands. However, the potential reduction in wetland area associated with the changes in groundwater level is expected to be minor relative to the size of the wetland systems, particularly in combination with the proposed Sequalitchew Creek Restoration Plan activities (see *Cumulative Impacts* below for detail).

CUMULATIVE IMPACTS WITH PROPOSED ACTION AND SEQUALITCHEW CREEK RESTORATION PLAN

Introduction

As indicated in **Chapter 2** (Description of Proposed Action and Alternatives) of this EIS, the 2011 Settlement Agreement indicates that any approval for mining under the Pioneer Aggregates South Parcel Project shall include a provision that prohibits mining until permits are in place to implement the Sequalitchew Creek Restoration Plan developed by CalPortland and the Environmental Caucus, as a separate but related action. The Sequalitchew Creek Restoration Plan seeks to restore and enhance streamflow and ecological functions from Sequalitchew Lake through Edmond Marsh into Sequalitchew Creek ravine. The Restoration Plan seeks to address almost two centuries of human manipulation. The principal goals of the Restoration Plan are to restore flows in Sequalitchew Creek, portions of which are now dry. This goal will be achieved by implementing a series of actions in a coordinated and adaptively managed project. The Restoration Plan is intended to sequentially restore diverted flows back to the creek, improve the sustainability of flows through the system, and restore aquatic habitat by removing flow-related fish passage barriers and increasing the habitat available to aquatic species.

The Sequalitchew Creek Restoration Plan has the potential to restore an annual average of 12.9 cfs to a 1,200-foot reach of Sequalitchew Creek that currently experiences little to no consistent flow. Seasonally, the flows in this reach following restoration are predicted to be between 2.5- cfs in August up to just over 26 cfs in March. Flows of this magnitude would re-establish a functioning stream in the now frequently dry channel, providing new aquatic and riparian habitat and a connection between the Sequalitchew Creek ravine and the marshes. This would provide a corridor for both aquatic and terrestrial species and would provide new opportunities for species expansion and recovery.

Cumulative Conditions

The combined impacts of mining under the Proposed Action together with implementation of the Sequalitchew Creek Restoration (the 'cumulative condition') on stream and wetland habitat is discussed below.

Sequalitchew Creek

The combined impacts under the cumulative condition on stream habitat would include re-establishing flow from Sequalitchew Lake to flow through the marshes and into Sequalitchew Creek ravine. The cumulative condition would also result in re-establishing the ecosystem process, specifically, the movement of water, sediment, nutrients, biota, and dissolved gases through the watershed from the headwater springs on Sequalitchew Lake to

Puget Sound. The increase in hydrology and stream energy are anticipated to increase aquatic ecosystem productivity and create and maintain habitat diversity. See Section 3.3, **Fisheries**, for discussion on cumulative conditions associated with stream flow and creek water quality.

Wetlands

The Sequalitchew Marsh wetland complex has increased in size by more than 30 acres since the late 1990s when efforts to maintain a channel through the system were abandoned, and beaver dams began to raise water levels, preventing flow from reaching the ravine and redirecting nearly all flow to the Diversion Canal (see **Figure 3.6-1**). A fundamental goal of the Sequalitchew Creek Restoration Plan is to direct flows from the Diversion Canal back down Sequalitchew Creek. This requires restoring the historical gradient from the outlet of Sequalitchew Lake to the top of the ravine, which would require a lowering of water levels in some parts of the wetland complex resulting in a reduction of wetland acreage.
Some wetland and lake fringe habitats would be gained with the Sequalitchew Creek Restoration Plan. Raising water levels in Hamer Marsh would compensate for some wetland loss. Removing fill from Edmond Marsh would also compensate for some wetland loss and more connectivity and function in the wetland.

Marsh Water Levels

As outlined in the Sequalitchew Creek Restoration Plan, reconnecting flow from Sequalitchew Lake to the Sequalitchew Creek ravine will require lowering water levels in some areas of the marshes in order to establish a consistent downhill gradient (refer to **Appendix H** for additional detail).

A water balance model analysis was conducted to evaluate the combined effects of the Sequalitchew Creek Restoration and mining under the Proposed Action, includes an assumption that there would be little variation in wetland water levels in the cumulative condition, as there would almost always be more than enough flow from Sequalitchew Lake to keep the wetlands full to their target elevations. However, there would likely be some summers when water levels in Eastern East Edmond Marsh would dip below the target elevations for a month or more. East and West Edmond Marshes would also experience occasional dips below the target elevation, but of lesser magnitude and much less frequently. These impacts could be reduced or eliminated by managing water level behind the beaver dams to store water and release it slowly during periods of low flow. The hydraulic gradient through the marshes would always be maintained, however, as the water level in Eastern East Edmond Marsh never dips below the water level in East Edmond Marsh allowing water stored in the marsh to flow downstream to the ravine.

The model results indicate that most months of the year (September through June), the wetland system would experience contribute a small amount of additional water to the flow from Sequalitchew Lake, ranging from a 8% gain in April up to a 26% gain in October.

However, in the driest months (July and August) some flow (up to 3%) would be lost in the wetlands from evaporation and losses to groundwater. (see **Appendix H** for additional detail).

Wetland Water Quality

The cumulative condition would benefit the water quality in Eastern East Edmond Marsh and Edmond Marsh by providing a large amount of high-quality water. The residence time in the wetlands would be less than at present, decreasing from weeks or months to days. Water quality in the wetlands would be dominated by the input from Sequalitchew Lake. As a result, dissolved oxygen would be higher, and the pH would be slightly more neutral. Temperature and turbidity have been about the same in the lake and marshes, so little change is anticipated in these parameters. It is also anticipated that the elevated iron concentrations observed in the center of Edmond Marsh would be resolved through flushing and dilution with Sequalitchew Lake water (see **Appendix H** for detail).

Conifer Forest

The restoration of the watershed under the cumulative condition would allow the re-establishment of conifer forests around the perimeter of Edmond Marsh. These forests have been recently lost due to raising water levels, particularly on the northern boundary of East Edmond Marsh. Other impacts would be similar to those described for the Proposed Action.

Landmark Trees, Shrublands, and Grasslands

Landmark tree, shrubland and grassland conditions would not be affected by the cumulative condition, and conditions would be similar to described for the Proposed Action.

Aquatic Resources

West Edmond Marsh - The marsh would be more frequently and continuously inundated in the deeper areas of the wetland, and seasonal fluctuations in water levels would decrease in the cumulative condition. This would occur as a lower and more stable outlet hydrology is established in place of the existing beaver dam. The beaver dam currently prevents flow out of West Edmond Marsh, but it is occasionally breached. Reducing or eliminating these rapid changes in hydrology under the cumulative condition would help to stabilize the vegetation communities which are currently susceptible to hydrologic fluctuations.

East Edmond March - Water levels in East Edmond Marsh are currently higher than in Eastern East Edmond Marsh and West Edmond Marsh. This reverses the gradient of Sequalitchew Creek preventing surface flow to the ravine from West Edmond Marsh. The cumulative condition (specifically the Sequalitchew Creek Restoration Plan) would lower water levels in East Edmond Marsh to restore a gradient from Lake Sequalitchew to the ravine. This would impact habitats, particularly along fringes of the wetland where forested

areas would be able to re-establish. Forested wetland and wetland buffer has been lost over the past decades as water levels have risen. Rising water levels have also been responsible for the loss of scrub-shrub vegetation and detritus from those communities has prevented establishment of an emergent vegetation community.

Sequalitchew Creek Ravine Wetlands - Changes in groundwater flow under the Proposed Action in combination with the Sequalitchew Creek Restoration Plan would be anticipated to still result in a disruption of Ravine (seep) Wetland habitat (as described for the Proposed Action). In addition, the Sequalitchew Creek Ravine Wetlands would be impacted as flows in the creek are restored in the cumulative condition. This would cause a change in the bankfull width of Sequalitchew Creek as well as the sediment load being actively transported downstream. Over the subsequent several decades, the riparian and floodplain wetland communities would be affected by deposition of new floodplain terraces, channel migration, increased wet season flows and other natural stream processes.

Brackish Marsh - Due to the increased base and peak flows in Sequalitchew Creek in the cumulative condition (particularly with the Sequalitchew Creek Restoration Plan), the Brackish Marsh at the mouth of Sequalitchew Creek is likely to be affected by increased sediment inputs and decreased salinity due to increased volumes of fresh water discharging into the wetland.

Increased sediment inputs into the Brackish Marsh due to increased flows in Sequalitchew Creek could modify the existing wetland topography, and as a result, the existing vegetation. Sedimentation would be minimized by controlling the discharge into Sequalitchew Creek during implementation of the Restoration Plan to prevent a rapid mobilization of sediments in the stream reaches upstream of the Brackish Marsh. Stream flows would be slowly increased to allow the channel and stream bank vegetation to adapt to the increased flow rates. With appropriate upstream mitigation, changes in sediment loading to the Brackish Marsh are expected to be minimal and would be further minimized by tidal flushing.

Salinity in the Brackish Marsh would continue to be driven by tidal inflows and decreases in salinity associated with freshwater flows would only be expected during high flow events in winter months. Increased flow in Sequalitchew Creek with cumulative conditions is not expected to affect existing Brackish Marsh vegetation or functions.

Other Wetlands - The cumulative condition is not anticipated to impact the Nearshore Springs or Nearby Wetlands.

Birds

The cumulative condition (specifically the Restoration Plan) would reverse the changes in bird habitat in East and West Edmond Marsh that have occurred over the last three decades. This would include a reorganization of some specific habitats to include scrub-

shrub wetlands and forested wetlands. It would increase the area of forested wetland buffer as water levels in some areas of East Edmond Marsh drop and increase the amount of and persistence of emergent wetland habitat in the west end of West Edmond Marsh.

Mammals

Beaver in the Edmond Marsh complex would be actively managed under the cumulative condition (specifically the Sequalitchew Creek Restoration Plan). The intent is to maintain the beaver population while managing water levels to restore flow. Other mammal species are expected to see increases in available habitat, particularly where water levels drop providing additional denning opportunities in the wetland banks and increasing the size of upland islands within the wetland complex.

Amphibians and Reptiles

Amphibian reproduction can be adversely affected by sudden, non-seasonal changes in water levels. This occurs in West Edmond Marsh when the large beaver dam above the dry reach is breached. Amphibian eggs attached to the stalks of emergent vegetation would suddenly be above water, causing complete mortality. Areas of reduced wetland area under the cumulative condition in the Edmond Marsh complex could reduce the area of habitat for some amphibian species, while others would benefit from the re-establishment of the forested riparian buffer.

ALTERNATIVE 2 – NO ACTION

The No Action Alternative includes two scenarios: Scenario A - Continuation of Existing Conditions; and Scenario B - Site Development under Existing Zoning.

Scenario A

Under Scenario A the Proposed Action would not occur and clearing and mining activities, and resulting impacts to plants and habitat, would not occur. The site would not undergo remediation from Tacoma Smelter Plume impacts leaving high concentrations of lead and arsenic in the soils which could impact animals.

The Sequalitchew Creek Restoration Plan would not receive funding from the Pioneer Aggregates South Parcel Project applicant without the Proposed Action, although it is possible that funding for the Plan could be provided from another source. Under the No Action Alternative, the improvements and benefits to habitat and impacts to groundwater with implementation of the Sequalitchew Creek Restoration Area may not occur. Also, If the Sequalitchew Creek Restoration Plan is not implemented, wildlife species within the Sequalitchew Creek Restoration would not benefit from improved aquatic resource habitat conditions.

Scenario B

Development could occur on the site consistent with underlying zoning. Future development is assumed to be consistent with the DMC Critical Areas chapter (DMC 25.105), which could allow for development within 50 feet of the top of the Sequalitchew Creek ravine. In contrast, DuPont City ordinance 95-521 prohibits mining within 100 feet of the top of Sequalitchew Creek ravine so any future development following the proposed action would be at least 100 feet from the top of the ravine, whereas future development under Scenario B could occur 50 feet from the top of the ravine. Existing coniferous forest within the Expansion Area portion of the site could be cleared with future development, with landmark trees retained in accord with DMC requirements. There would be no changes in the use of the areas of the South Parcel zoned for Open Space; these areas currently include the naturally vegetated slope of the Sequalitchew Creek ravine and the Sequalitchew Creek pedestrian trail.

Development on the site consistent with underlying zoning would also result in clearing of forested and shrub habitat, reducing habitat for wildlife species that use these habitats. Direct impacts associated with future development under existing zoning to animals would be similar to those described for the Proposed Action.

There would be no change in use of the areas within the existing mine. However, once the Re-Mine Area is reclaimed, it would likely be redeveloped according to its underlying zoning, similar to the South Parcel. The Kettle Wetland is within the existing mine and is assumed to remain intact, the buffers would remain vegetated, and mining operations would continue in other portions of the existing mine. The Kettle Wetland, its buffer, and other mine-related buffers could be reduced to the minimum width in the DMC.
The Sequalitchew Creek Restoration Plan would not receive funding from the Pioneer Aggregates South Parcel Project applicant without the Proposed Action, although it is possible that funding for the Plan could be provided from another source. Under the No Action Alternative, the improvements and benefits to habitat and impacts to groundwater with implementation of the Sequalitchew Creek Restoration Area may not occur.

3.6.3 Mitigation Measures

The following mitigation measures have been included in the Proposed Action to reduce impacts to plant and animal communities, including impacts to on-site resources and indirect impacts to off-site resources due to changes in groundwater hydrology.

Proposed On-Site Mitigation

- Revegetation of cleared and mined area on the site would occur as part of segmental reclamation under the Reclamation Plan reviewed and approved by the Washington State Department of Natural Resources.

- Mitigation for impacts for the removal of the Kettle Wetland are identified in the Project *Wetland Mitigation Plan*. The design of the mitigation wetland complex is intended to create aquatic, wetland, riparian, and upland forest habitat by using groundwater intercepted within the mine. Specific Kettle Wetland mitigation goals include the following:
    - Create a constructed palustrine depressional wetland complex consisting of forested, scrub-shrub, emergent, and aquatic bed wetland areas at least 3.4 acres in size.
    - Provide adequate wetland acreage, functions, and values to mitigate all Project-related wetland impacts to the Kettle Wetland.
    - Construct a vegetated buffer at least 100 feet around the boundary of the wetland.
    - Create a larger complex of seep wetlands and springs within the mine.

- Springs and seeps will generally emanate on the eastern and southeastern slopes of the proposed mine in the South Parcel. Generally, seeps and springs will form within the lower one-third of the mine slope, approximately 20 to 30 vertical feet above the Olympia Beds. These areas will be colonized or planted with pioneer wetland species, such as horsetail *(Equisetum* sp.), buttercup (*Ranunculus* sp.), and miner's lettuce (*Montia fontana*). Additional species would be introduced later, once the soils have developed sufficiently to support seral grasses such as foxtails, rushes, sedges etc. The buffers around these new seeps will be subject to the City of DuPont's Critical Areas Ordinance (DMC 25.105.050) and protected. The minimum buffer size is 50 feet. These buffers would be planted in accordance with the mine reclamation plan and monitored in accordance with the Wetland Mitigation Plan. Control of Scot's broom, reed canarygrass, Himalayan blackberry (*Rubus armeniacus*), and other noxious weeds within areas affected by the proposed Project would also be included as part of the Project mitigation activities.

- The Applicant (CalPortland) has provided a tree replacement proposal as part of its application and will coordinate with the City of DuPont regarding the appropriate strategy for replacement of removed landmark trees through proposed mine reclamation plans.

Proposed Mitigation for Off-Site Resources

- Implementation and monitoring of the Sequalitchew Creek Restoration Plan would provide mitigation to minimize potential impacts to aquatic resources and vegetation resulting from changes to groundwater levels. As described in Chapter 2 of this DEIS, the Sequalitchew Creek Restoration Plan will be permitted and implemented contemporaneously with mining of the South Parcel.
  Conditions associated with this mitigation measure are the same as described above in the subsection Cumulative impacts with Proposed Action and Sequalitchew Creek Restoration Plan.

Other Possible Contingency Mitigation Measure

- As an element of the approval conditions for the Proposed Action, the City of DuPont could require a Monitoring and Response Plan. The Monitoring and Response Plan could include, among other things, definition of monitoring methodology, establishment of performance thresholds, and identification of contingency response measures to the considered for implementation if monitoring indicates exceedance of a performance threshold. The Monitoring and Response Plan could incorporate elements of the adaptive management processes proposed to be established for the Proposed Action and the Sequalitchew Creek Restoration Plan.

  The Sequalitchew Creek Restoration Plan is a separate but related action that is intended to be implemented in parallel with the Proposed Action. The mine and the stream restoration project each have their own adaptive management process tailored to achieving the goals and objectives of each specific project. The interaction between the two adaptive management processes could include: 1) project schedules that encourage restoration in advance of the potential impacts from mining; 2) development of performance thresholds for mining that support restoration and 3) coordinated monitoring and open sharing of information. The City, as the permitting authority for both projects would have a key role in assuring consistency between the two adaptive management plans.

3.6.4 Significant Unavoidable Adverse Impacts

Development of the Proposed Action would result in the loss of existing conifer forest/shrublands, the existing kettle wetland, and associated animal habitat on the site. The proposed site reclamation plan and wetland mitigation plan would mitigate loss of on-site resources. These impacts would be unavoidable but not considered significant with mitigation described above in Sub-section 3.6.3.

The Proposed Action would indirectly impact the off-site Seep Wetlands associated with the Sequalitchew Creek Ravine by disrupting the hydrology of these wetlands. This impact

would be unavoidable and mitigated by creation a larger complex of seep wetlands on the eastern slope of the reclaimed mine, resulting in a net impact that is considered insignificant.

Cumulatively, implementation of the Sequalitchew Creek Restoration Plan would further mitigate for the loss of wetland acreage associated with reduction in groundwater levels. The intent of the proposed mitigation measures described in Sub-section 3.6.3 with the Sequalitchew Creek Restoration Plan, is to reduce these unavoidable adverse impacts to a non-significant status. If implementation of the proposed mitigation measures fails to mitigate these unavoidable adverse impacts, the City will consider implementing other possible contingency mitigation measures listed in Sub-section 3.6.3 as part of the adaptive management process.

3.7 NOISE

This section of the DEIS describes existing noise conditions on the site and in the site vicinity. Potential impacts associated with the EIS Alternatives are evaluated and mitigation measures are identified. This section is based on the *Noise Study* (September 2022) prepared by Ramboll U.S. and peer reviewed by BRC Acoustics (see **Appendix K**).

3.7.1 Affected Environment

Noise is sometimes defined as unwanted sound; the terms noise and sound are used more or less synonymously. The human ear responds to a very wide range of sound intensities. The decibel scale (dB) used to describe sound is a logarithmic rating system which accounts for the large differences in audible sound intensities. This scale accounts for the human perception of a doubling of loudness as an increase of 10 dB. Therefore, a 70-dB sound level will sound about twice as loud as a 60-dB sound level. People generally cannot detect differences of 1 dB; in ideal laboratory situations, differences of 2 or 3 dB can be detected by people, but such a change typically would not be detectable in an average outdoor environment. A 5-dB change would typically be perceived under normal listening conditions.

When addressing the effects of noise on people, it is useful to consider the frequency response of the human ear. Sound-measuring instruments are therefore often programmed to weight measured sounds based on the way people hear. The frequency-weighting most often used is A-weighting because it approximates the frequency response of human hearing and is highly correlated to the effects of noise on people. Measurements from instruments using this system are reported in "A-weighted decibels" or dBA. All sound levels in this evaluation are provided in A-weighted decibels.

Regulatory Context

Section 9.09.040 of the DuPont Municipal Code (DMC 9.09.040) specifies noise limits based on the limits set in the Washington Administrative Code (WAC 173-60). DMC 9.09.040 establishes limits on sounds crossing property boundaries based on the Environmental Designation for Noise Abatement (EDNA) of the sound source and the receiving properties. Section 9.09.040(b) of the DuPont City Code identifies Class A EDNAs as residential areas, Class B EDNAs as commercial areas, and Class C EDNAs as industrial areas. The allowable noise level limits are displayed in **Table 3.7-1**.

Table 3.7-1
DUPONT MAXIMUM PERMISSIBLE SOUND LEVELS (DBA)

EDNA of Source Property	EDNA of Receiving Property		
	Class A Day/Night [a]	Class B	Class C
Class A	55/45	57	60
Class B	57/47	60	65
Class C	60/50	65	70

Source: DMC 9.09.040.

[a] The limits for noise received in Class A EDNAs are reduced by 10 dBA during nighttime hours (10 PM to 7 AM).

The city noise rule allows the limits presented in Table 3.7-1 to be exceeded for certain periods of time: 5 dBA for no more than 15 minutes in any hour, 10 dBA for no more than 5 minutes of any hour, or 15 dBA for no more than 1.5 minutes of any hour. These allowed increases can be described in terms of the percentage of time a certain level is exceeded, using statistical noise descriptors (Lns). For example, L25 represents a sound level that is exceeded 25% of the time, or 15 minutes in an hour. Similarly, L8.33 and L2.5 are the sound levels that are exceeded 8.33 and 2.5% of the time, or 5 and 1.5 minutes in an hour, respectively. At no time can the allowable sound level be exceeded by more than 15 dBA, represented by the Lmax.

DMC Section 9.09.040(c) provides a map that specifically designates the EDNA's for various properties within the City (Appendix A of Ordinance 208). The EDNA boundaries shown in this map identify a small Class A (Residential) EDNA on both sides of Barksdale Avenue in the historic village of DuPont, a small Class B (Commercial) EDNA between the historic village and I-5, and the remainder of the DuPont area as a Class C (Industrial) EDNA. DuPont Ordinance 208 and the associated map in Appendix A were adopted in 1978; they are no longer representative of current zoning and comprehensive land use plan designations. Furthermore, the 1978 map of EDNA designations does not adequately represent the basic uses identified in 9.09.040(b) that define EDNAs. It is, therefore, unclear whether the EDNA designations shown in the 1978 map or the EDNA identifications based on land uses in 9.09.040(b) should apply.

For this noise analysis, land use zones (as identified in DuPont's Zoning Map) are used to determine the appropriate noise limits for the various receiving properties. This approach is consistent with the more modern language and identification of EDNA designations based on actual uses and represents a more accurate reflection of current and expected future conditions. But applying either method for identifying the appropriate EDNAs, the site would be considered a Class C EDNA, and the applicable Ln noise limits for a Class C EDNA noise source affecting different types of receiving properties are displayed in **Table 3.7-2.**

Table 3.7-2
APPLICABLE LN NOISE LIMITS FOR CLASS C EDNA NOISE SOURCES

EDNA of Source Property	Ln Limits			
	L25	L8.3	L2.5	Lmax
Class A [a]	60/50	65/55	70/60	75/65
Class B	65	70	75	80
Class C	70	75	80	85

Source: DMC 9.09.040 (d).

[a] The limits for noise received in Class A EDNAs are reduced by 10 dBA during nighttime hours (10 PM to 7 AM) and are shown for Day/Night.

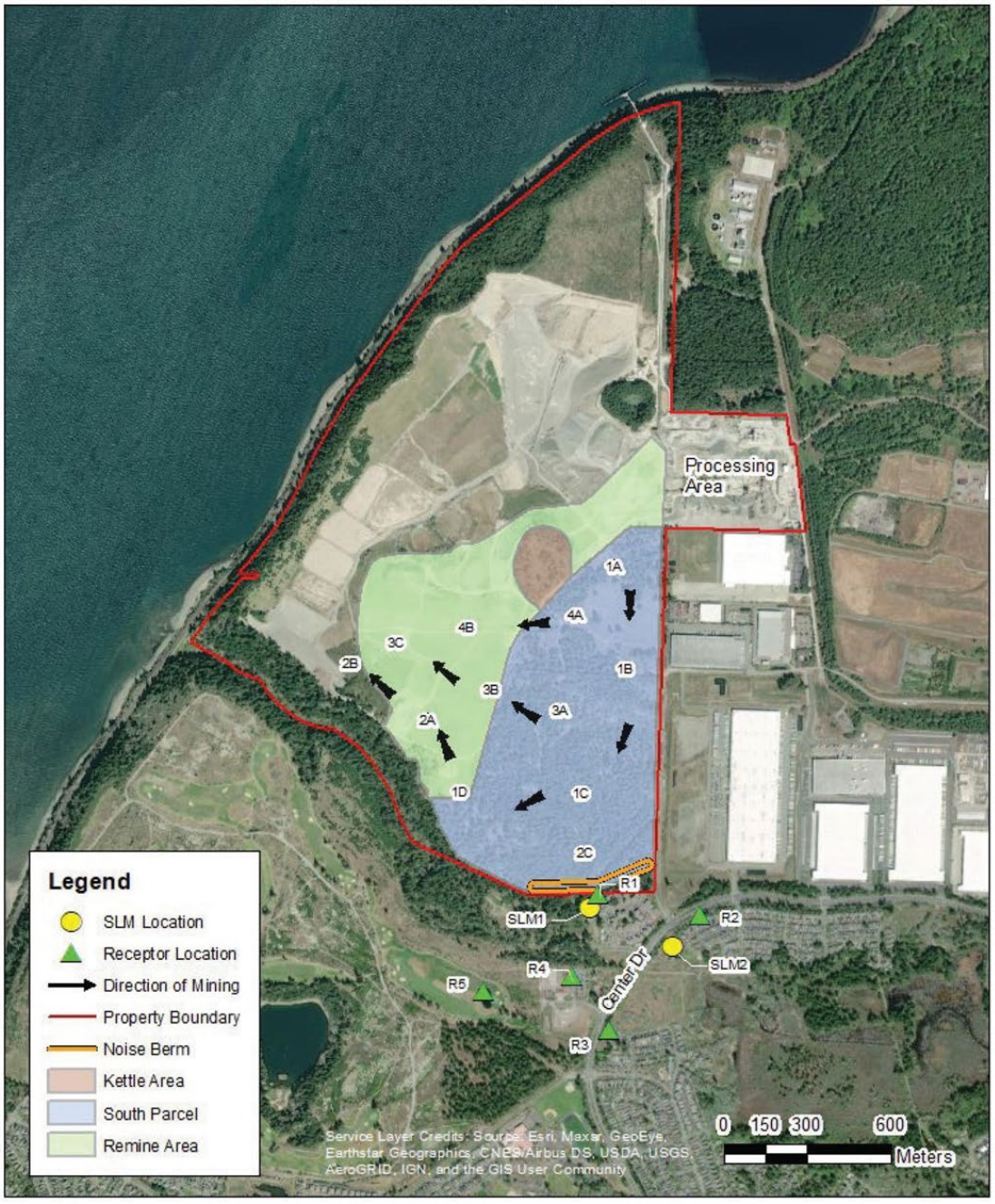
Because noise generated by mining would typically be fairly consistent over an hourly period, the allowances for short-term increases in the noise level limits would rarely apply. Therefore, the most stringent/conservative noise limit for mining activities (a Class C source) would be an L25 of 70 dBA at nearby Class C EDNAs, an L25 of 65 dBA at nearby Class B EDNAs, or an L25 of 60 dBA between 7 AM and 10 PM and 50 dBA between 10 PM and 7 AM at nearby Class A EDNAs.

DMC 9.09.050 exempts the following sources from the above noise limits:

- Temporary construction noise, except when received in Class A EDNA properties between the hours of 10 PM and 7 AM;
- Sounds created by motor vehicles when regulated by the state noise limit (Chapter 173-62 WAC), adopted by reference in DMC 9.09.040; and
- Sounds created by motor vehicles, licensed or unlicensed, when operated off public highways, except when such sounds are received in Class A EDNAs.

Existing Sound Levels

As part of the noise study prepared for this EIS, sound level measurements were taken from two locations (see **Figure 3.7-1** for a map of the locations). SLM1 was chosen to represent the nearest residences south of the mine on the north side of the Creekside Apartment complex. SLM2 represents the residential community across Center Drive from the Expansion Area portion of the site. At both measurement locations, noise from the existing Pioneer Aggregates facility was not audible and did not substantively contribute to the measured levels. A summary of the sound level measurement results is displayed in **Table 3.7-3**.



Source: Ramboll, 2022.

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Figure 3.7-1

Sound Level Measurement and Receptor Location Map

Table 3.7-3
RANGE OF EXISTING MEASURED HOURLY SOUND LEVELS (DBA)

Location	Time [a]	Leq [b]	Lmax	L2	L8	L25	L90	Ldn [b]
SLM1	Day	39-48	52-72	43-56	42-49	37-47	33-45	47
	Early Morning	42-44	56-58	46-47	45-46	43-45	40-43	
	Night	35-44	48-58	39-47	37-46	35-45	33-43	
SLM2	Day	49-54	61-83	55-61	53-57	50-56	41-51	56
	Early Morning	52-55	69-700	57-59	56-58	53-56	45-49	
	Night	42-55	57-70	48-59	45-58	41-56	38-49	

Source: Ramboll, 2022.

[a] Daytime hours are defined as between 7 AM and 10 PM, early morning hours are between 5 and 7 AM, and nighttime hours are between 10 PM and 7 AM.

[b] The Leq is an energy-average sound level defined over a specified period of time, often one hour. It is useful for representing the energy of a fluctuating sound with a single number. The Ldn is a similar to a 24-hour Leq, except the Ldn includes an additional 10 dBA added to sound levels in each hour between 10 PM and 7 AM to account for increased sensitivity to noise at night.

SLM1 – Located behind the Creekside Apartment complex. Noise sources included JBLM and civilian aircraft, including helicopters. The noise environment at the apartment complex was relatively quiet during deployment and retrieval of the meters.
SLM2 – Located at the Edmond Village Park to represent the residential setbacks from Center Drive. The primary noise source was traffic along Center Drive. Sporadic noise sources included aircraft noise, both military and civilian.

3.7.2 Impacts of the Alternatives

This sub-section identifies and analyzes noise impacts on and in the vicinity of the site under the EIS Alternatives, including with proposed clearing and mining.

ALTERNATIVE 1 – PROPOSED ACTION

Construction Impacts

Construction directly related to the Proposed Action would be limited to logging, preparation of new mining phases/segments for excavation, expansion of the on-site conveyor system to connect the expanded mining area to the existing processing facility, and the construction of the berm on the south side of Phase 2C for noise attenuation. Much of the construction activity would entail heavy equipment similar to, or the same as, the equipment required during excavation. Therefore, the sound levels of construction are expected to be similar to the modeled operational sound levels identified below. The

exception would be sound levels associated with construction of the berm on the south side of Phase 2C. During construction of the berm, sound levels at nearby receivers may be noticeable and, at times, intrusive. This could result in temporary and short-term noise impacts at nearby properties. Construction activity is exempt from DuPont's noise regulations during daytime hours (7 AM to 10 PM).

Operational Impacts

Noise Sources

Equipment required for mining under Alternative 1 includes two front-end loaders, a bulldozer and conveyors and an electric conveyor drive motor. This equipment would work in tandem; the bulldozer would push material down the mining face to the loaders, which would load the material onto a conveyor going to the existing processing plant. The bulldozer and loaders would be the dominant noise sources at the nearest sensitive receivers to the Expansion Area portion of the site.

Noise from the excavation equipment was considered in noise modeling to estimate future noise associated with the facility. Noise from most equipment was characterized using measurements of equipment operating at the existing Pioneer Aggregates facility. The measurement of the electric conveyor drive motor was measured at a different facility and is from source sound level archives.

Because the noise from a sand and gravel operation is typically fairly constant over the course of an hour, the noise standard that would be most limiting would be the hourly L_{25} limit. In order to relate the calculated sound levels more closely with the applicable noise limits, the measured L_{25} of each source was used when this information was available. in instances where L_{25} data were not available, the Leq was used to represent an L_{25}.

Noise Model

The CadnaA noise model was used to estimate sound levels expected to be generated by the expansion equipment under the Proposed Action. CadnaA is a computer program that calculates sound levels after considering the noise reductions or enhancements caused by distance, topography, ground surfaces, atmospheric absorption, and meteorological conditions. The modeling process included the following steps: (1) characterizing the noise sources based on frequency-specific measurements of representative equipment; (2) creating three-dimensional maps of the site and vicinity to enable the model to evaluate effects of distance and topography on noise attenuation, (3) assigning the equipment sound levels to the appropriate locations on the site, and (4) placing model "receptors" at several model receptor locations to represent places where the noise will be received (see **Appendix K** for details).

Noise Modeling Results

As part of the noise assessment conducted for this EIS, the model-calculated sound levels were first compared with the applicable City noise limits to assess potential compliance with the limits. Sound levels from proposed excavation activities were modeled at six receptor locations representing three residential areas, a civic center, and a golf course nearest the Expansion Area portion of the site. The receptor locations are shown in **Figure 3.7-1**. The predicted future sound levels and detailed descriptions of each receptor location are provided in **Table 3.7-4**. Noise from the existing Pioneer Aggregates operations does not substantively contribute to the sound levels at the receptor locations considered in this assessment, and the predicted sound levels provided in **Table 3.7-4** can be considered representative of the entire operation with mining under the Proposed Action.

Table 3.7-4
MODEL-CALCULATED SOUND LEVELS (LEQ/L25, DBA)

Model Receptor Location	Modeled Sound Level				Noise Limit [a]
	Phase 1B	Phase 2C	Phase 2C (No Bulldozer)	Phase 3B	
R1a	42	55	48	43	60/50
R1b	41	46	42	40	60/50
R2	40	45	43	37	60/50
R3	36	40	37	36	60/50
R4	37	39	36	38	65
R5	36	38	37	39	65

Source: Ramboll, 2022.
Receptor Locations:
R1a – Upper floor of the Creekside Apartments nearest the South Parcel
R1b – Ground floor of the Creekside Apartments nearest the South Parcel
R2 – Residences in Edmond Village
R3 – Residences in Palisade Village
R4 – Dupont Civic Center
R5 – The Home Course Golf Course
(a) The noise limits shown for residential locations are for daytime/nighttime hours, where daytime hours are from 7 AM to 10 PM and nighttime hours are from 10 PM to 7 AM.

As indicated in **Table 3.7-4,** sound levels from the Proposed Action would comply with the applicable noise limits during daytime hours (i.e., 7 AM to 10 PM) at all locations. However, sound levels at the upper floors of the Creekside Apartments facing the site may exceed the noise limits if full mining activity occurs in Phase 2C during early morning hours (i.e., between 5 and 7 AM).

Because the dominant noise source at the Creekside Apartments during Phase 2C excavation is the bulldozer, the noise benefits of restricting bulldozer use in this phase to

daytime hours only was considered. Prohibition of bulldozer use during the early morning hours results in modeled sound levels below the nighttime noise limits applied between 5 and 7 AM at all receptor locations (see **Appendix K** for details).

Receptor location R1b provides modeled sound levels at the location closest to the Sequalitchew Creek trail. Sound levels during mining phase 2C, which is closest to the trail and to recreational users, is modeled to be within applicable noise limits and is not anticipated to result in a significant adverse impact to trail users.

Increases over Existing Sound Levels

In addition to evaluating the potential compliance of on-site sources associated with Proposed Action activities, potential noise conditions associated with project-related increases over existing baseline sound levels are also considered. This assessment was restricted to residential receptor locations potentially affected by increases over existing levels under the Proposed Action.

For Proposed Action sound levels during daytime hours, the worst-case modeled levels expected during all phases of excavation were used. For sound levels during early morning hours, the worst-case modeled sound levels during all phases of excavation were used assuming no bulldozer in Phase 2C. Because mining activities in Phase 2C may exceed the nighttime noise limit of 50 dBA at the upper floors of the Creekside Apartments with all equipment in operation, use of the bulldozer in Phase 2C would be restricted to daytime hours only. The resulting increases over existing levels are displayed in **Table 3.7-5**.

The sound levels when a bulldozer is working very near the Expansion Area portion of the site boundaries in Phase 2C are substantially higher than the baseline sound levels at the upper floors of the Creekside Apartments (R1a), resulting in potential increases of 8 to 16 dBA. If these sound levels were experienced throughout the life of the project, they would represent a substantial increase. However, the modeled levels at the Creekside Apartments are dominated by noise from a bulldozer working on the slope of 2C very near the southern site boundary. This worst-case condition would only occur during Phase 2C excavation. Even during Phase 2C excavation, the bulldozer would split its time between excavation in Phase 2C and excavation in the existing mining areas farther north and west, and sound levels much of the time would be substantially lower than the worst-case levels identified. The variation in sound levels over the life of the mine and the variation in day-to-day bulldozer activities would reduce the reported potential noise impacts at the Creekside Apartments due to increases over baseline levels.

Table 3.7-5
CALCULATED INCREASES OVER EXISTING SOUND LEVELS (LEQ, DBA)

Model Receptor Location	Time of Day [a]	Measured Existing Levels	Level with South Parcel Expansion		
			Project Only [b]	Cumulative [c]	Increase [d]
R1a	Day	39-48	55	55-56	8-16
	Night	42-44	48	49-50	5-7
R1b	Day	39-48	46	46-50	2-8
	Night	42-44	42	45-46	2-3
R2	Day	49-54	45	51-55	0-1
	Night	52-55	43	52-55	0
R3	Day	49-54	40	50-55	0
	Night	52-55	37	52-55	0

Source: Ramboll, 2022.
Notes:
(a) Daytime hours are from 7 AM to 10 PM. Nighttime hours for the purpose of this evaluation are from 5 to 7 AM, when early morning excavation may occur.
(b) The daytime project levels shown are the highest modeled sound levels from all phases of South Parcel activities considered in this assessment. The nighttime levels shown are the highest levels from all modeled phases except 2C.
(c) Cumulative levels represent the existing measured sound levels + the modeled project-related sound levels.
(d) Apparent discrepancies in any calculated increases are artifacts of rounding the displayed sound levels to the nearest whole number.

At the more distant residential locations (R2 and R3), increases over background sound levels are 1 dBA or less during even the worst-case Phase 2C activities. Such increases would not be discernable in an active outdoor environment and would result in no impact (see **Appendix K** for details).

CUMULATIVE IMPACTS

The annual amount of mining activity, and associated noise conditions, with the Proposed Action in combination with mining at the Existing Mine would not exceed current levels, and cumulative mining noise impacts are not anticipated. In addition, noise impacts associated with mining would be temporary in nature and would occur some distance from potential future development that could occur in the vicinity, and no significant cumulative noise impacts are anticipated.

ALTERNATIVE 2 – NO ACTION

There are two No Action Alternatives- Scenario A Continuation of Existing Conditions; and Scenario B Site Development Under Existing Zoning.

Scenario A

Under Scenario A, mining activities associated with the Re-Mine Area of the site and the Existing Mine would continue as currently permitted. Mining and reclamation would continue within the currently permitted footprint of the existing mine and would continue to generate noise, similar to existing conditions. The Existing Mine has an estimated remaining life of 6 to 10 years with mining currently limited to 10 feet above groundwater. The Expansion Area portion of the site is assumed to remain undeveloped and would continue in its vegetated condition.

Scenario B

Under Scenario B, the proposal would not occur. The site would be developed for urban uses consistent with the City's Future Land Use Map. The majority of the area affected is currently designated by the City of DuPont Comprehensive Plan as Manufacturing and Research, with a smaller area designated for residential uses. The corner of the property near Center Drive is designated as Residential 12, which would allow higher density residential development where multifamily density averages 12 units per acre. Urban development, as permitted under current planning and zoning designations, is assumed to occur east of the lease line demarcating existing mining operations. The timing and nature of any such development would be driven by market forces.

Development of individual parcels would result in construction-related noise impacts. Operation of development on individual parcels would also generate noise from operational activities, depending on the type of development on the site.

3.7.3 Mitigation Measures

The following mitigation measures have been included in the Proposed Action to reduce noise impacts.

Proposed Construction Measure

- Construction activities (i.e., logging and construction of the southern berm) would be conducted during daytime hours only (7 AM to 10 PM) to minimize noise impacts.

Proposed Operation Measures

- The plans for the site include construction of a 20-foot high berm on the south side of Phase 2C to reduce noise at off-site locations, especially at the Creekside Apartments. With such a berm, modeled sound levels of worst-case mining activities are well below the applicable daytime noise limits at all receptor locations.

- Excavation in Phase 2C during early morning hours (i.e., between 5 and 7 AM) may exceed the stricter nighttime limit of 50 dBA applicable at the Creekside Apartments. Restriction of the bulldozer to daytime hours only within Phase 2C reduces the modeled sound levels at the Creekside Apartments to 48 dBA or less, which would comply with DuPont's nighttime noise limit.

3.7.4 Significant Unavoidable Adverse Impacts

With construction of the proposed berm as noted above and with restriction of hours of bulldozer operation in Phase 2C to daytime hours only, the project is expected to comply with City of DuPont noise limits. Furthermore, potential noise impacts at the Creekside Apartments (R1) can be mitigated by the proposed mitigation measures, although short-term unavoidable noise impacts may be expected. Due to the short-term nature of the impacts at R1, any such impacts would not be considered significant.

3.8 LAND USE

This section of the DEIS describes the existing land use patterns and conditions occurring on the Pioneer Aggregates South Parcel Project site and site in the site vicinity. This section evaluates how development under the EIS Alternatives would affect existing and future land uses on and in the vicinity of the site, either directly or indirectly, and identifies any needed mitigation.

Methodology

The land use analysis was prepared based on a land use reconnaissance of the site and vicinity conducted in October 2021 as well as review of available digital information. This section also includes review of pertinent land use plans, policies, and regulations, including the Washington State Growth Management Act, and City of DuPont Comprehensive Plan and Land Use Code.

3.8.1 Affected Environment

The City of DuPont is located in southwestern Pierce County (see **Figure 2-1** in **Chapter 2**). The City is generally bounded by Puget Sound to the west, Joint Base Lewis McCord (JBLM) to the north, the Fort Lewis Golf Course and I-5 on the south, and DuPont-Steilacoom Road and JBLM to the east. The nearest incorporated communities are Steilacoom and Lakewood, which are located approximately five miles to the north and northeast of the City of DuPont, respectively.

The City of DuPont contains approximately 3,770 acres. Based on Comprehensive Plan data, land use in the City at buildout will be as follows: approximately 22% will consist of critical areas/buffers and open space; 32% will be used for housing; 35% for business and employment uses; 3% for public use; and 7% for military, roads and other uses.

The South Parcel site (site) is located in the northern portion of the City of DuPont. The characteristics of the site are described below in the context of land use patterns, Comprehensive Plan and zoning designations, and surrounding development.

DuPont Land Use Plan

The City of DuPont Comprehensive Plan (2015 Periodic Update) indicates that DuPont is a master planned community, with its first community plan established around the DuPont Chemical Company's operations at the turn of the last century, and Northwest Landing (a concept of the Weyerhaeuser Company) emerging approximately 80 years later. Northwest Landing is an approximate 3,000-acre mixed-use master planned community being developed over a 15- to 30-year period; it encompasses most of the City. The Master

Plan is embodied in the City's Comprehensive Plan Land Use Map, shown on **Figure 3.8-1**, and Zoning Map, shown on **Figure 3.8-2**. Overall, the City of DuPont's land area is allocated among residential neighborhoods (1,214 acres); open space and sensitive areas (829 acres), public and civic uses, including parks, trails and recreation areas (95 acres); commercial and industrial uses (1,341 acres); and, military use (290 acres). In general, the land use plan reflects a planned balance among residential, business and open space/parks uses. Based on current estimates, the City is expected to accommodate 12,100 people and 21,400 workers at buildout, which is estimated to occur around 2040. Existing population (April 1, 2020) is estimated at 10,151, and employment is estimated at 3,619.

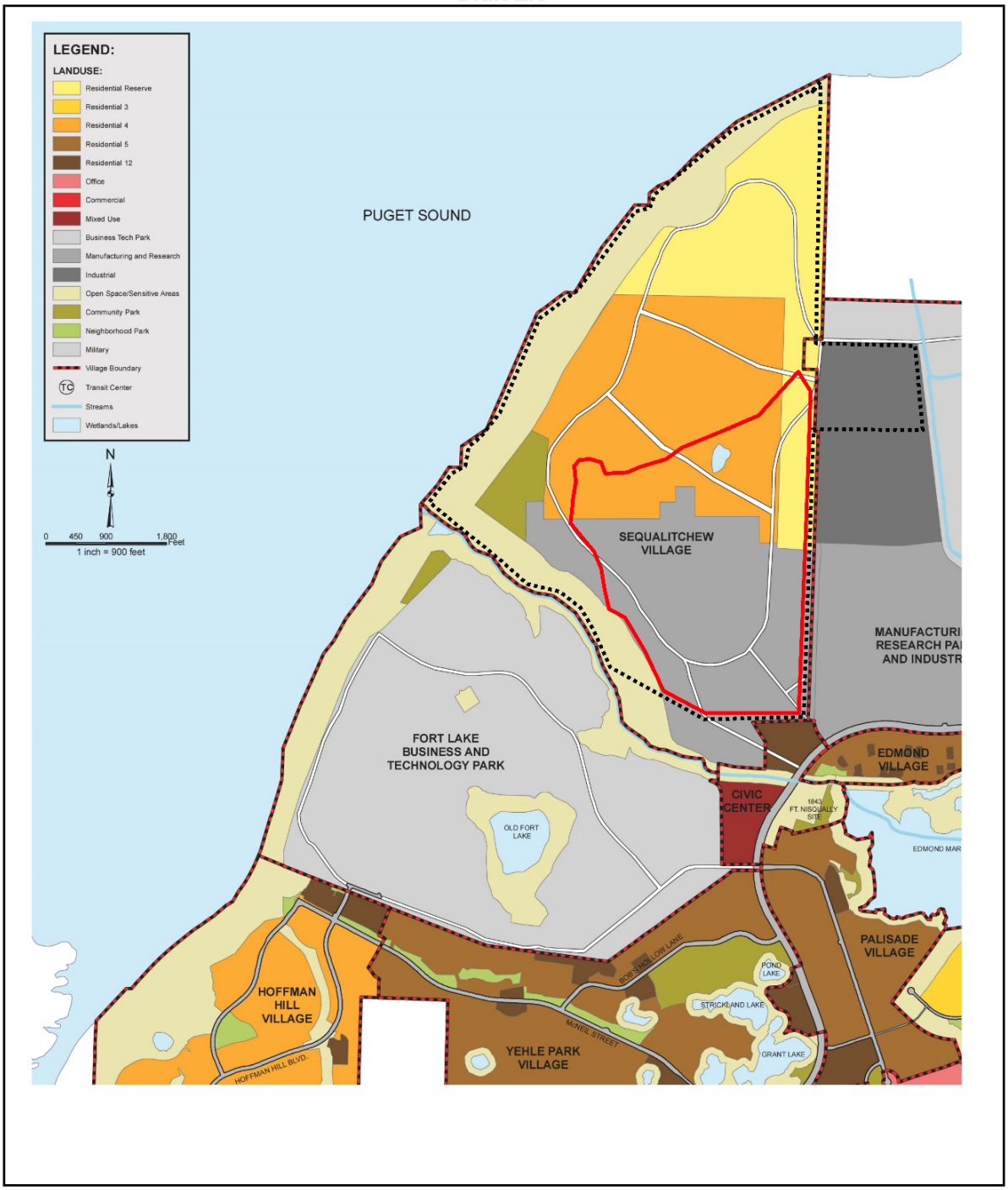
A brief discussion on the various City neighborhoods in proximity to the site, as defined in the Comprehensive Plan, follows.

Sequalitchew Village

The site is located within Sequalitchew Village. The Sequalitchew Village area consists of approximately 845 acres and is primarily designated for residential use: Residential Reserve (RR) in the northern one-third and northeastern border, which includes the North Parcel portion of the Pioneer Aggregates Mine; Residential 4 in the central one third, which contains the Existing Mine and processing facility; Manufacturing and Research Park (MRP) in the southern one-third, which includes the South Parcel portion of the site; and Industrial at the eastern boundary of the Village (includes the mining processing area). The area along Puget Sound on the western boundary of the Village, and the area adjacent to Sequalitchew Creek on the southern boundary of the Village, are designated for open space and a community park. A Mineral Resource Overlay, also applies to most of Sequalitchew Village (excluding the open space areas) and allows mining in addition to the underlying land use designations. Mining and undeveloped land are currently the major land uses in the Sequalitchew Village area.

Old Fort Lake Business and Technology Park

The Old Fort Lake area, which consists of approximately 654 acres located south of Sequalitchew Creek, is designated for Business and Technology Park. The Home Course golf course currently occupies approximately one-third of the area, and the balance is primarily undeveloped. Designated open space is located along the Puget Sound bluffs, adjacent to Sequalitchew Creek and around Fort Lake. A number of historic sites are located in a portion of the Old Fort Lake Business and Technology Park and a portion of the adjacent Sequalitchew Village.



Source: City of DuPont, 2022.

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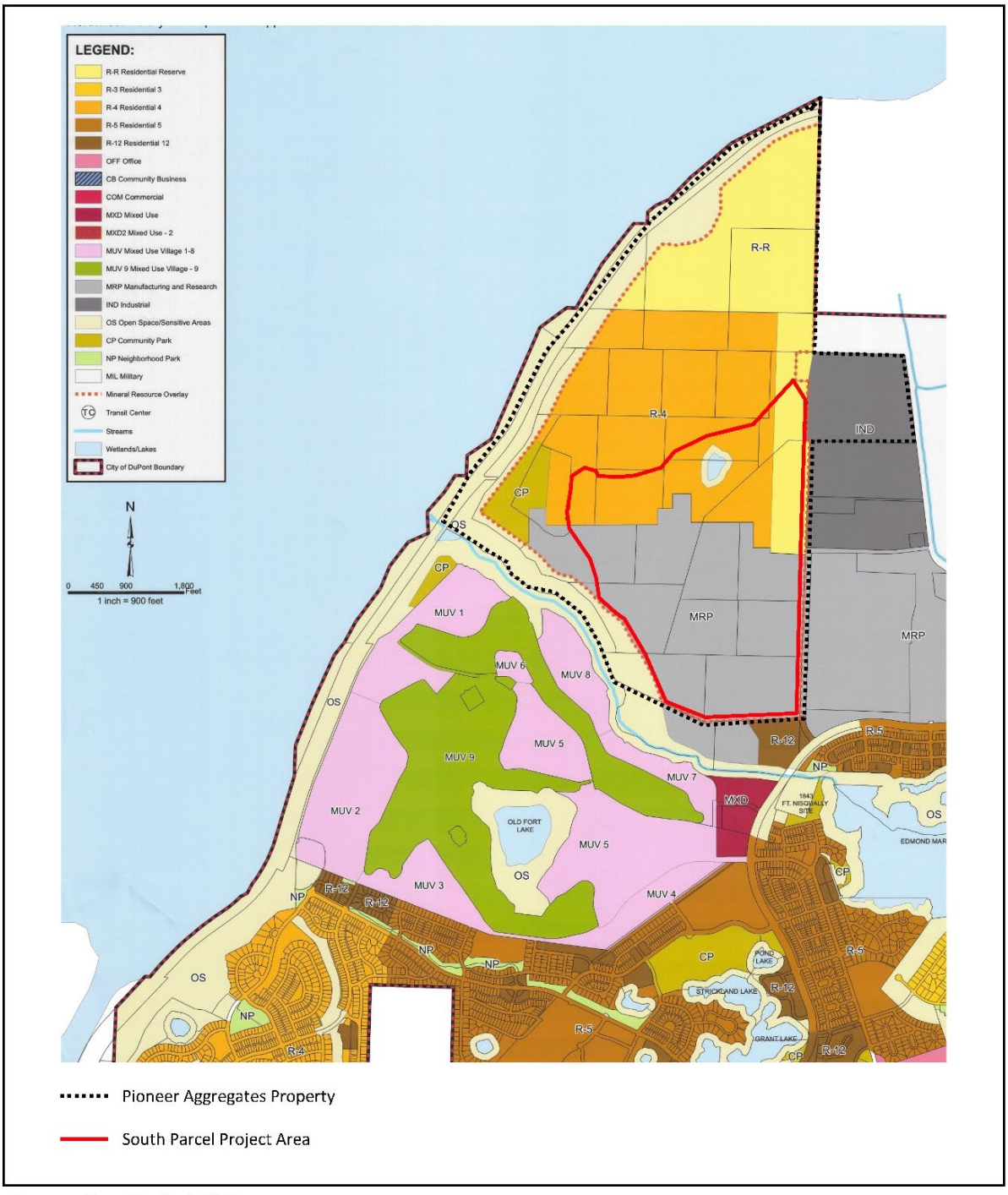
Figure 3.8-1

City of DuPont Comprehensive Plan Map



Source: City of DuPont 2022.

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Figure 3.8-2

City of DuPont Zoning Map

Civic Center and Edmonds Village

The Civic Center consists of approximately 56 acres and is located in the approximate center of the City of DuPont, on the eastern border of the Fort Lake Business and Technology Park, bisected by Center Drive. It contains City Hall and Police and Fire Department facilities, and the Historic Fort Nisqually site. The Civic Center also contains a mixed-use area and a residential area. Edmond Village, which contains approximately 54 acres, is developed for residential use, is located to the east of the Civic Center and is bounded by Center Drive on the north and Edmond Marsh on the south. Creekside Village, a multi-family residential development is located west of Center Drive and north of the Civic Center.

Manufacturing, Research Park and Industry

The northeastern portion of the City – generally between Powerline Road, Center Drive and DuPont-Steilacoom Road – consists of approximately 903 acres and designated for Manufacturing and Research Park and Industrial use. This area is planned to accommodate most of the City's employment growth. Existing larger uses include the Amazon Fulfillment Center, FedEx Distribution Center, and the Costco Logistics building and CalPortland's processing facility.

Other Neighborhoods

Commercial land uses in DuPont, including retail, office and service uses, are concentrated near the two I-5 interchanges, in the approximately 135-acre DuPont Station and the approximately 166-acre Historic Village. These areas are approximately 0.5 mile from the site.

Other neighborhoods in the City of DuPont include the approximately 390-acre Hoffman Hill Village (primarily in residential and open space use), the approximately 321-acre Yehle Park Village (primarily in residential and park use), the approximately 164-acre Palisade Village (primarily in residential use), the approximately 63-acre Bell Hill (primarily in residential use), and the approximately 18-acre El Rancho Madrona Village (primarily in residential use).

Comprehensive Plan and Zoning Designations

City of DuPont Comprehensive Plan designations for the site are illustrated in **Figure 3.8-1** and include Manufacturing and Research, Community Park, Residential 4, and Open Space. Reflective of the Comprehensive Plan designations, City of DuPont zoning designations for the site include Manufacturing and Research (MRP), Residential 4 (R-4), and Community Park (CP). See **Figure 3.8-2** for an illustration of site zoning designations.

Mineral Resource Overlay Area

The site is located within the Comprehensive Plan's designated Mineral Resource Overlay, which applies to approximately 700 acres of land in the northern portion of the City (see **Figure 3.8-1**). The Mineral Resource Overlay area is generally bordered on the north by Tatsolo Point and the City's corporate boundary; to the east by Powerline Road and JBLM; to the south by Sequalitchew Creek; and to the west by Puget Sound.

The purposes of the Mineral Resource Overlay, as stated in the DuPont Municipal Code (DMC 25.60.010), are to identify mineral resource lands of long-term commercial significance; to protect these sites from conflicting uses while resources are being extracted; to protect surrounding sites from adverse effects of mineral extraction activities; and to establish a no duplicative permit process for considering mineral extraction proposals. Mining is a permitted use within the Mineral Resource Overlay, subject to site plan review.

Current Mining Operations

CalPortland's original approximately 355-acre sand and gravel mine was permitted in 1996 and is referred to as the "Existing Mine".

In 2013 CalPortland applied for permits to allow mining of approximately 142 acres within the North Parcel; the North Parcel mining expansion was permitted in 2014.[1]

Current activities at the Pioneer Aggregates Mine include mining, processing, transport of sand and gravel, and manufacturing of concrete. The processing area is located adjacent to the mine site on a 52-acre parcel owned by Glacier Northwest ("Glacier"). Sand and gravel is removed from the mine by bull dozers and wheel loaders and transferred to the processing area by conveyor belts. At the processing facility, the material from the mine is crushed, washed, and separated into different size gradations. Aggregate products are stored in stockpiles in the processing area for distribution.

After completion of the production process, the majority (approximately 80%) of the finished aggregate products are transported from the plant area by conveyors and placed onto barges at Glacier's dock and barge-loading facility at Tatsolo Point on Puget Sound (see **Figure 2-1** in **Chapter 2**). The remainder (approximately 20%) is sold as aggregate or used to make concrete onsite; in both cases it is transported by truck.

Water used to wash gravel during processing is recycled through a clarifying process to remove silt and clay. The fine sediments are then run through a belt press to remove excess water and transported by truck and placed in holding cells in the mine where it is allowed to dry for up to three years. After drying, fines may be used to raise the floor of the mine by

[1] *Consistent with applicable provisions of the 2011 Settlement Agreement (see Section 2-3 of **Chapter 2** for detail).*

placing the material in cells separated by rock curtains to facilitate drainage. The material is placed in approximately 6-inch lifts and compacted. Once filled to the desired height with fines from the belt press in this manner, a gravel cap of not less than 10 feet is placed over the compacted fines to mitigate potential for settlement and facilitate drainage.

Historic Land Uses

The site is the location of past industrial activities, which have resulted in concentrations of heavy metals in some portions of the Expansion Area. These include the Former DuPont Works which was a commercial explosives and munitions factory that operated from 1909 to 1976. Cleanup activities were completed in 1993 and resulted in a Consent Decree with the Department of Ecology and recording of a restrictive covenant limiting future land use to industrial uses. This restriction resulted in the MRP zoning that applies to much of the Expansion Area portion of the site. This area is also located within the 1,000-square mile area affected by airborne pollution from the Asarco smelter. Affected soils would be cleaned up pursuant to Ecology's Voluntary Cleanup Program (VCP). CalPortland submitted a proposed Cleanup Action Plan (CAP) to Ecology; the agency subsequently issued an opinion letter that "no further action" would likely be necessary at the property after implementation of the CAP and described the possibility of removing the restrictive covenant after arsenic and lead concentrations in soil are reduced on the property.

Existing Land Uses

Site Land Uses

The South Parcel Project site includes areas previously undisturbed by mining deemed the Expansion Area. The 188-acre Expansion Area includes portions of the 168-acre South Parcel, the 10.8 acre kettle wetland and surrounding buffer and a 9.2-acre buffer strip between the existing mine and the south parcel property boundary. The South Parcel Project also includes a plan to mine deeper within a portion of Existing Mine, referred to as the "Re-Mine Area". The Expansion Area is located southeast of the existing mine. The Existing Mine Area and the Expansion Area are included within the Mineral Resource Overlay in the City of DuPont's adopted Comprehensive Plan. The Re-Mine Area consists of 125 acres in the southeastern portion of the Existing Mine where current mining activities are permitted above current groundwater levels. See **Table 3.8-1** for a breakdown of existing land uses on the site; also refer to **Figures 2-1** and **2-2** for an illustration of these areas.

The Re-Mine Area is primarily in previously mined and active mine areas. In general, the northern portion of the Re-mine Area is in active mining, with the central portion of the Re-mine Area in previously mined area in initial reclamation. The southwest corner of the Re-mine Area is in reclaimed area with established vegetation.

The Expansion Area is primarily in vegetation, including previously logged and replanted area on the South Parcel (including trees meeting the definition of Landmark trees (DMC 25.10.120.005) such as Oregon white oak, Douglas fir, western red cedar, Pacific madrone, and Pacific yew), unmined area associated with the Existing Mine with shrubs, and wetland and buffer area associated with the Kettle Wetland. Logging roads traverse the site.

Table 3.8-1
EXISTING SITE CONDITIONS

Land Use	Area [1] in Acres				
	Existing Conditions				
	Expansion Area			Re-Mine Area	Total
	South Parcel	Kettle Area	Buffer Strip		
Buildings	--	--	--	--	0.00
Roads, Access, and Parking	--	--	0.4	9.2	9.55
Processing Areas	--	--	0.2	17.9	18.08
Active Mining	--	--	--	--	0.00
Active Reclamation	--	--	0.2	20.5	20.62
Cleared for Mining	--	--	--	--	0.00
Water Management Ponds	--	--	--	--	0.00
Total Built Areas	**0**	**0**	**0.8**	**47.5**	**48.26**
Natural & Reclaimed Areas					
Areas Reclaimed as Forest	--	--	--	3.3	3.3
Areas Reclaimed as Grass	--	--	--	68.5	68.5
Wooded Areas	146.2	5.6	7.4	5.8	165.1
Grass Areas	21.3	--	1.0	0.21	22.5
Wetland	--	1.8	--	--	1.8
Wetland Buffer	--	3.4	--	--	3.4
Total Natural & Reclaimed Areas	**167.5**	**10.8**	**8.4**	**77.7**	**264.5**
Total	**167.5**	**10.8**	**9.2**	**125.2**	**312.7**

Source: CalPortland, 2022.

Notes: -- Indicates no area of this type.

1) Totals may not exactly equal the sum of their components due to rounding.

Site Vicinity Land Uses

The land use character of the area in the vicinity of the site is varied and contains mining, warehouse/distribution, military joint base, open space, recreation, municipal and

residential. **Figure 3.8-3** provides an aerial photograph illustrating land uses in the immediate vicinity of the site. Land uses in the vicinity of the site include:

- **To the North** – Existing Mine operation including active mining, processing facilities, and reclaimed area located to the immediate north. Joint Base Lewis McCord (JBLM) North Lewis, the JBLM Solo Point Wastewater Treatment Plant, and Solo Point recreational open space are located farther to the north and northeast.

- **To the West** - Existing Mine operation including active mining and reclaimed area to the immediate west. Puget Sound is located farther to the west.

- **To the South** – Sequalitchew Creek and associated ravine, vegetation and public trail to the immediate south. Creekside Village Apartments complex is located adjacent to the southeast corner of the site. Farther to the south, across the Sequalitchew Creek ravine, are the Sequalitchew Creek Trail Head, The Home Course golf course, and the City of DuPont Civic Center (City Hall and Police Department buildings).

- **To the East** – Powerline Road is located to the immediate east of the site. Farther to the east, across Powerline Road, are the DuPont Community Garden, and warehouse/distribution uses (including the Amazon Fulfillment Center, FedEx Distribution Center, and the Costco Logistics building).

Source: EA Engineering, 2023.

EA Engineering, Science, and Technology, Inc., PBC

Figure 3.8-3

Existing Land Uses Map

3.8.2 Environmental Impacts

Potential land use impacts are generally described as direct, indirect or cumulative. Direct land use impacts can generally include development of undeveloped lands, conversion to more intensive uses, displacement of existing uses, conflicts between different types of uses, and changes in the character of the area. Indirect land use impacts are those that could be associated with peripheral development resulting from changes or intensification of land use at the site. Cumulative land use impacts are those that could occur as a result of the proposal in combination with other foreseeable development.

ALTERNATIVE 1 – PROPOSED ACTION

Conversion of Land Use

The Washington State Growth Management Act and the DuPont Comprehensive Plan/Mineral Resource Overlay identify conversion to mining as an appropriate interim use of the site. Reclamation of the site, consistent with a DNR approved reclamation plan, and subsequent potential redevelopment under existing zoning would follow mining under the Proposed Action.

Under the Proposed Action mining activities would continue on the approximately 125-acre Re-mine Area where proposed mining would deepen a portion of the Existing Mine, and expansion of mining in the approximately 188-acre Expansion Area currently undisturbed by mining (**Table 3.8-2)** provides a summary/comparison of existing land uses of the site and site land uses under the Proposed Action.

As indicated in **Table 3.8-2**, proposed mining and reclamation activities at the site would convert approximately 188 acres of wooded, grass, wetland and wetland buffer area on the Expansion Area portion of the site to mining area that would be reclaimed subsequent to the completion of mining activities.

The existing approximately 125-acres of mining use on the Re-mine Area portion of the site would continue as mining use under the Proposed Action, with this area reclaimed after completion of mining activities (see **Table 3.8-2**).

Conversion to More Intensive Land Use

No existing uses would be displaced by proposed mining under the Proposed Action. Proposed continuation of mining activities in the Re-mine Area of the site would continue the levels of mining activity as under current activities, including levels of dust and noise, and mining in this portion of the site would not represent an increase in the intensity of land use. Mining activities on the Re-mine Area portion of the site would lower the surface elevation and mining would occur approximately 14 years longer than under the No Acton

Alternative, although the levels of mining activity on this portion of the site would be similar to previous mining.

Proposed extension of mining to the currently undeveloped Expansion Area portion of the site would increase the intensity of land use. Logging, and phased clearing and mining activities in this portion of the site would increase the levels of dust and noise compared to current conditions. Mitigation measures would be employed to limit these potential impacts (see Section 3.2, **Air Quality**, and Section 3.7, **Noise**, for detail on impacts and mitigation measures).

Relationship to Surrounding Uses

As described in the Affected Environment portion of this section, The Re-mine Area portion of the site has been, or currently is, in mining activity, is not proximate to off-site land uses, and mining under the Proposed Action on this portion of the site would not be anticipated to directly impact any surrounding land uses.

Portions of the Expansion Area are proximate to surrounding sensitive uses off the site and has the potential to impact surrounding uses, including recreational and residential land uses.

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Proposed logging and phased mining activity under the Proposed Action would occur in proximity to Sequalitchew Creek ravine and trail; mining phases 1C, 1D, 2A and 2B would occur along the southern edge of the site and in proximity to the Sequalitchew Creek ravine and trail. Clearing, mining and reclamation would be phased, thus minimizing the duration of these activities at any specific area. A minimum 100-foot wide vegetated setback from the top of the ravine slope, coupled with a 20-foot high berm where the trail is not in the ravine, would be provided to limit the potential for visual, dust and noise impacts to users of the trail.

The natural buffer provided by the Sequalitchew Creek ravine, distance, proposed on-site buffer and berm, and proposed noise and air quality mitigation measures would limit the potential for direct land use impacts to uses farther to the south such as the Home Course golf course and DuPont Civic Center.

The southeast corner of the Expansion Area portion of the site is proximate to the Creekside Village apartment complex and phase clearing and mining (Phase 2C) would occur in proximity to this off-site residential use and would increase to the potential to increase levels of dust and noise in the area. Along with specific measures to limit air quality and noise impacts, the approximately 100-foot wide vegetated buffer, with a 20-foot high berm, would be provided along the southern boundary of the site and limit the potential for visual, dust and noise impacts to residents of the Creekside Village apartment complex.

TABLE 3.8-2
SITE CONDITIONS COMPARISON

Land Use	Area [1] in Acres									
	Existing Conditions					Proposed Action - Post-Reclamation				
	Expansion Area			Re-Mine Area	Total	Expansion Area			Re-Mine Area	Total
	South Parcel	Kettle Area	Buffer Strip			South Parcel	Kettle Area	Buffer Strip		
Built Areas										
Buildings	--	--	--	--	0.00	--	--	--	--	0.00
Roads, Access, and Parking	--	--	0.4	9.2	9.55	--	--	--	--	0.00
Processing Areas	--	--	0.2	17.9	18.08	--	--	--	--	0.00
Active Mining	--	--	--	--	0.00	--	--	--	--	0.00
Active Reclamation	--	--	0.2	20.5	20.62	--	--	--	--	0.00
Cleared for Mining	--	--	--	--	0.00	--	--	--	--	0.00
Water Management Ponds	--	--	--	--	0.00	--	--	--	--	0.00
Total Built Areas	**0**	**0**	**0.8**	**47.5**	**48.26**	**0**	**0**	**0.00**	**0.00**	**0.00**
Natural & Reclaimed Areas										
Areas Reclaimed as Forest	--	--	--	3.3	3.3	29.4	0.6	0.6	35.8	66.4
Areas Reclaimed as Grass	--	--	--	68.5	68.5	138.2	10.2	8.6	89.4	246.4
Wooded Areas	146.2	5.6	7.4	5.8	165.1	--	--	--	--	0.0
Grass Areas	21.3	--	1.0	0.21	22.5	--	--	--	--	0.0
Wetland	--	1.8	--	--	1.8	--	--	--	--	0.0
Wetland Buffer	--	3.4	--	--	3.4	--	--	--	--	0.0
Total Natural & Reclaimed Areas	**167.5**	**10.8**	**8.4**	**77.7**	**264.5**	**167.5**	**10.8**	**9.2**	**125.2**	**312.7**
Total	**167.5**	**10.8**	**9.2**	**125.2**	**312.7**	**167.5**	**10.8**	**9.2**	**125.2**	**312.7**

Source: CalPortland, 2022.

Notes: -- Indicates no area of this type.

2) Totals may not exactly equal the sum of their components due to rounding.

On an overall basis, proposed mining under the Pioneer Aggregates South Parcel Project is not expected to indirectly affect future land uses at the site or in the surrounding area. Proposed mining activities are considered a transitional use, and any potential impacts would not prevent planned future use of the area, consistent with the underlying Comprehensive Plan and zoning designations. It is not anticipated that the Proposed Action would generate any spin-off uses in the area, such as commercial or residential uses.

CUMULATIVE IMPACTS

The change in the undeveloped nature of the site and use for mining would be consistent with the Mineral Resource Overlay Area designation, and the future land uses planned for the site under the underlying zoning (Residential and Manufacturing/Research Park). Following mining, the site would be developed for residential and employment uses.

No existing uses would be displaced. Potential impacts to surrounding land uses resulting from mining would not interfere with, preclude, or significantly conflict with existing or planned land use of the surrounding areas, and mining would not compete with or preclude other uses in the near term. Impacts from construction and operation of the mining facility – primarily dust-, visual-, and noise related impacts – could potentially affect operations of current and planned uses in the short term, JBLM as well as surrounding development. However, mitigation measures would be employed to limit these potential impacts on the surrounding area (please see Section 3.2, **Air Quality**, 3.7, **Noise**, and 3.11, **Transportation**, for detailed information concerning these mitigation measures). Mining impacts would also be temporary, and would occur some distance from and be buffered from surrounding development. As discussed in Section 3.9, **Aesthetics,** of this Draft EIS, the site is not visible from most surrounding locations. Overall, impacts to land use on and immediately adjacent to the site would be transitory and relatively minor. No significant long-term impacts are anticipated.

Indirectly, mining is not expected to affect future land uses on the in the surrounding area. Mining operations are a transitional use, and any potential impacts would not interfere with or prevent the planned future land use of the area, consistent with the underlying Comprehensive Plan and zoning designations. It is noted that industrial uses have continued to develop adjacent to the existing mining operation, so mining apparently has not been a deterrent or caused significant conflicts with planned growth. Proposed mining would not be likely to generate any spin-off uses in the area.

ALTERNATIVE 2 – NO ACTION

There are two No Action Alternatives- Scenario A Continuation of Existing Conditions; and Scenario B Site Development Under Existing Zoning.

Scenario A

Under Scenario A, mining activities associated with the Re-Mine Area of the site and the Existing Mine would continue as currently permitted. The mining operation would retain a vegetated buffer at its perimeter, and dust, noise, traffic conditions that currently exist would continue. The Existing Mine has an estimated remaining life of 6 to 10 years with mining currently limited to 10 feet above groundwater. The Expansion Area portion of the site is assumed to remain undeveloped and would continue in its vegetated condition.

Scenario B

Under Scenario B, the proposal would not occur. The site would be developed for urban uses consistent with the City's Future Land Use Map. The majority of the area affected is currently designated by the City of DuPont Comprehensive Plan as Manufacturing and Research, with a smaller area designated for residential uses. The corner of the property near Center Drive is designated as Residential 12, which would allow higher density residential development where multifamily density averages 12 units per acre. Urban development, as permitted under current planning and zoning designations, is assumed to occur east of the lease line demarcating existing mining operations. The timing and nature of any such development would be driven by market forces.

In general, development of manufacturing/research park and housing would change the land use character of the site (including the Expansion Area) from an undeveloped property to manufacturing park and suburban residential area. Construction would occur over an extended period of time and would generate impacts related to traffic, noise, dust and surface water runoff. Upon completion of construction, the traffic and public service demands typical of the manufacturing park and residential neighborhoods would occur, including increased demand on the Sequalitchew Creek Trail.

3.8.3 Mitigation Measures

No significant adverse land use impacts have been identified. However, the following mitigation measures have been identified to further reduce the potential for land use impacts associated with the proposed South Parcel Project.

Proposed Mitigation Measures

- Maintain a vegetated buffer along Powerline Road. Trees will be planted densely to establish screening during mining operations. After mining is completed, selective thinning may be necessary to facility a healthy future forest within the buffer.

- Mitigation measures identified throughout the EIS would minimize impacts to land use from mining activities, consistent with City regulations (see Section 3.1, **Earth**, Section 3.2, **Air Quality**, Section 3.6, **Noise**, and Section 3.10, **Transportation**).

3.8.4 Significant Unavoidable Adverse Impacts

The proposed Pioneer Aggregates South Parcel Project would result in an unavoidable change to the land use character of the existing landscape within the Expansion Area portion of the site. The extraction of mined material would result in a permenant change in the land use character of the site. However, the Proposed Action is not expected to result in a significant adverse impact to land uses of the surrounding community. Mining is a transitional use of the site; although mining would alter the site for a number of years, after mining is complete, the site would likely be developed to another permitted use.

3.8.5 Relationship to Plans and Policies

Washington State Growth Management Act

Summary: The Growth Management Act (GMA) was originally enacted in 1990 and contains a comprehensive framework for managing growth and coordinating land use planning activities. The GMA contains thirteen planning goals, which provide direction to cities to create local plans that express their own visions for growth but which are also consistent with the GMA goals. Cities must also adopt development regulations that implement and are consistent with their plans. Most relevant to the current proposal, jurisdictions must identify, designate and regulate resource lands of long-term commercial significance, including mineral resource lands. Development regulations must assure the conservation of identified resource lands, and that adjacent land uses will not interfere with the continued use of designated resource lands. As established by state rules, "conservation" means measures designed to assure that resource lands will remain available to be used for commercial production (WAC 365-196-815(b)).

Discussion: The City has designated mineral resource lands on its Comprehensive Plan Land Use Map and has adopted Mineral Resource Overlay regulations, which are discussed below.

City of DuPont Comprehensive Plan

Mineral Resource Overlay

Summary: As noted above, the GMA requires that cities and counties identify, designate and adopt regulations to conserve resource lands of long-term commercial significance, including lands containing mineral resources. The intent is to ensure that designated resources remain available for commercial production. WAC 365-195-815(1)(a)-(b).

The DuPont Comprehensive Plan provides a Mineral Resource Overlay designation, which is applied to the Manufacturing/Research Park and Residential Reserve land use categories north of Center Drive and Sequalitchew Creek (LU-40), within the planned Sequalitchew Village. This area is underlain by commercially significant mineral resources. The Plan acknowledges that phased mining and reclamation may occur in the Overlay area subject to City review of a site-specific proposal.

*Discussion: The Pioneer Aggregates South Parcel Project proposal is consistent with Comprehensive Plan policies and procedures applicable to mineral resource lands. As shown on the Comprehensive Plan Land Use Map (**Figure 3.8-1**), the site is within the designated Mineral Resource Overlay area. The City will consider the site-specific mining proposal for the Pioneer Aggregates South Parcel project using its site plan review process, as set forth in the Land Use Code (DMC 25.150).*

Summary: Sequalitchew Village includes the area of the City bounded by Puget Sound to the north and west, the manufacturing research park and industrial areas to the east and Sequalitchew Creek on the south. This village is planned as a mixture of residential types and densities in the northern two-thirds of the area, and manufacturing and research park uses in the southern one-third. It is named for the creek and canyon which form its southern border. Nearly this entire village is within the mineral resource overlay boundary. Gravel extraction by Glacier Northwest is currently underway in this area and is expected to proceed over a long term. Development is not likely to begin within this area within the foreseeable future. As a result of mineral extraction, the surface elevation of this village will be many feet lower than the present height. No mining is permitted within 100 ft of the top of Sequalitchew Creek Ravine. Mining is also set back from the top of the bank along the western side of the property to preserve the bluffs overlooking Puget Sound. The Sequalitchew Creek Ravine and Puget Sound bluffs are designated open space.

Discussion: The Pioneer Aggregates South Parcel Project proposal is consistent with the DuPont Comprehensive Plan goals for Sequalitchew Village applicable to the Proposed Action. Mining under the Proposed Action would be setback further than 100 feet from the top of Sequalitchew Creek ravine and would not directly impact open space associated with Sequalitchew Creek or the Puget Sound bluffs.

City of DuPont Land Use Code

Mineral Resource Overlay (DMC 25.60)

Summary: The Mineral Resource Overlay designation in the Land Use Code is intended to implement the GMA, the Surface Mining Act (RCW 78.44), and the DuPont Comprehensive Plan. Permitted uses in the Overlay include mineral extraction, along with associated structures and equipment. The regulations state that potential impacts relating to traffic, lighting, visual screening, vegetation, noise and sensitive areas shall be examined, while recognizing that impacts to other elements of the environment, including air and water

quality are within the jurisdiction of federal, state or regional agencies. Site plan approval (Type III/Hearing Examiner Process) is required for all mining proposals.

Discussion: The site is located within the designated Mineral Resource Overlay area, and mining is a permitted use. A site plan application for mining (Pioneer Aggregates South Parcel Project) was submitted to the City and was determined to be complete. The Pioneer Aggregates South Parcel Project EIS is considering potential impacts relating to traffic, lighting, visual screening, vegetation, noise and sensitive areas, as well as other issues (e.g., air and surface water/groundwater) that are within the jurisdiction of federal, state or regional agencies.

Residential Reserve Zoning District (25.20)

Summary: The underlying zoning classification for a small portion of the South Parcel is Residential Reserve. The purpose of the Residential Reserve district is to designate property not needed to meet the City's 20-year growth projections. The district applies a 5-acre minimum lot size as an interim measure, so as to provide time for further planning, evaluation and eventual redesignation when additional residential land is needed.

Discussion: As noted above, mining is a permitted use in the Mineral Resource Overlay notwithstanding the underlying zoning classification. The Residential Reserve designation indicates that the subject property was not needed to meet the 20-year growth projection. Subsequent to completion of mining activities and completing of reclamation, the .site would be suitable for residential development.

3.9 AESTHETICS

This section of the DEIS describes existing aesthetics conditions on the site and in the site vicinity. Potential impacts associated with the EIS Alternatives are evaluated and mitigation measures are identified. This section is based on the *Visual Impact Analysis* (December 2022) prepared by ESA with peer review by EA Engineering (see **Appendix L**).

3.9.1 Methodology and Viewpoints

Methodology

The visual impact methodology employed for this EIS is intended to document the nature of the existing landscape, and to identify impacts to visual resources that would result from alteration of the landscape from proposed mining and reclamation. The assessment relies on the preparation of computer-based visual simulations of the landscape that would result from mining of the Expansion Area. Simulations are a generally accepted means to evaluate the nature of proposed visual change.

A number of key viewpoints were identified from a variety of locations around the site. The selected viewpoints are intended to be representative of viewpoints where public views toward the site are available, and to illustrate the potential for significant visual impacts to the public from the Proposed Action (see discussion of *Key Viewpoint Selection below)*. At each of these locations, existing conditions were photographed, and these photographs are used as a basis of comparison against simulated conditions at the same viewpoints.

The visual impact assessment is based on a combination of identifying potential for public views, evaluating existing visual quality, identifying viewer sensitivities, and evaluating degree of visual change resulting from a proposed project. For this analysis, levels of visual quality and viewer sensitivity are estimated based on criteria that establish ratings of "high," "medium," and "low." Visual change is qualitatively evaluated based on the visual simulations. By qualitatively combining rankings of visual quality, visual sensitivity, and the direct visual change identified in the simulations, an overall determination can then be made regarding the potential impact on a given viewpoint. For example, mining-related actions at a particular viewpoint may show a high level of impact in the simulations, but when combined with a low visual quality and sensitivity ranking, would be considered to have little overall impact to visual quality in that area.

Visual quality for this analysis is evaluated using the following criteria:

- **Low**: Landscape is common to the region and exhibits few, if any, memorable features, or patterns that provide visual diversity. A prevalence of encroaching human elements or landscape modifications exists, which do not compatibly blend

with the natural surroundings. Human alterations exhibit low maintenance, design quality, or siting sensitivity.

- **Medium or Moderate**: Landscape exhibits generally attractive natural and man-made features/patterns, although they are not visually distinctive or unusual within the region. The landscape integrity of the area provides some positive visual experiences such as natural open space with some existing disturbance or well-maintained development.

- **High**: Landscape exhibits distinctive and memorable visual features and patterns that are largely intact and undisturbed – usually a rural or open space setting. Development or visual disturbances, if present, are well planned to integrate with natural landscape materials or character.

Viewer sensitivity is considered dependent on viewer types and exposure to a proposed activity, number of viewers, availability of views to the proposed activity, view orientation and duration, and viewer expectation. Levels of viewer sensitivity are evaluated by the following criteria:

- **Low**: Viewer types represent viewers of low visual sensitivity including workers who are involved in their work and not focused on the landscape. Viewer numbers and view duration are low. Viewers have low expectations of experiencing high quality views and are not typically in search of a quality visual experience. Views are often screened or limited.

- **Medium or Moderate**: Viewer types represent viewers of medium visual sensitivity including recreationists and passing motorists. Viewer numbers and view duration are moderate in scope. Viewers have only a moderate expectation of experiencing high quality views and may or may not be engaged with the passing visual experience.

- **High**: Viewer types represent viewers of high visual sensitivity including tourists and homeowners. Viewer numbers and view duration are high, with views oriented towards a specific landscape or vista. Viewers have every expectation of experiencing high quality views and are often in search of a quality visual experience. Views are often wide and sweeping, or from a superior vantage point.

(See **Appendix L** to his Draft EIS for detail on visual analysis methodology.)

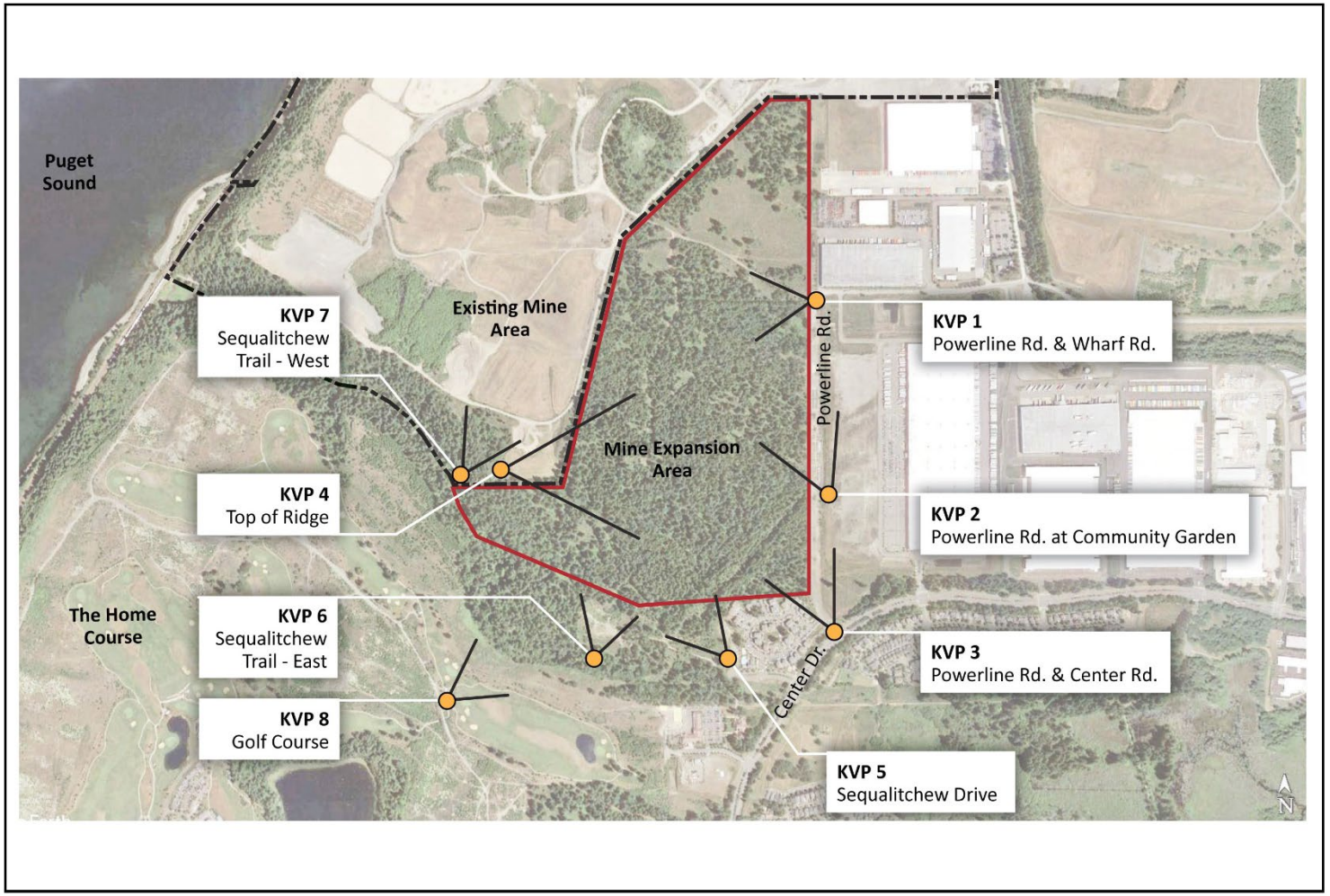
Viewpoint Selection

Due to existing topography and vegetation, there are very few locations outside the site from which existing operations are now visible or would be visible in the future. Natural topographic relief in the area is minimal, outside the Sequalitchew Creek Canyon, which is a relatively deep ravine. Although views into the site from the vicinity is minimal, proposed mining operations would remove some of the existing vegetation, which would affect some off-site views.

A viewshed analysis using Google Earth (2022) demonstrated that there are no surrounding areas of higher ground that afford views of the site. Aerial photos show that current mining operations have maintained vegetated buffers along the west and south sides of the mine. As a result, there are no views into the site from Puget Sound or the Sequalitchew Creek canyon. Views into the site from the north are only available from the existing mine. There are no public viewpoints of the site to the west, due to presence of the vegetated bluff at the west perimeter of the mine along Puget Sound. No public viewpoints are available from the northwest; the only views are from the mining access road and the abandoned Fort Lewis landfill. Therefore, the viewpoints chosen for simulations are limited to locations to the south and east of the site.

Key Viewpoints (KVPs) were selected to illustrate the greatest or "worst case" potential for visual impact to the public from the Proposed Action. Visual simulations were developed from the four KVPs around the proposed mine site where a view to the proposed mining activity is available (KVPs 1, 2, 3 and 4), as identified in **Figure 3.9-1**. A summary description and selection criteria for these four KVPs is provided in **Table 3.9-1**. These viewpoints were chosen to provide representative depictions of the future landscape that would best illustrate proposed project changes from a variety of viewpoints. To the degree possible, "sensitive" viewpoints were selected from locations accessible to the public; these were believed to potentially impact the greatest number of people.

The four other viewpoints (KVPs 5, 6, 7 and 8) were considered but simulations were not considered necessary because the site is blocked from view by vegetation and/or topography and would remain so during and after proposed mining at the site (both Re-mine Area and Expansion Area portion of the site). This included a view at the west end of Sequalitchew Drive (KVP 5); a public road that is expected to be eventually extended but currently serves as an access point to a public trailhead; a typical view looking northwest towards the site along Sequalitchew Trail (KVP 6); and a view from a semi-public viewpoint – The Home Course golf course south of Sequalitchew Creek (KVP 7). For these viewpoints, photos are included showing the approximate location of the site beyond the vegetation and topography that obstructs views of the site (see **Appendix L** for additional detail on selected viewpoints).



Source: ESA, 2022.

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Figure 3.9-1
Key View Point Location Map

Table 3.9-1
SUMMARY DESCRIPTION OF SIMULATION KEY VIEWPOINTS (KVPS)

Key Viewpoint Description	Location and Viewers	Selection Rationale
1: Powerline Rd. at Wharf Rd. This viewpoint lies along Powerline Road at the point where there is a 90-degree bend in the road. The camera angle is looking in a westerly direction, down into the basin of the new creek bed.	Private Road: Vehicle passengers	Wharf Road is used primarily by trucks turning around for the adjacent warehouses, but Wharf Road is open to the public. Pedestrians and cyclists using Powerline Road can access this intersection. Views of vegetation along this road would be heavily affected.
2. Powerline Rd. at Community Garden. This viewpoint lies on the east side of Powerline Road near the south entrance to the community Garden. The camera angle is looking in a northwesterly direction.	Private Road: Garden users, cyclists, pedestrians.	Community garden users can drive to the community garden on Powerline Road. Pedestrians and cyclists also use Powerline Road.
3: Powerline Rd./Center Dr. This viewpoint lies on the northwest side of the intersection of Powerline Road and Center Drive. The camera angle is looking in a northwesterly direction.	Public: Vehicle passengers, DuPont residents	This represents a key public viewpoint. The public traveling along Center Drive can look into the site along the proposed access road and have a glimpse of the site alteration that is taking place. The view would be affected by removal of existing vegetation as part of mining operations…
4: Top of Ridge This viewpoint sits on top of the ridge between the active mining site and Sequalitchew Creek, at the southwest edge of the Expansion Area. The camera angle is looking in east northeast direction, giving an overview of the mine site after mining and restoration are complete.	Private: CalPortland employees	This viewpoint models a view that is located on the privately-owned site and is not available to the public. There currently is no public road or trail providing access to this spot. An observer must climb from the existing mine road up a small brush-covered knoll to reach it. Although not public, the viewpoint offers an extensive view of the project from above, which is intended to help the reader understand the character of the project landscape after reclamation.
Key Viewpoints considered but not simulated		
5: Sequalitchew Drive. This viewpoint lies at the current west end of this road, where public trail users frequently park. The camera angle is looking in a northwesterly direction.	Public: Trail users	This viewpoint shows where the project site stands in relation to this popular public trailhead along Sequalitchew Creek. Vegetation and topography block views of the project site.
6: Sequalitchew Trail - East This viewpoint lies on the public trail leading down to the Sound. The camera angle is looking in a northerly direction.	Public: Trail users	This viewpoint shows where the project site stands in relation to this popular public trail along Sequalitchew Creek. Vegetation and topography along Sequalitchew Creek block views of the project site.
7: Sequalitchew Trail - West This viewpoint lies on the public trail leading down to the Sound. The camera angle is looking in a northwesterly direction.	Public: Trail users	This viewpoint shows the lower portion of Sequalitchew Creek Trail at approximately the closest point on the trail to the project site. Because the site is directly uphill from this location, the view is not facing the site but shows the slope along the trail's north side. Vegetation and topography along Sequalitchew Creek block views of the project site and would not be affected.
8: The Home Course (Golf Course). This viewpoint lies near the edge of the golf course, near the edge of the Sequalitchew Creek ravine. The camera angle is looking in a northerly direction, toward Sequalitchew Creek and the project site.	Semi-Private: Golfers/Recreationists	This viewpoint shows where the project site stands in relation to the golf course. Vegetation within the golf course and along Sequalitchew Creek block views of the project site.

Source: ESA 2023.

3.9.2 Affected Environment

The visual character of the site is varied. The Expansion Area portion of the site includes a mixture of open grassland and mature, open prairie forest dominated primarily by Douglas fir. This forest cover varies in density throughout the Expansion Area, typical for a south Puget Sound prairie landscape, but is comparatively dense on the eastern edge, along Powerline Road and Center Drive. The Re-mine Area portion of the site is primarily disturbed by previous mining activity, with some undisturbed natural area. Forested evergreen buffers provides a measure of visual opaqueness to the site, such that passersby currently cannot view the existing mining operations.

As noted previously, due to existing topography and vegetation, there are few locations where the public can view the site, and there are no views to the site from Puget Sound or Sequalitchew Creek ravine.

Existing Conditions at Viewpoints

KVP 1 – Powerline Road at Wharf Road

KVP 1 is located at the centerline of Powerline Road, immediately south of the right-angle bend, looking directly westward into the future mining Expansion Area. The gravel road on the right-hand side of the photo is an active service road for the existing mining operations. These operations are currently screened by existing mature vegetation that is typical of south Puget Sound prairie forests. The dense forest seen on the left side of the photo is typical of the dense buffer of Douglas fir that is found along the west side of Powerline Road from KVP 1 south to Center Drive.

The visual quality is judged to be moderate. No extended views are present. Existing vegetation is a mixture of disturbed and undisturbed vegetation. Some visual clutter is present, such as fences and gates.

Viewers are expected to be of a low sensitivity, including the occasional local motorist, bicyclist, or pedestrian. The landscape is common to the region and a prevalence of encroaching human elements or landscape modifications exist, which do not compatibly blend with the natural surroundings

KVP 2 – Powerline Road at Community Garden

KVP 2 is located on Powerline Road at the existing Dupont Community Garden between Wharf Road and Center Drive, looking northwest towards the site. Paved roadway, gravel shoulder, Community Garden entrance, and forest area are visible in the foreground. Existing overhead wires and transmission line poles are visible in the background. The visual quality is judged to be moderate. No extended views are present. Existing vegetation is a mixture of disturbed and undisturbed vegetation. Some visual clutter is present, such as fences, gates, and signage. The east side of Powerline Road is dominated by large transmission line poles and overhead wires.

Viewers are expected to be of a low to moderate sensitivity and be more numerous than for KVP 1. Viewers include the community garden users, and the occasional local motorist, bicyclist, or pedestrian, and City staff accessing a plant nursery. The landscape is common to the region and a prevalence of encroaching human elements or landscape modifications exist, which do not compatibly blend with the natural surroundings.

KVP 3 – Powerline Road and Center Drive

KVP 3 is located on the berm on the east side of Center Drive (facing directly toward the Expansion Area portion of the site), directly in line with the centerline of Powerline Road as it intersects Center Drive. The existing power transmission towers following Powerline Road are clearly visible in the middle-ground of the photo. The dense forest of mature Douglas fir in the background is typical of the forest buffer along the eastern border of the Expansion Area portion of the site. It is a continuation of the forest seen in the left-hand side of the photo seen in KVP 2 Existing. This forest continues with similar density to the west. The density of the forest in the far-left hand side of the photo continues west along the existing Sequalitchew Creek to Puget Sound.

The visual quality is judged to be moderate. The view is a mixture of mature second-growth forest in the background contrasting with a developed arterial collector road in the foreground, the Creekside Village Apartments on the left side of the view, and a high-tension power transmission line in the middle-ground.

Viewers are expected to be of medium sensitivity, including workers or residents of DuPont, as well as visiting recreationists driving along Center Drive.

KVP 4 – Top of Ridge

KVP 4 is located on a high point on the ridge between the Sequalitchew Creek canyon and the existing mine area. The viewpoint is on the Existing Mine site, in an isolated, inaccessible location, requiring a hike through unmarked forest, and members of the public would not typically see this view[1]. The grassy field in the foreground consists of reclaimed area from the existing mining operations that was re-contoured and hydroseeded.

Visual quality is classified as medium, with sweeping open views of the landscape and mature forests in the background. The middle ground view is dominated by the newly reclaimed mine area, showing evidence of recent vegetation growth.

Viewer sensitivity was not classified, as this view is on private property where public access is prohibited by safety regulations enforced by the Mine Safety and Health Administration (MSHA).and would remain inaccessible until mine reclamation is complete.

KVP 5 – Sequalitchew Drive

KVP 5 is located on the west end of Sequalitchew Drive, looking in a northwesterly direction towards the Expansion Area portion of the site. Sequalitchew public trail users frequently park near this location. The photo shows the gravel trail entrance with residential structures in the background. The existing vegetation is comprised of evergreen native conifers and invasive scotch broom, which has overtaken the understory and open areas along the trail. The foreground includes a wooden fence, sign and concrete slab with wooden bollards indicating the entrance to Sequalitchew public trail.

[1] *The viewpoint was selected as one of the simulation viewpoints because it gives an unobstructed view of the Expansion Area mining area.*

KVP 6 – Sequalitchew Trail - East

KVP 6 is located on the center of the existing historic railroad bed to the southwest of the Expansion Area portion of the site. The photo shows the density of existing vegetation in the creek canyon, which obscures any clear view of the steep canyon walls. Viewers would be expected to be of high sensitivity, principally hikers, and other recreationists using the proposed trail system based on the existing old narrow gauge railway path. Visual quality is judged to be high, with a view of a mature second-growth forest surrounding the viewer.

KVP 7 – Sequalitchew Trail - West

KVP 7 is located on the lower portion of Sequalitchew Creek Trail at approximately the closest point on the trail to the project site. The site is directly uphill from this location, so the view is not facing the site but shows the slope along the trail's north side on the right-hand side of the photo. Existing vegetation and topography along Sequalitchew Creek currently block views of the site. Viewers are expected to be of high sensitivity, principally hikers and other recreationists. Visual quality is judged to be high, with an unbroken view of the forest and Sequalitchew Creek Trail

KVP 8 – The Home Course

KVP 8 is located on the top of a high knoll at the north side of the Home Course, a privately owned golf course immediately south of Sequalitchew Creek. This knoll is the highest point of land along the north side of the golf course. The tree line marks the top of the slope leading into the canyon. Viewers are expected to be of high sensitivity, principally users of the golf course. Visual quality is judged to be high, with an unbroken view of an attractive mature second growth forest viewed across an open grassy meadow.

3.9.3 Impacts of the Alternatives

This section identifies and analyzes impacts to existing aesthetic character and views associated with the EIS Alternatives.

Introduction

Visual simulation of conditions under the proposed Pioneer Aggregates South Parcel Project requires depiction of vegetation removal and changes in topography, as well as revegetation of the landscape at a future point in time (see **Appendix L** for detail on visual simulation methodology). For the purposes of this analysis, simulations were prepared at three future points in time, referred to as Year X, *Year X+* and Year Y. Where the proposed mining is not visible behind trees or another obstruction, the mine/portion of mine is shown with hatching, brackets, or another method (see KVP 5, KVP 6, KVP 7 and KVP 8).

For KVP 1, 2 and 3, Year X simulates the view when the visual impact of the project would be the greatest. This is expected to occur in approximately two years from the beginning of mining). At KVP 2, an additional simulation, Year X+ simulates the view approximately five years after the trees along Powerline Road have been planted, establishing a dense conifer screening that is expected to reach heights between eight and twelve feet by Year X+. *For all KVPs,* Year Y is chosen to depict conditions ten years after the end of mining, when revegetation of the site is well established. Mining of the South Parcel is assumed to take approximately 14 years. Therefore, Year Y would be approximately 24 years after project inception. By that time, it is assumed that the temporary power lines along the east perimeter of the Expansion Area portion of the site would be removed and woody vegetation such as trees and shrubs would be established on the slopes.

Year X and Year Y simulations were prepared for KVP 1, 2, and 3. KVP 4 is from a location where the public would not be permitted to be present, so a simulation was only prepared for the Year Y condition.

ALTERNATIVE 1 – PROPOSED ACTION

As indicated in **Chapter 2** of this Draft EIS, the Proposed Action includes horizontal expansion of mining on approximately 188 acres of undisturbed forested area (Expansion Area) and vertical expansion on approximately 125 acres of mostly disturbed area where re-mining would deepen a portion of the existing mine (Re-Mine Area). Prior to initiation of mining operations, logging and clearing of existing vegetation on the majority of the Expansion Area portion of the site and on a portion of the Re-mine Area portion of the site, which would change the existing aesthetic character of the site. As proposed mining progresses, completed mine phases would be reclaimed, including regrading and revegetation.

Changes in the aesthetic character of the site under the Proposed Action are anticipated to occur incrementally over an approximately 14-year period.

As indicated earlier, a number of key viewpoints (KVPs) were selected to illustrate the potential for visual impact to the public. Visual simulations were developed for the four

KVPs where a view to proposed mining would be visible. For KVPs where no view to proposed mining would be available, the intervening vegetation and/or topography is illustrated.

KVP 1 – Powerline Road at Wharf Road

Figure 3.9-2 illustrates the existing view and proposed Year X and Y conditions from KVP 1. The deep excavation resulting from new mining operations of the Proposed Action would eliminate the mature trees that screen the existing mining operations from/and along Powerline Road. The beginnings of reforestation efforts are visible in the Year X simulation, which would eventually allow new trees to grow up and screen the views again. However, it would take five to seven years to develop a full screen and longer for a more mature forest to develop. While visual change is evident, the Proposed Action would not have a significant adverse visual impact at KVP 1. This is due to the lack of sensitive viewers and the relative rapidity with which the landscape is expected to recover. Most of the unobstructed view from the road is expected to be screened within a five-year period due to vegetation regrowth.

KVP 2 – Powerline Road at Community Garden

Figure 3.9-3 illustrates the existing view and proposed Year X, X+ and Y conditions from KVP 2. Evergreen trees will be planted along the property line adjacent to Powerline Road; estimated to be planted in fall/winter of 2022/2023, depending on weather conditions and the availability of trees. Prior to the beginning of proposed mining the existing chain link fence would be moved to the property line.

Shrubby vegetation and large evergreen trees currently block views of the site. That vegetation would be removed at the beginning of mining at the Expansion Area portion of the site. An access road would parallel the east property line and would have temporary overhead power lines to power dewatering wells. Removal of the second growth conifers and groundcover would contrast sharply with current conditions and would temporarily open up views of the Expansion Area, an industrial use that is currently not visible from this location. Overhead lines would add an element of visual clutter. Given the sensitivity of viewers, this is considered a moderate impact on visual quality; the impact would be mitigated by the evergreen screening that would limit the duration of this impact.
In Year X, the site would be partially screened by densely planted evergreens along the fence line. By Year X+, the trees are expected to grow to approximately 8 to 12 feet in height. By Year Y, mining would be complete along this section. The power poles used for dewatering shown in Year X and Year X+ would be removed. Additionally, the fence along the perimeter would be removed in Year Y. The trees may be thinned as required for overall health.

KVP 1: Existing Condition

KVP 1: Year X

KVP 1: Year Y

Source: ESA, 2022.

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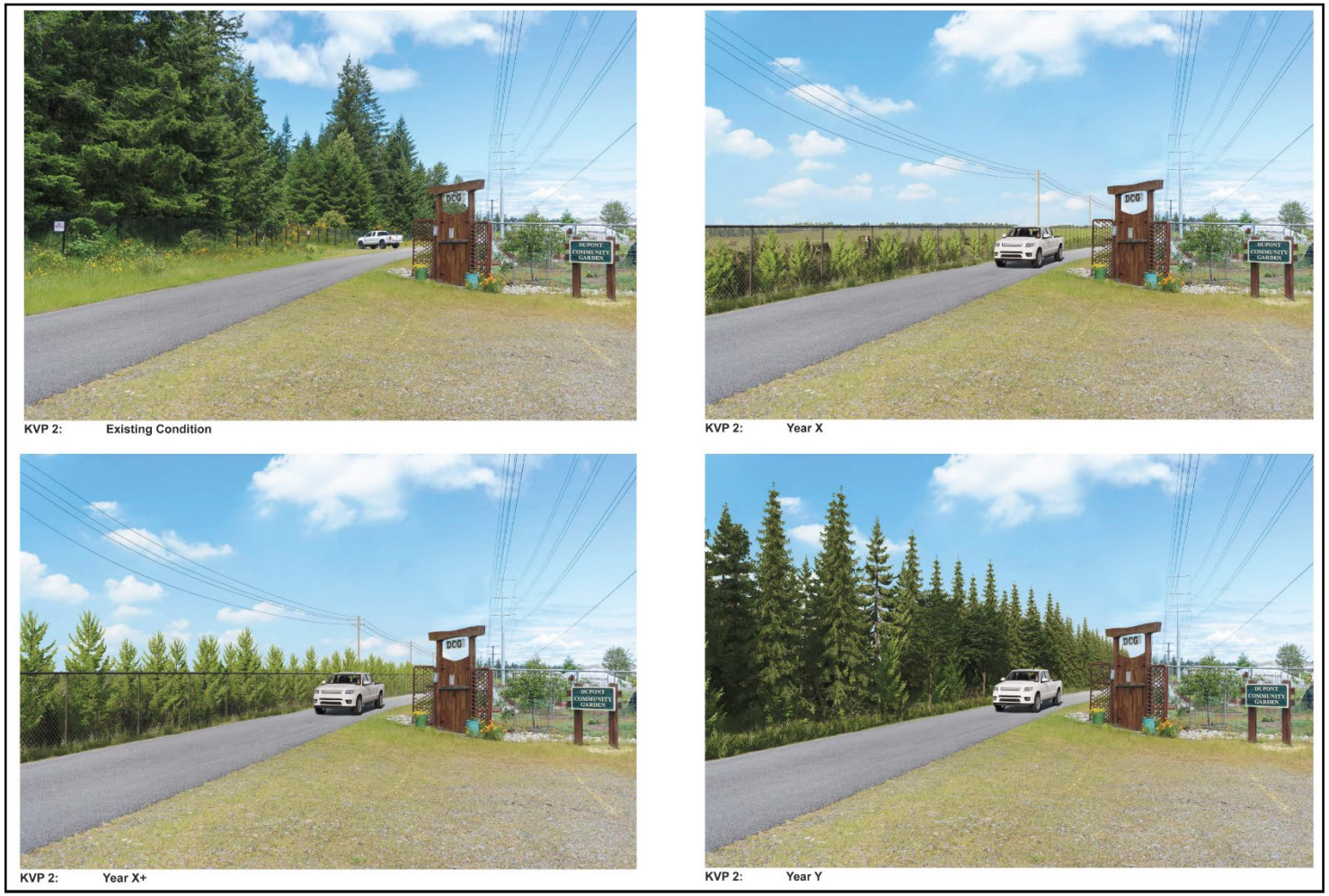
Figure 3.9-2

Key View Point Location 1



Source: ESA, 2022.

EA Engineering, Science, and Technology, Inc., PBC

Figure 3.9-3

Key View Point Location 2

KVP 3 – Powerline Road and Center Road

Figure 3.9-4 illustrates the existing view and proposed X and Y years from KVP 3. As shown in the simulation of KVP 3 at Year X, the cut through the forest would be clearly visible on the right-hand side closest to the power pole. The simulation demonstrates that the mining operation would not be visible from KVP 3. This is due to the grading, which would cause the land to fall away quickly from the viewer. Additionally, a 20-foot-high berm planted with trees and other native landscape vegetation would be placed in this area to shield residents in Creekside Village Apartments from potential visual and auditory impacts resulting from mining activities in the Expansion Area. The proposed Project is not anticipated to have a significant adverse visual impact at this KVP due to a low degree of visual change combined with the moderate existing visual quality and viewer sensitivity. The trees, which are cleared at Year X, would show regrowth by Year Y, although it would take many more years beyond Year Y before the trees would reach the same height as existing trees.

KVP 4 – Top of Ridge

Figure 3.9-5 illustrates the existing view and proposed Year Y from KVP 4. The scene in the Year Y simulation depicts the interior of the proposed mine following the completion of mining activity and restoration. In the foreground, the ground plane is relatively level with only minor variations in terrain. In the background, plateau benches step up towards the south end of the site to anticipate and facilitate future development. All side slopes are shown with dense tree plantings whereas the floor of the mine is relatively open having only been hydroseeded with native ground cover. Along the distant horizon, the screening vegetation effectively obstructs Powerline Road beyond. Although the visual environment has been altered in this viewpoint, the impact is not judged to be significant. This is due to the inaccessibility of the viewpoint and total absence of sensitive viewers on the west and south sides of both the existing and proposed mining sites.

KVP 5 – Sequalitchew Drive

Figure 3.9-6 illustrates the existing view and future view from KVP 5. As shown, the proposed mining area would be screened by existing vegetation. Vegetation and topography block views of the project site, which is generally indicated by the shaded band. All trees visible from this viewpoint are off-site and would not be affected. This view has not been simulated as the visible trees are privately owned. Viewers would be expected to be of high sensitivity, principally hikers and other recreationists using the trail system. Visual quality is judged to be high because this is an established hiking trail.

KVP 3: Existing Condition

KVP 3: Year X

KVP 3: Year Y

Source: ESA, 2022.

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Figure 3.9-4

Key View Point Location 3

KVP 4: Existing Condition

KVP 4: Year Y

Source: ESA, 2022.

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Figure 3.9-5

Key View Point Location 4

KVP 5: Existing Condition

KVP 5: Proposed Action

Source: ESA, 2022.

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Figure 3.9-6

Key View Point Location 5

KVP 6 – Sequalitchew Trail - East

Figure 3.9-7 illustrates the existing view and future view from KVP 6. All trees are located offsite and would not be affected by proposed mining, therefore no change to visual quality would occur as a result of proposed mining. Sequalitchew Creek is below the trail to the left and the viewer is surrounded by undisturbed vegetation.

KVP 7 – Sequalitchew Trail - West

Figure 3.9-8 illustrates the existing view and future view from KVP 7. As shown, the proposed mining area would be screened by existing topography and vegetation. The site is directly uphill from this location and is not visible; the view provided shows the slope along the trail's north side (right-hand side of **Figure 3.9-8**). Vegetation and topography along Sequalitchew Creek block views of the project site and would not be affected. All disturbance associated with proposed mining would be outside of Sequalitchew Creek ravine and set back a minimum of 100 feet from the top of the slope associated with Sequalitchew Creek. All trees are offsite and would not be affected under the Proposed Action. Visual quality would not change as a result of the proposed mining.

KVP 8 – The Home Course

Figure 3.9-9 illustrates the existing view and future view from KVP 8. As shown, the proposed mining area would be screened by existing topography and vegetation. All trees visible from this viewpoint are off-site and would not be affected. Similarly, viewer sensitivity and visual quality would not be affected.

CUMULATIVE IMPACTS

Cumulative impacts to views could, hypothetically, occur due to clearing that has taken place on the Existing Mine together with proposed mining under the Proposed Action. From viewpoints around the site, including KVPs 1, 2, and 3, however, there are no views of the Existing Mine. When clearing of the site occurs as part of the Proposed Action, views of the Existing Mine would be temporarily opened up. The screening that is proposed for the Proposed Action along the east perimeter would screen these views after the plantings reach a height of six feet or greater which is expected to occur by *Year X+ or sooner.* Views from KVP 5, 6, 7, and 8 would not be affected by clearing of the Expansion Area portion of the site given that screening trees from these viewpoints are located offsite. As such, cumulative impacts would be limited to the first few years prior to Year X. No other cumulative view impacts are anticipated.

KVP 6: Existing Condition

KVP 6: Proposed Action

Source: ESA, 2022.

EA Engineering, Science, and Technology, Inc., PBC

Figure 3.9-7

Key View Point Location 6

Source: ESA, 2022.

EA Engineering, Science, and Technology, Inc., PBC

Figure 3.9-8
Key View Point Location 7

KVP 8: Existing Condition

KVP 8: Proposed Action

Source: ESA, 2022.

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Figure 3.9-9

Key View Point Location 8

ALTERNATIVE 2 – NO ACTION

There are two No Action Alternatives- Scenario A Continuation of Existing Conditions and Scenario B Site Development Under Existing Zoning.

Scenario A

Under Scenario A, mining activities associated with the Re-Mine Area of the site and the Existing Mine would continue as currently permitted. The mining operation would retain a vegetated buffer at its perimeter with no lighting, and the interior of the mine would likely not be seen from existing public places. The Existing Mine has an estimated remaining life of 6 to 10 years with mining currently limited to 10 feet above groundwater. The Expansion Area portion of the site is assumed to remain undeveloped and would continue in its vegetated condition.

Scenario B

Under Scenario B, the proposal would not occur. The site would be developed in urban uses consistent with the City's Future Land Use Map. The majority of the area affected is currently designated by the City of DuPont Comprehensive Plan as Manufacturing and Research, with a smaller area designated for residential uses. The corner of the property near Center Drive is designated as Residential 12, which would allow higher density residential development where multifamily density averages 12 units per acre. Urban development, as permitted under current planning and zoning designations, is assumed to occur east of the lease line demarcating existing mining operations. The timing and nature of any such development would be driven by market forces.

In general, future structures would rise above the ground level and would likely be more visible within the surrounding landscape than under the Proposed Action. Light and glare from buildings, the street, and security lighting would extend these effects into the nighttime hours. Future development would draw a greater number of daily users and viewers into the site than currently have access to it, both physically and visually. The degree of visual change outside of the site could be similar to or greater than under the Proposed Action, depending on buffer vegetation and the visual intensity and bulk of structures.

3.9.3 Mitigation Measures

The following mitigation measure have been included in the Proposed Action to reduce aesthetics impacts.

Proposed Mitigation Measures

- A vegetated buffer would be maintained along Powerline Road. Trees would be planted densely to establish screening during mining operations. After mining is completed, selective thinning may be necessary to facility a healthy future forest within the buffer.

- As mining progresses, completed mine segments would be reclaimed to a vegetated condition. The reclamation plan would be reviewed by the Washington State Department of Natural Resources ("DNR") for consistency with the Surface Mining Act (RCW 78.44). In general, reclamation would consist of regrading, replacement of topsoil, and revegetation.

3.9.4 Significant Unavoidable Adverse Impacts

The Proposed Action would result in an unavoidable change to the visual character of the Expansion Area portion of the site. The extraction of mined material would result in a permeant change in the visual character of the site. However, the Proposed Action is not expected to result in a significant adverse impact to the visual environment of the surrounding community. The mining operation is expected to be only minimally visible to the general public from outside of the property boundary. In addition, mining is a transitional use of the site; although mining would alter the site for a number of years, after mining is complete, the site would be reclaimed and ultimately it would be available for development to another permitted use.

3.10 CULTURAL RESOURCES

This section of the DEIS describes existing cultural resources conditions on the site and in the site vicinity. Potential impacts associated with the EIS Alternatives are evaluated and mitigation measures are identified. This section is based on the *Cultural Resources Analysis* (November 2022) prepared by Historical Research Associates with peer review by Cultural Resource Consultants (see **Appendix M**).

3.10.1 Affected Environment

Methodology

Background research was conducted as part of the Cultural Resources Analysis for information pertaining to a search radius of 1/8 mile (mi) (660 ft) from the Area of Direct Impacts (ADI) which encompasses approximately 313 acres of land north of Sequalitchew Creek[1]. This search radius was chosen because mining related activities would not occur outside of the ADI and because there is a large enough amount of data within the radius to provide adequate background information. A review of the Washington Information System for Archaeological and Architectural Records Data (WISAARD) was completed, which is maintained by the Washington Department of Archaeology and Historic Preservation (DAHP) for archaeological site records, cultural resources survey reports, historic register information, and cemetery records. Historic plats and maps dating from 1854 to 1960, were also reviewed, along with the DAHP predictive model.

Existing Conditions

Previous Cultural Resource Studies

The ADI and its general vicinity are rich in archaeological resources. As a result of extensive research and numerous studies and evaluations since 1970, the area is now known to contain more than 50 archaeological sites and cultural isolates. They represent both Native American and non-Native occupation of the area. Many of these sites have been disturbed by historic activities, yet a number of them still retain intact cultural deposits and several have been determined eligible for listing in the National Register of Historic Places (NRHP). A summary of previous cultural resources studies in the ADI and its general vicinity is included in **Appendix M**.

Work in the vicinity of the ADI has included a number of studies involving recordation of now demolished buildings within Site 45PI70, archaeological sites, site testing, and data recovery excavations, as well as the recordation of cultural isolates.

[1] *See **Appendix M** for a map illustrating the ADI.*

Previous Archaeological Sites

Table 3.10-1 provides a summary of known archaeological sites in or near the ADI and the status of determinations of eligibility for listing in the NRHP.

Table 3.10-1
PRECONTACT AND HISTORIC-PERIOD SITES WITHIN OR NEAR THE SOUTH PARCEL ADI

Site No.	Site Name	NRHP Status	Period	Location / Comments
45PI54	Sequalitchew Archaeological Site/Nisqually House	Listed in NRHP and WHR*, 1979	Precontact/early historic	South of the mouth of Sequalitchew Creek/Disturbed by tidal action and railroad construction
45PI62	Railroad dump #2	Not eligible	Old town	In ADI/Small disturbed scatter of nondiagnostic DuPont-period artifacts
45PI63	Railroad dump #3	Not eligible	Old town	In ADI
45PI64	Burning ground dump site	Not eligible	DuPont	South of ADI/Highly disturbed by DuPont soil remediation
45PI66	Methodist Episcopal Mission	Eligible	HBC**/PSAC***	South of ADI/Has been tested and soil remediation has taken place at it
45PI67	Wilkes Observatory	Eligible	Former location of observatory	Southwest of ADI
45PI70	DuPont Company plant	Recommended not eligible	DuPont	Only remains of black powder portion, which was razed in the 1940s, are located in the ADI
45PI71	Sawmill	Not eligible	Historic	—
45PI75	Crystallizer	Not eligible	Precontact	South of ADI/Above south side of Sequalitchew Creek, extensive damage from DuPont-period construction
45PI76	Nisqually burials	****Undetermined	Historic/precontact	Southwest of ADI above north side of Sequalitchew Creek mouth
45PI401	Hudson's Bay Company employees' house	Undetermined	HBC/PSAC	South of ADI/Data recovery conducted, largely destroyed by the construction of Center Drive
45PI405	Hudson's Bay Company employees' house	Undetermined	HBC/PSAC	South of ADI/Data recovery conducted, largely destroyed by the construction of Center Drive
45PI453	Inskip Observatory	Undetermined	Historic marker	Southwest of ADI/Site destroyed, historical marker in place
45PI455	9th U.S. Cavalry Bivouac Buffalo Soldiers Occupation	Undetermined	HBC/PSAC	South of ADI/Has been tested, partially intact
45PI485	Historic refuse dump	Undetermined	HBC/PSAC	South of ADI/Limited damage from DuPont-period construction
45PI576	Lithic scatter	Undetermined	Precontact	South of ADI/Apparently not intact

Site No.	Site Name	NRHP Status	Period	Location / Comments
45PI1225	Concrete loading platform	Undetermined	Historic	South of ADI
45PI1226	Bridge abutment—narrow-gauge railroad	Undetermined	Historic	South of ADI
45PI1272	N. Fort Lewis Demolition Training Area/Gas Chamber	Not eligible	Historic	North of ADI
45PI1296	Three excavation pits from Pioneer (Seattle) Sand and Gravel Company	Undetermined	Historic	Northwest of ADI

Source: HRA, 2022.

*WHR – Washington Heritage Register

**HBC – Hudson's Bay Company

***PSAC – Puget Sound Agricultural Company

****Undetermined means the site has not been evaluated for the NRHP

Precontact occupation sites are located near Sequalitchew Creek: 45PI54, 45PI75 and 45PI76. Site 45PI54 represents the remains of Sequalitchew Village and the Hudson's Bay Company (HBC) Nisqually House, located south of the creek mouth. Site 45PI75 was a lithic scatter destroyed by the construction of a DuPont-period facility located upstream. Site 45PI76 is a gravesite destroyed by the construction of the railroad along the bluffs of Puget Sound. These sites represent relatively recent late precontact activities. Site 45PI485, a small shell deposit originally thought to be precontact and later interpreted to be associated with the HBC era, was identified and recorded during remediation activities. Site 45PI576, a lithic scatter of undetermined age, is located south of the site.

Archaeologists have examined the immediate vicinity of Site 45PI576 on several previous occasions. None of these researchers reported the presence of precontact lithic materials here. In 2004, Gary Wessen excavated 60 shovel test pits and two 1 by 2 m test units yet failed to find intact cultural deposits. The cultural deposits had been profoundly disturbed by DuPont Works developments.

In 2007, data recovery excavations at Site 45PI777 were conducted, a precontact lithic site located on the south side of Hoffman Hill about 2 mi south of the ADI. The site appeared to have been used as a field camp approximately 1889 to 1775 years before present (B.P.) and 505 to 331 B.P. for cooking and the production and maintenance of stone tools.
Within or close to the ADI, recorded Sites 45PI62, 45PI63, 45PI64, 45PI66, 450l455 and 45PI70 are recorded (see **Table 3.10-1** and **Appendix M**).

Archaeological Sites In or Near the ADI

Sites 45PI62, 45PI63, and part of 45PI70 are located within the ADI, while Site 45PI66 is located just to the south of the ADI.

Site 45PI62, Railroad Dump #2 is a small scatter of DuPont-period artifacts associated with a narrow-gauge railroad grade in the vicinity of the former DuPont Works magazine #4. This site was determined not eligible for listing in the NRHP.

Site 45PI63, Railroad Dump #3 consists of artifacts comprising almost exclusively ceramic fragments from common and inexpensive items, primarily table ware, and glass from bottles, canning jars, and glasses. A few nails and fragments of fabric also were recovered. The dump appears to date mainly between 1910 and 1930. The site is located at the junction of two narrow-gauge railroad tracks that had been part of the DuPont Plant network. A dirt road, developed after the track was abandoned, crossed it and may have divided a once continuous deposit. Thus, two loci, PI63a and PI63b, have been distinguished. This site was determined not eligible for listing in the NRHP.

Site 45PI66, the Methodist Episcopal Mission Monument Site included apparent hearth area around the monument. Other remains near the hearth included square nails, bottle glass fragments, window glass shards, and two pieces of ceramics. Eleven artifacts found within 45 m of the monument included brick fragments and clay, square nails, a transfer-print ceramic fragment, two pieces of copper, a piece of green bottle glass and some scattered shell and bone. It was concluded that the mission site had been identified. The State Historic Preservation Office (SHPO) determined that this site is eligible for listing in the NRHP (see **Appendix M** for details).

Site 45PI70. The DuPont Company razed the Black Powder Area Plant buildings and structures in 1945. The plant itself has not been treated as an archaeological site. Previous recording includes documentation of 18 features located within the Black Powder Area, which is within the Expansion Area portion of the site. The features were demolished, and eight of the features were removed under Consent Decree 91-2-01703-1 in the early 1990s; other features were subsequently removed (see **Appendix M** for detail).

The Nisqually Point Defense Fund prepared an NRHP nomination form for the proposed Nisqually-Sequalitchew Historic District. The proposed district covers about 360 acres along both sides of Sequalitchew Creek, with 13 archaeological sites. The district's northern boundary passes around the Methodist Episcopal Mission Monument Site (45PI66) and the 9th Cavalry Bivouac Site (45PI455) and extends into part of the Expansion Area portion of the site. The listing of the district is noted as pending fulfillment of several terms provided for in a Memorandum of Agreement among several parties interested in the district and the land on which it is located. According to DAHP, the district nomination was never ratified. Weyerhaeuser was the primary landowner within the district, and they objected to the nomination; per NRHP guidelines, if the primary landowner objects, the district cannot proceed.

As noted earlier, pedestrian survey within the Expansion Area portion of the ADI and limited shovel probing in the southwest portion of the ADI was conducted. During the survey,

ground visibility was poor; however, it was indicated that there were disturbed areas where mineral soils were visible (see **Appendix M** for detail).

Archaeological Sites 45PI62 (Railroad Dump #2), 45PI63 (Railroad Dump #3), and 45PI70 (Black Powder Area of the Dupont Company Plant), which are located within the Expansion Area of the ADI were revisited. Sites 45PI62 and 45PI63 have been determined not eligible for listing in the NRHP. Site 45PI70 was razed in 1945, and an Historic American Building Survey (HABS) that included the site was prepared in 1990. The site was recommended as not eligible for the NRHP in 2008, but concurrence has not been received (see **Appendix M** for details).

Archaeological Expectations

The occurrence in the site vicinity of precontact sites dating up to 6000 B.P. and Euroamerican sites dating up to 1832/1833 suggests that both types of sites and isolated artifacts could be present in the site area. Precontact sites could contain artifacts and features relating to domestic and hunting, fishing, and gathering use. Euroamerican sites might yield artifacts and features relating to structures, trade, agricultural, and industrial use. Both types of sites could contain floral and faunal remains. Precontact and historic-period burials could be present. The probability of identifying precontact sites is assumed to increase closer to Sequalitchew Creek.

3.10.2 Impacts of the Alternatives

This section identifies and analyzes impacts to cultural resources[2] on and in the vicinity of the site under the EIS Alternatives.

ALTERNATIVE 1 – PROPOSED ACTION

Potential Indirect or Direct Impacts

Archaeological Sites 45PI62 and 45PI63

Archaeological site 45PI62, Railroad Dump #2, which has been determined not eligible for listing in the NRHP, is within the Expansion Area portion of the site and may be disturbed or removed during proposed mining operations. Archaeological site 45PI63, Railroad Dump #3, which also has been determined not eligible for listing in the NRHP, lies within the Expansion Area portion of the site; this site may be disturbed or removed by the Proposed Action. Because neither of these sites have been determined eligible for listing in the NRHP, their removal would not be considered a significant indirect or direct adverse impact.

[2] *Impact to cultural resources is defined as direct or indirect damage that may cause an irrevocable loss of information pertaining to history of NRHP eligible resources.*

Archaeological Site 45PI66

Archaeological site 45PI66, the Methodist Episcopal Mission Monument, lies outside of the Expansion Area portion of the site. Section 4.7 of the 2011 Settlement Agreement for Dupont Mine, Restoration of Sequalitchew Creek Watershed, and Preservation of Puget Sound Shorelands and Adjacent Open Space states that, "the parties agree that CalPortland will not conduct mining within 189 ft of the Mission Marker as defined herein" (Washington State Department of Ecology et al. 2011). As long as this agreement is enforced, there would be no significant indirect or direct impact to this resource.

Archaeological Site 45PI70

As noted in Sub-Section 3.10.1, archaeological site 45PI70, DuPont Company Plant, was recommended not eligible for listing in the NRHP in 2008; however, DAHP did not respond to the recommendation of non-eligibility. Given that Site 45PI70 has been thoroughly documented several times and a HABS report was prepared for the entire plant site including the Black Powder Area, more information is not likely to be gleaned from further study; therefore, the previous recommendation that the plant is not eligible is still valid. As long as concurrence with the recommendation is received, the removal of the remains of this site would not be considered a significant indirect or direct adverse impact (see **Appendix M** for details).

CUMULATIVE AND INDIRECT IMPACTS

Potential indirect and cumulative impacts could hypothetically include changes to the visual environment that change the context of historic resources. However, a change to the visual environment of the site and adjacent mining sites, is considered an unavoidable impact of mining. The significance of any such impacts is uncertain. As noted previously, mining is a transitional use and any change would be temporary, lasting until mining is completed. As previously stated, no historically significant cultural resources have been identified within the site to date; therefore, no indirect or cumulative impacts would occur to known resources. If a previously unidentified cultural resource is discovered within the ADI, there is a potential for indirect or cumulative impacts to occur if the resource is determined to be eligible for the NRHP (see **Appendix M** for details).

ALTERNATIVE 2 – NO ACTION

The No Action Alternative assumes no mining on the South Parcel within the context of existing conditions (Scenario A). The No Action Alternative also assumes possible future development of the site in accordance with existing zoning (Scenario B). This would permit development for business park and residential uses. Because the site does not include sites determined eligible for listing in the NRHP, cultural resources impacts would not be anticipated under Scenario A or Scenario B.

3.10.3 Mitigation Measures

The following mitigation measures have been included in the Proposed Action, or in a prior decision applicable to the property, to reduce cultural resources impacts.

Proposed Mitigation Measures

- Based on the additional evaluation and assessment of cultural resources for the project that was completed and included in **Appendix M**, it is recommended that additional shovel probing be conducted in the two areas shown in **Appendix M**, with a high probability for containing archaeological resources prior to clearing, mining and/or construction of the proposed noise berm. A study plan should be developed in consultation with DAHP and the affected Indian Tribes. Alternatively, archaeological monitoring of any ground disturbing activities in these areas should be conducted.

- Mitigation requirements that address archaeological monitoring and inadvertent discovery of cultural resources or human remains prior to ground disturbance or during mining as required as a result of the 2004 Settlement Agreement between Quadrant Corporation, Weyerhaeuser real Estate Company, the City of DuPont and the Nisqually Tribe. These mitigation requirements apply to all Weyerhaeuser properties in the City of DuPont, and have been recommended, applied as conditions of approval, and implemented as ongoing management practices in all Glacier NW/CalPortland mining projects in the City. These mitigation measures should continue to be implemented as applicable to the South Parcel Project. These measures include the following (paraphrased from North Parcel conditions No. 28-30):
    - Notification of Nisqually Indian Tribe resource representative in advance of any clearing or topsoil stripping for each mine segment; and employment of the tribal Archaeologist to write a closing report to DAHP documenting coordination with the Nisqually Indian Tribe and observed conditions.
    - Notification of DAHP and the Nisqually Indian Tribe if any Native American remains are unearthed.
    - Monitoring of clearing activities by the Nisqually Indian Tribe to identify any historic resources and appropriate notice and treatment of any resources discovered.

- If any archaeological sites are identified under the Proposed Action, and they are determined to be eligible for the NRHP, and that proposed mining activities would constitute a significant adverse impact to them, then DAHP and the affected Tribes should be consulted for guidance regarding appropriate mitigation measures. Mitigation measures may include, but not be limited to data recovery and/or interpretation (e.g., displays, exhibits).

3.10.4 Significant Unavoidable Adverse Impacts

No historically significant cultural resources have been previously identified within the site to date; therefore, no significant adverse impacts would occur to known resources. However, if a previously unidentified cultural resource is discovered with in the ADI, there is potential for a significant adverse impact to occur if the resource is determined to be eligible for the NRHP.

3.11 TRANSPORTATION

This section of the DEIS describes existing transportation conditions on the site and in the site vicinity. Potential impacts associated with the EIS Alternatives are evaluated and mitigation measures are identified. This section is based on the *Traffic Impact Assessment* (July 2022) prepared by Heffron Transportation and the *Parking Narrative* (November 2020) prepared by Anchor QEA, both peer reviewed by Transpo Group (see **Appendices N** and **O**).

3.11.1 Affected Environment

Existing Conditions

The existing Pioneer Aggregates mine, processing plant, and barge loading dock at Tatsolo Point have been in operation since 1997. The expansion of the mine to the 142-acre North Parcel (described in the 2013 FEIS) assumed extraction of approximately 2.8 million cubic yards of sand and gravel annually. It also assumed that 80% of that aggregate would be transported by barge, the same rate that had been historically barged. The remaining 20% was assumed to be exported from the site by truck, either as mined aggregate or as part of processed concrete.

Existing Mine-Generated Traffic Volumes

The 2013 FEIS included detailed trip generation estimates for the mine, which were based on historic operations and annual extraction rates. The trip generation estimates assumed that 20% of the mined aggregate would be transported from the site by truck (the remaining 80% would be by barge and not affect roadways). **Table 3.11-1** summarizes the trip generation estimates from the 2013 North Parcel FEIS and is presented below.

Table 3.11-1
SUMMARY OF PROJECT-GENERATED OFF-SITE TRIPS – 2013 NORTH PARCEL FEIS

			AM Peak Hour			PM Peak Hour		
Trip Type	**Vehicle Type**	**Daily**	**In**	**Out**	**Total**	**In**	**Out**	**Total**
Typical Day								
Employee Commute	Automobile	126	3	0	3	0	3	3
Service & Deliveries	Light Truck	18	2	2	4	2	2	4
Product Transport	Heavy Truck	246	9	9	18	1	1	2
Logging[1]	Heavy Truck	0	0	0	0	0	0	0
TOTAL		**390**	**14**	**11**	**25**	**3**	**6**	**9**
Peak Day								
Employee Commute	Automobile	200	7	3	10	0	4	4
Service & Deliveries	Light Truck	30	5	2	7	3	3	6
Product Transport	Heavy Truck	710	25	25	50	5	5	10

Trip Type	Vehicle Type	Daily	AM Peak Hour			PM Peak Hour		
			In	Out	Total	In	Out	Total
Logging[1]	Heavy Truck	24	0	0	0	0	0	0
TOTAL		**964**	**37**	**30**	**67**	**8**	**12**	**20**

Source: FEIS for CalPortland DuPont North Parcel Mining, 2013.

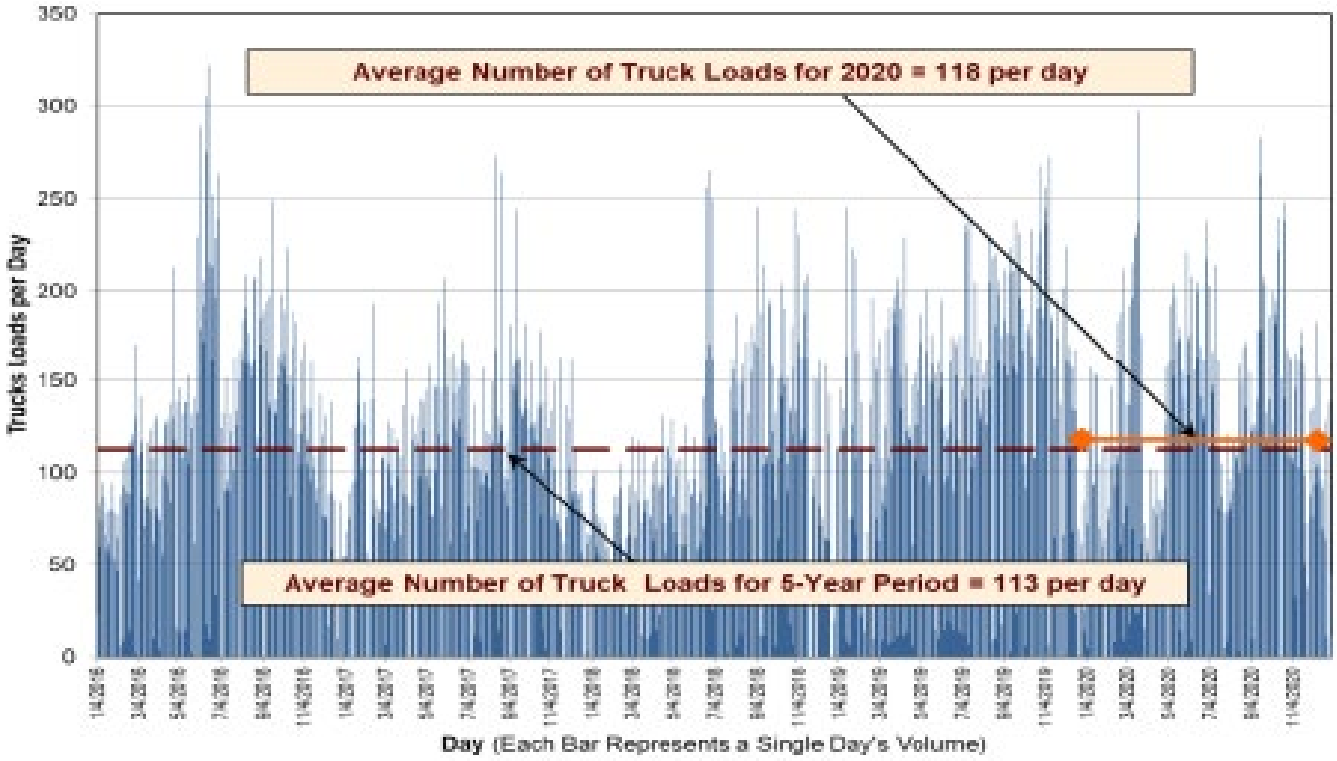
[1] Logging the North Parcel would occur only during the first year of operation.

The FEIS had estimated that the mine would generate an average of 390 trips per day (195 trips entering the site and 195 trips exiting the site). Of these, 264 trips per day (132 inbound and 132 outbound) would be truck trips. On the peak day, daily trips were expected to increase to 964 trips per day (482 inbound and 482 outbound) of which 764 would be truck trips (382 inbound and 382 outbound). Trips during each of the commuter peak hours—AM and PM—were also determined. More traffic was expected to occur during the AM peak hour when product is typically transported out to construction sites. During the peak day, the mine was expected to generate 67 AM peak hour trips (37 inbound and 30 outbound). The PM peak hour would have much lower volumes, expected to be 20 trips on the peak day (8 inbound and 12 outbound).

Actual Truck Trips – 2016 through 2020

CalPortland tracks all trucks that exit the site with a load of material (e.g., truck loads). Five full years of data (from January 1, 2016, through December 31, 2020) were obtained from CalPortland and compiled to show the number of truck loads that exit the site each day. It is noted that each truck load reflects an outbound trip (an inbound trip is made by an empty truck and is accounted for later in the analysis). **Figure 3.11-1** below shows each day's concrete and aggregate loads (trucks exiting the site).

Figure 3.11-1
DAILY TRUCK LOADS (OUTBOUND TRUCK TRIPS): 2016 – 2020



More detailed information was compiled for 2020. While the COVID-19 pandemic affected activity during some weeks of the year, the total aggregate mined was 2,776,615 cubic yards, just below the 2.8 million cubic yards anticipated by the 2013 FEIS. The average truck loads per day over the five-year span (113 truck loads per day) were very similar to the average for the year 2020 (118 truck loads per day). Further analysis was performed for the full year of 2020 data to derive average truck loads by time of day. **Figure 3.11-2** shows the percentage of each day's trucks for each hour.

Figure 3.11-2
PERCENT TRUCKS BY HOUR – WEEKDAY (2020)

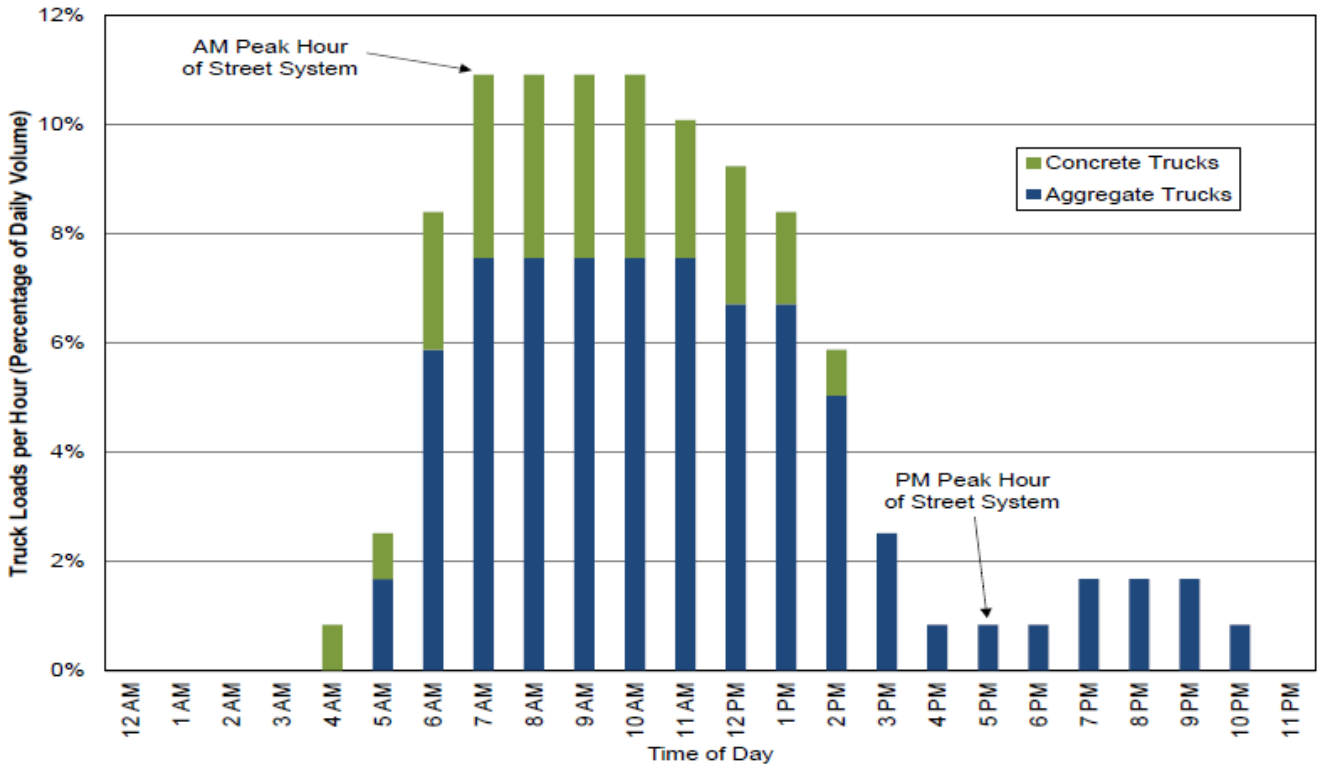


Table 3.11-2 compares the daily and peak hour truck trips from 2020 to those assumed in the FEIS. A total of 118 truckloads were processed on the average day in 2020, which results in 236 truck trips (empty truck inbound plus loaded truck outbound). The peak day of the year had 297 truckloads, equaling 594 truck trips. The total daily trips were below the level estimated in the FEIS. Actual AM peak hour trips were slightly higher for an average day (26 trips compared to the estimated 22 trips), but lower on the peak day (52 trips compared to the FEIS level estimated 57 trips). PM peak hour trips were lower for the average day and the same as expected for the peak day.

Table 3.11-2
COMPARISION OF FEIS TRUCK ESTIMATES TO ACTUAL TRUCK VOLUMES

		AM Peak Hour			PM Peak Hour		
Trip Type	**Daily**	**In**	**Out**	**Total**	**In**	**Out**	**Total**
FEIS Estimated Truck Trips							
Average Day	266	11	11	22	3	3	6
Peak Day	740	30	27	57	8	8	16
Actual Truck Trips – Year 2020							
Average Day[1]	236	13	13	26	1	1	2
Peak Day[2]	594	26	26	52	8	8	16
Absolute Peak Day in Five-Year Period (6.15.2016)[3]	**644**	**13**	**49**	**62**	**10**	**2**	**12**

Source: CalPortland North Parcel FEIS, 2013 and Heffron, 2022.

[1] Based on average loads per hour for all of year 2020.

[2] Based on actual loads for the Peak Day in 2020 (March 18, 2020).

[3] Highest day in five-year period between 1/1/2016 and 12/31/2020. This day had substantial concrete truck activity associated with a continuous pour operation.

As shown above on **Figure 3.11-1**, the absolute highest volume in the past five years (June 15, 2016) generated 322 truck loads or 644 truck trips per day. This day had a very high number of concrete truck trips associated with a continuous-pour operation. The actual trips for that day were compiled to determine the peak hour volumes. The daily and PM peak hour trips were below the values assumed in the FEIS, but the AM peak hour was slightly higher due to the high number of outbound trips in the morning for the continuous pour. That type of event is very rare, and those volume levels were only observed one time in the five-year period.

3.11.2 Impacts of the Alternatives

This section identifies and analyzes impacts to transportation on and in the vicinity of the Pioneer Aggregates South Parcel Project site with proposed clearing and mining.

ALTERNATIVE 1 – PROPOSED ACTION

Future Traffic

The proposed Pioneer Aggregates South Parcel Project would allow for continued mine operations that are similar to those already permitted. The processing plant would remain in the same location, and the market area and travel patterns are expected to remain the same. Trip generation is expected to continue at current levels and would remain below the peak day estimates that had been evaluated in the 2013 North Parcel FEIS., which considered cumulative impacts with the South Parcel project. Expansion to the South Parcel

would have a short period when logging trips are added to the traffic stream. The FEIS had estimated up to 24 logging truck trips per day (12 loads). This is likely to be conservatively high since the timber to be logged on the South Parcel is of poorer quality than for the previously logged North Parcel.

The 2013 North Parcel FEIS had evaluated traffic operations at area intersections for the future horizon year of 2035. The year 2035 conditions had accounted for substantial growth in traffic due to a dozen major development projects and background growth and were consistent with assumptions in the I-5 Joint Base Lewis-McChord (JBLM) Transportation Analysis.[1] Impacts of the project were evaluated for the peak day condition, which as shown above, reflect a higher trip condition than occurred during the peak day in 2020. The North Parcel FEIS traffic operations analysis found that, "*…project-generated trips are expected to constitute 3% or less of total trips through the LOS E and F intersections in the AM peak hour, and less than 1% in the PM peak hour. This reflects projected conditions on a day of peak mining operations; on days of more typical mining operations, these proportions would be even lower.*" It goes on to conclude, "*Because the project-generated trips would represent a small proportion of traffic volumes at the study area intersections and would have negligible effect on the levels of service at the I-5 ramps and city intersections, no adverse level of service impacts are projected to result from the South Parcel proposal*." The conclusion is still reasonable given that the trips are expected to remain similar to or less than those evaluated in the 2013 FEIS, and that the horizon year evaluated (2035) is reasonable to capture the extended life of the mine with expansion to the South Parcel.

The proposed Pioneer Aggregates South Parcel Project is not expected to exacerbate transportation conditions in the study area. Trip generation is expected to continue at current levels and would remain below the peak day estimates that had been evaluated in the 2013 FEIS. Traffic operations were evaluated in the 2013 North Parcel FEIS for the anticipated South Parcel traffic and extended mine life and concluded that the South Parcel would not adversely affect traffic operations in the site vicinity. This conclusion is still reasonable and significant transportation impacts would not be anticipated.

ALTERNATIVE 2 – NO ACTION

There are two No Action Alternatives- Scenario A Continuation of Existing Conditions; and Scenario B Site Development Under Existing Zoning.

Scenario A

Under Scenario A , mining activities associated with the Re-Mine Area of the site and the Existing Mine would continue as currently permitted. The mining operation would retain a vegetated buffer at its perimeter, and traffic conditions that currently exist would continue.

[1] *Washington State Department of Transportation (WSDOT) and the Tranpso Group, I-5 Transportation Alternatives Analysis & Traffic Operational Model, from Mounts Road to SR 512. Prepared for the City of Lakewood, September 2010.*

The Existing Mine has an estimated remaining life of 6 to 10 years with mining currently limited to 10 feet above groundwater. The Expansion Area portion of the site is assumed to remain undeveloped and would continue in its vegetated condition.

Scenario B

Under Scenario B, the proposal would not occur. The site would be developed for urban uses consistent with the City's Future Land Use Map. The majority of the area affected is currently designated by the City of DuPont Comprehensive Plan as Manufacturing and Research, with a smaller area designated for residential uses. The corner of the property near Center Drive is designated as Residential 12, which would allow higher density residential development where multifamily density averages 12 units per acre. Urban development, as permitted under current planning and zoning designations, is assumed to occur east of the lease line demarcating existing mining operations. The timing and nature of any such development would be driven by market forces.

In general, development of manufacturing/research uses and housing would result in construction-related activity that would occur over an extended period of time and would generate an increase in construction-related traffic. Upon completion of construction, traffic would be generated that would be typical of other manufacturing/ research uses and residential neighborhoods.

3.11.3 Mitigation Measures

No transportation-related mitigation measures are necessary, and no additional transportation-related measures are provided.

3.11.4 Significant Unavoidable Adverse Impacts

The proposed Pioneer Aggregates South Parcel Project is not expected to result in significant transportation impacts in the study area. Trip generation is expected to continue at current levels and would remain below the peak day estimates that had been evaluated in the 2013 FEIS.

3.12 FISCAL CONDITIONS

This section of the DEIS examines the tax revenues and costs of services that can be attributed to the site at an assumed base year (2022) under the EIS Alternatives. The section is based on the *Fiscal Condition Assessment* (February 2024) prepared by ECONorthwest (see **Appendix P**).

3.12.1 Affected Environment

Fiscal conditions presented below provide background about the revenues, expenditures, and tax bases of the city of DuPont. This analysis is focused on general government funds primarily include the city's General Fund which accounts for services to the public including public safety, street maintenance, land use, parks and recreation, and administrative functions. These services are largely supported by taxes, fees and charges, and intergovernmental revenues (i.e., state and federal contributions). This analysis is specifically focused on the taxes used to support the city's public services.

The analysis does not include the enterprise funds related to operating the Water Utility and Stormwater Utility. These enterprises are operated like a stand-alone business where with customer user fee are used to support all operating costs. Resources of the utilities cannot be used to subsidize general government functions.

City Tax Revenue Sources

Below is a discussion of the city of DuPont's primary tax revenue sources and trends from 2011 to 2021. Unless cited otherwise, informing this memorandum is data from Washington state's Local Government Financial Reporting System for the city of DuPont. As with many cities in Washington State, the three largest revenues sources for the City of DuPont are (1) property taxes, (2) sales and use taxes, (3) utility taxes, and (4) business and occupation taxes (B&O). Taxes made up 74% of the city's overall revenue in 2021.

Current Expense Property Taxes

Initiative 747 limited local property tax increases to 1.0% each year, resulting in an erosion of the tax's purchasing power over time. Because of the method for calculating DuPont's property tax levy (equal to the 101% of the previous year's levy plus new construction add-on value), new construction is important to the city's ability to limit the erosion of the purchasing power of the property tax and to grow the levy beyond the statutory limitations. In 2023, property tax levy was $2,014,558.

EMS Property Taxes

The city also collects a regular property tax for emergency medical services provided by the city. In 2023, property tax levy was $877,716.

Local Option Retail Sales and Use Taxes

One of the key revenue sources that cities rely on is the retail sales tax. Of the 9.4% sales tax currently collected in the city on general retail purchases, a 1% "local" share of the tax accrues to local jurisdictions. The city receives 85% of the 1% local tax and Pierce County gets 15%. The current rate accruing to the city is 0.85%. The local option sales tax generated $2,353,599 in local sales tax revenues for the city in 2021. This tax is levied not only on businesses in the area, but also on construction activity and some transactions that are related to housing, such as certain online purchases. The city also receives a population pro-rata share of 90% of the city allocation of Pierce County's 0.1% criminal justice sales tax.

Business and Occupation Taxes

This category of revenue includes monies received from business and occupation taxes (B&O tax) on general business activities. The B&O tax rate in DuPont is 0.1%. The B&O tax generated $746,828 in tax revenues for the city in 2021.

Utility Taxes

The city levies a business and occupation tax on utilities; however, this tax is passed on to users of the utilities as part of their periodic bills. The city levies the following rates to the gross receipts of the utility providers: Electricity 6%; Water 12%; Sewer 6%; Stormwater 10%; Telephone 6%; Natural Gas 6%; and Solid Waste 8%.

The utility tax generated $ $1,647,377 in tax revenues for the city in 2021.

Other Revenue Sources

The city of DuPont collects revenues from a range of other local sources, including:

- Hotel/Motel Tax: The city receives a sales tax credit against the state portion of the sales tax of 2% on accommodations purchases. The proceeds of the tax are dedicated to economic development purposes supporting the tourism sector.

- Real Estate Excise Tax (REET). Real estate transactions are subject to a 0.50% local tax on the value of the transaction. REET revenues are restricted to finance capital projects. REET revenues are uncertain, given the volatility in the real estate market. Since REET is based on the total value of real estate transactions each year, the

amount of REET revenues the city receives can vary substantially from year to year based on the normal fluctuations in the real estate market.

- Admission Tax. The city charges a tax on the value of transactions on admissions to a place or event. The admissions tax rate in DuPont is 5%.

City Tax Revenue Trends

Figure 3.12-1 presents a summary tax revenue for the city from 2011 to 2021. B&O tax revenues include both the tax on business gross receipts and utility providers (utility taxes). Property taxes have been a consistent and growing source of revenue for the city over the time. Sales taxes have also grown but a more volatile source of funding. The city has seen stronger relative growth in its B&O taxes (gross receipts and utility taxes). Other taxes are primarily consisted of the REET.

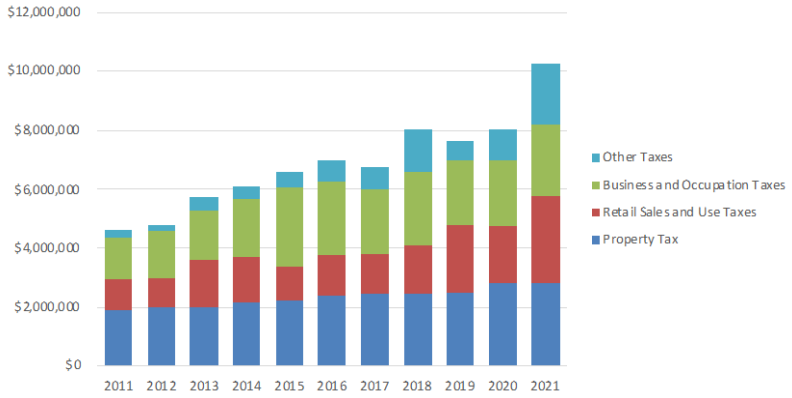


Figure 3.12.1
SUMMARY TRENDS OF MAJOR TAXATION SOURCES, CITY OF DUPONT: 2011 - 2021

City Expenditures

This section discusses the City of DuPont's primary expenditures and trends from 2011 to 2021. Unless cited otherwise informing this memorandum is data from Washington state's Local Government Financial Reporting System for the city of DuPont. The City of DuPont's major expenditures are described below.

Public Safety

This category of expenditures includes costs for law enforcement, fire and emergency medical, detention/corrections, protective inspection services, and dispatch services. As of 2021, expenditures for public safety accounted for 55% of total city-wide expenditures.

General Government

This category of expenditures includes costs for personnel and centralized services; legislative, and executive activities; financial, recording, and election activities; and legal. As of 2021, expenditures for the general government accounted for 21% of total city-wide expenditures.

Transportation

This category of expenditures includes roads/streets maintenance, roads/streets administration and overhead. As of 2021, expenditures for transportation accounted for 7% of total city-wide expenditures.

Culture and Recreation

This category of expenditures includes library and park facilities costs. As of 2021, expenditures for culture and recreation accounted for 10% of total city-wide expenditures.

Natural and Economic Environment

This category includes work in community and economic development. As of 2021, expenditures for culture and recreation accounted for 7% of total city-wide expenditures.

City Expenditure Trends

As indicated in **Figure 3.12-2**, expenditures in the City of DuPont totaled $10.1 million in 2021, up from $4.9 million in 2011 (104% change).

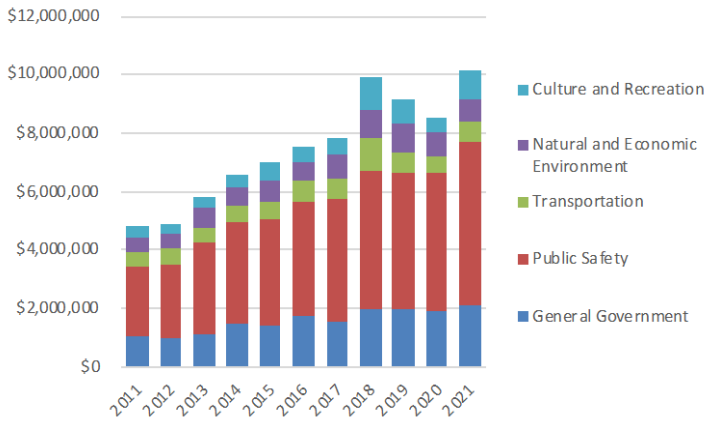


Figure 3.12-2
SUMMARY TRENDS OF EXPENDITURES, CITY OF DUPONT: 2011 - 2021

Selected City Tax Bases

Selected tax bases described below include: Assessed value and new construction; and, taxable retail sales.

Assessed Value and New Construction

The Pierce County Assessor assesses the land and improvement value of all properties in the county for the purpose of levying property taxes. The assessor also values the amount of new construction for calculating the amount of "add-on" value to property tax collections. The trends for the city follow.

- In 2011, DuPont's local assessed value (AV) was $1.9 billion, about $1.5 billion more than local assessed value estimates in 2002.

- Valuation from new construction added substantially to DuPont's base from 2006 through 2009. The Great Recession did, however, cut this trend short. In 2010. New construction levels have picked up in the last several years but continue to be at levels lower than they have in the past (see **Figure 3.12-3**).

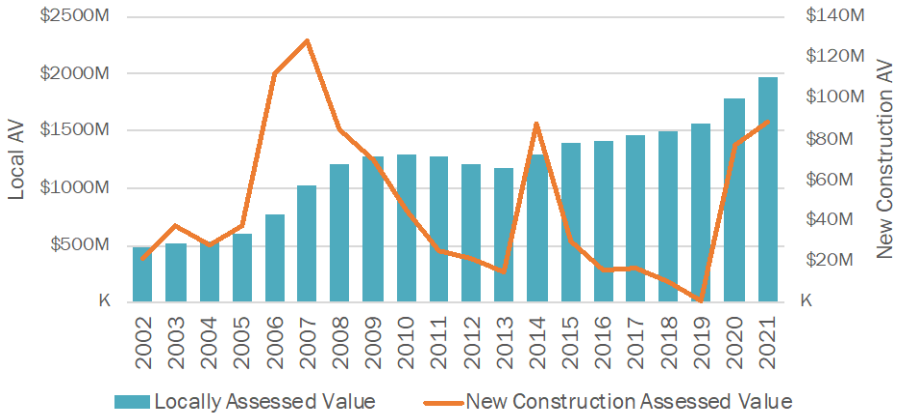


Figure 3.12-3
ASSESSED VALUE AND NEW CONSTRUCTION, CITY OF DUPONT: 2002 - 2021

Most taxing jurisdictions in Washington state must ensure that the amount of revenue they levy in the current year will not exceed the amount levied in the preceding year (plus additional funds for new construction, improvements to property, newly constructed wind turbines, solar, biomass, geothermal facilities, if the facility is not state assessed, increases in the value of state-assessed property, annexations, and refunds). In 2021, DuPont's highest lawful levy was $1,971,024 prior to the additional funds for new construction (see **Figure 3.12-4**).

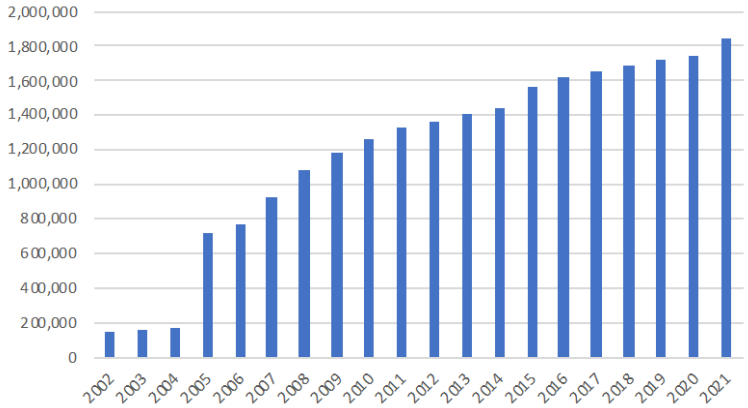


Figure 3.12-4
HIGHEST PRIOR LEVY, CITY OF DUPONT REGULAR LEVY: 2002 - 2021

Taxable Retail Sales

Retail sales reflect spending that occurs within the city and is a significant source of tax revenue for the city (see **Figure 3.12-5**).

- Taxable retail sales (TRS) have grown steadily over the last several years. Total sales (particularly for the construction sector) dipped following the onset of the recession (around 2009), but sales have since increased.

- The retail trade sector and accommodations & food services accounts for most of the remaining growth.

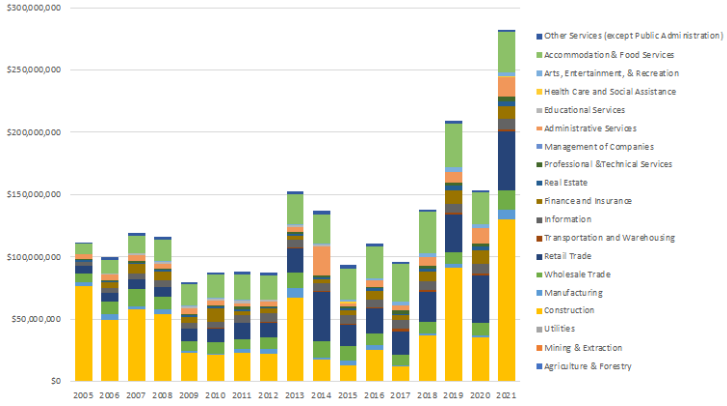


Figure 3.12-5
HIGHEST PRIOR LEVY, CITY OF DUPONT REGULAR LEVY: 2005 – 2021

3.12.2 Environmental Impacts

This section identifies and describes fiscal conditions under the EIS Alternatives.

ALTERNATIVE 1 – PROPOSED ACTION

Fiscal conditions under Alternative 1 – Proposed Action is primarily a function of tax revenues to the City of DuPont generated by the Pioneer Aggregates South Parcel Mining Project, and City of DuPont services costs associated with the project.

Tax Revenues

Tax revenues most relevant to Alternative 1 include Property Taxes, Sales & Use Taxes, Business & Occupation Taxes, and Utility Taxes.

Property Tax

Property tax revenues are estimated using the parcel list of the site and associated 2022 certified taxable assessed values (for 2023 property taxes). The assessed values are then multiplied by the tax rate for the city's regular levy and EMS levy. Based on this summary, the site currently generates approximately $58,000 in property taxes ($40,000 for the regular levy and $17,600 for the EMS levy); see **Table 3.12-1**.

Table 3.12-1
SUMMARY OF ASSESSED VALUE AND LEVY ESTIMATES

	Assessed Total	Taxable Total	Tax Rate (2023 taxes)	City Regular Levy	City EMS Levy	City Total
South Lease Area	$3,142,100	$3,142,100	$1.14924	$2,515	$1,096	$3,611
Existing Mine Lease Area	$5,845,200	$5,845,200	$1.14924	$4,679	$2,039	$6,718
Processing Area	$39,406,900	$39,406,900	$1.14924	$31,544	$13,743	$45,288
North Area	$2,075,700	$2,075,700	$1.14924	$1,662	$724	$2,385
Total	$50,469,900	$50,469,900		$40,400	$17,602	$58,002

Source: Pierce County Assessor, 2022.

The site also pays property taxes for personal property. Personal property includes machinery, equipment, furniture, and supplies of businesses and farmers. It also includes any improvements made to land leased from the government (leasehold improvements); see **Table 3.12-2**.

Personal property taxes are estimated to generate $3,600 in taxes in 2022.

Table 3.12-2
SUMMARY OF PERSONAL PROPERTY VALUE AND LEVY ESTIMATES

	Personal Property Assessed Total	Personal Property Taxable Total	Tax Rate (2023 taxes)	City Regular Levy	City EMS Levy	City Total
Personal Property	$13,300,000	$13,300,000	$1.14924	$2,515	$1,096	$3,611

Source: CalPortland, 2022.

Sales and Use Tax

Of the 9.4% sales tax currently collected in the city on general retail purchases, a 1% "local" share of the tax accrues to local jurisdictions. The city receives 85% of the 1% local tax and Pierce County gets 15%. The current rate accruing to the city is 0.85. Sales tax collected at the site can vary substantially from year to year depending on level of purchases. For example, CalPortland may purchase a new Caterpillar 992 loader (the largest wheel loader that Caterpillar makes) is scheduled in the 2023 year and will substantially impact local sales tax revenue from the mine due to its location of delivery within the city's taxing boundaries. It also makes annual capital improvements at the site that would be taxable construction expenditures. Likewise, sales tax revenue from customers making retail purchases at the site can also vary depending on the size of projects locally. CalPortland estimates that in a typical year the following taxable retail sales are made:

- Capital purchases: $100,000 - $300,000.
- Customer purchases: $10,000 - $30,000.

The analysis uses the mid-point for these categories: capital purchases: $200,000 and customer purchases: $20,000. Using these values produces a sales tax estimate of $1,870 in 2022 (see **Table 3.12-3**).

Table 3.12-3
SALES TAX ESTIMATES

	Estimated Taxable Retail Sales	City Sales Tax Rate	Estimated City Tax Due
Taxable Retail Sales	$220,000	0.0085	$1,870

Source: CalPortland and ECONorthwest calculations, 2022.

Business and Occupation Taxes

This category of revenue includes monies received from business and occupation taxes on general business activities. The B&O tax rate in DuPont is 0.1%. CalPortland estimates from

its B&O tax filing that in a typical year it reports a local gross receipt of $40,000,000. Using these values produces a B&O tax estimate of $75,690 in 2022 (see **Table 3.12-4**).

Table 3.12-4
B&O TAX ESTIMATES

	Estimated Gross Business Income	City B&O Tax Rate	Estimated City Tax Due
City B&O Tax Contribution	$40,000,000	0.0010	$40,000

Source: CalPortland and ECONorthwest calculations, 2022.

Utility Taxes

The city levies a business and occupation tax on utilities; however, this tax is passed on to users of the utilities as part of their bills – in this case, payable by CalPortland. The city levies the following rates to the gross receipts of the utility providers: Electricity -6%; Water - 12%; Sewer - 6%; Stormwater - 10%; Telephone - 6%; Natural Gas - 6%; and, Solid Waste: 8%.

CalPortland estimates from its previous spending that the following purchased are made in a typical year: Cell Phone - $7,200; Phone - $10,500; Electricity - $1,130,000; Water - $46,000; Sewer (private) - $1,240; and, Solid Waste - $15,500.
Using these values produces a utility tax estimate of $75,690 in 2022 (see **Table 3.12-5**.

Table 3.12-5
UTILITY TAX ESTIMATES

	Estimated Utility Purchases	City Utility Tax Rate	Estimated City Tax Due
Water	$46,000	12%	$5,520
Sewer	$1,240	6%	$70
Electricity	$1,130,000	6%	$67,800
Solid Waste	$15,500	8%	$1,240
Phone	$17,700	6%	$1,060
Total	$1,210,440		$75,690

Source: CalPortland and ECONorthwest calculations, 2022.

Summary of Taxes Generated

Table 3.12-6 summarizes the taxes generated by the mine in 2022. The analysis estimates that the existing mining operation generated $180,000 in taxes to the city. This figure represents 2.4% of the city's overall collections of these taxes.

Table 3.12-6
SUMMARY TAX ESTIMATES

Tax	Tax Estimate
Property Tax	$61,613
Sales Tax	$1,870
B&O Tax	$40,000
Utility Tax	$75,690
Total	$179,173

Source: CalPortland and ECONorthwest calculations, 2022.

Public Services

Cost Allocation Approach

Public agencies do not typically allocate the costs of their general services (e.g., those supported by general taxes) to individual or classes of taxpayers. These services are all differentially consumed not just between different classes of taxpayers, but are also consumed by non-taxpayers as well (such as a visitor requiring public safety services). However, all taxpayers derived at least some indirect benefit in the form of things like crime deterrence, economic stability, and quality life that accrue a very local, city-specific level. Given this complex issue, this analysis uses two different approaches (average value and use approach) to assign some cost "responsibility" to CalPortland's operations to provide some context on this issue. The first approach reasons that residents and businesses derive roughly equal value from city services regardless of how much they may use those services. The second approach uses more specific data proxies to estimate an amount public service use.

The average value approach to estimating a cost allocation to the mine uses the 2022 DuPont Adopted Budget costs divided by number of people and covered employees in the city. The rationale for this approach, while not perfect, provides a simple measure of constituent demand for services, namely that the main recipients of a city's public services (those that are in the general fund) are its resident population and employees of its businesses.

However, this approach may overstate public service demand and costs associated with non-residential development/employees relative to residential land uses. To the extent that service demand and costs related to non-residential development generally or to mining operations specifically can be overstated, the projected fiscal surplus to the City could be increased. The analysis uses the 2022 estimated population by the state's Office of Financial Management (10,180 people) and the Puget Sound Regional Council's estimate of covered

employment in the city for 2021(5,123). Combined, a population-employment factor of 15,303 is used for this analysis.

The second approach (use approach) uses more specific data in two key service areas where data is available. The city has been able to provide data on police calls for service near the mine as well as heavy vehicle traffic on the roads.

The cost allocation of approach (use approach) for the Police Department creates a cost-per-call for service metric by tabulating the average number of calls for service over the five-year time period (2016-2021) across the city. This metric is then applied to calls for service within a police service area that includes the site.

The cost allocation approach for Street Maintenance portion of the Public Works department is allocated differently. It assumes that 90% (accounting for the pavement related costs) are attributable to vehicle traffic and almost all the roadway wear and tear is attributable to heavy vehicles. The cost allocation of the Street Maintenance uses roadway counts for heavy vehicles and apportions them based on average daily trips from CalPortland of heavy vehicles.

Cost Allocation Metrics

Using this cost allocation metrics (use approach), the cost per population-employee and cost per use (for police and public works) is derived as illustrated in **Table 3.12-7**. This is done by dividing the budget item by 15,303, the population-employment factor for those elements. For police and public works, they are derived on a calls for service basis for police and heavy vehicle trips for streets.

Cost Allocation to Alternative 1

Based on the analysis contained in the Traffic Impact Assessment prepared for this EIS (see **Appendix P**), it is noted that 2013 FEIS estimates that a typical day would have 126 employee commute trips (assumed in this analysis to be 63 employees making inbound and outbound trips to the site). Given that this analysis was done in 2013, employee numbers have been estimated at 80 in 2022 for this report. This figure represents 0.5% of the city's overall costs in these areas.

Table 3.12-7
COST ALLOCATION FOR CITY OF DUPONT PUBLIC SERVICES

	2022 Adopted Budget	Cost Allocations Per Population-Employee	Cost Allocations Per Use (Police and Public Works)
Mayor/Council	$140,214	$9	$9
Executive	$211,051	$14	$14
City Clerk	$248,611	$16	$16
Human Resources	$274,481	$18	$18
Legal	$129,722	$8	$8
Finance	$303,941	$20	$20
Central Services	$47,900	$3	$3
Information Technology	$80,860	$5	$5
Police Department	$2,643,834	$173	$407
Fire Department	$2,300,405	$150	$150
Community Development	$904,241	$59	$59
Parks, Facilities, and Greenways	$1,104,844	$72	$72
Public Works - Streets*	$616,992	$40	$544

Note: * Streets are allocated on heavy vehicle basis. Police are allocated on calls for sevice.
Source: City of DuPont, 2022.

Table 3.12-8 that follows summarizes the cost allocation to mine using the two different methods. The Overall, the average cost approach allocates a smaller cost to the mine than the use approach. However, while the police cost under the use approach allocates a smaller amount than the average approach, the use approach allocates a relatively larger amount to streets than the average approach.

Table 3.12-8
COST ALLOCATION – AVERAGE / USE APPROACH COMPARISON

	Average Approach	Use Approach
Mayor/Council	$700	$700
Executive	$1,100	$1,100
City Clerk	$1,300	$1,300
Human Resources	$1,400	$1,400
Legal	$700	$700
Finance	$1,600	$1,600
Central Services	$300	$300
Information Technology	$400	$400
Police Department	$13,800	$2,200
Fire Department	$12,000	$12,000
Community Development	$4,700	$4,700
Parks, Facilities, and Greenways	$5,800	$5,800
Public Works - Streets	$9,500	$128,400
Total	$53,300	$160,600

Tax and Cost Allocation Balance

Table 3.12-9 compares tax revenues against public service costs. Based on this analysis, in 2022 revenues generated outpace costs and generate an annual surplus in the range of $18,400 to $125,700. These surpluses represent a cross subsidy to other taxpayers, which by itself, is not an atypical result when looking at narrow land uses[1].

It should be noted that this analysis reflects a single year and taxes and costs can vary from year to year – a surplus in a single year (here, 2022) does not guarantee a surplus in another year when taxes or costs might be different. Also, different measures to allocate costs could produce different cost allocations to the mine. Ultimately, the information provided in this analysis is intended to shed light on the nature of taxation and public services in the city of DuPont and how the specific conditions under Alternative 1 are anticipated to contribute to the city's fiscal bottom line.

[1] *These calculations are intended for generalized analysis and are not considered absolute.*

Table 3.12-9
ANNUAL ESTIMATED SURPLUS

	Estimate	Estimate
Taxes Generated	$179,000	$179,000
Allocated Costs	$53,300	$160,600
Surplus/Deficit	$125,700	$18,400

Source: ECONorthwest, 2023.

ALTERNATIVE 2 – NO ACTION

There are two No Action Alternatives- Scenario A Continuation of Existing Conditions; and Scenario B Site Development Under Existing Zoning.

Scenario A

No Action Alternative Scenario A assumes no mining on the South Parcel within the context of existing conditions. In this case, the short-term fiscal effects would be similar to those discussed in this analysis since there would be no change in operations and the output of the facility. However, over the longer-term the fiscal effects downstream of mining output limits on the site are difficult to gauge. On the cost side, less mining output would likely impact the largest cost driver to the city (i.e., less wear and tear on city operated streets) but it would also likely impact city revenues as sales taxes, utility taxes, and B&O taxes would decline.

Scenario B

No Action Alternative B reflects a condition where the Expansion Area of the site may be developed under existing zoning. Generally, it is understood that zoning of the site could allow approximately 75% Manufacturing/Research Park and approximately 25% Single-Family Residential. The fiscal impact in this scenario would be different than with mining in a couple respects. The longer-term downstream fiscal effects of this development would be hard to gauge without a specific proposal. On the revenue side, both manufacturing/research and residential uses represent a more intense use of the land that would lead to more property, sales, and utility, and other taxes on a per square foot basis. However, on the cost side these uses also generate more needs for public services such as public safety services for residential uses and public works needs to support manufacturing uses.

3.12.3 Mitigation Measures

No significant adverse fiscal impacts have been identified. Beyond the payment of required payment of applicable property tax, sales & use tax, business & occupation tax, and utility taxes, no additional mitigation is identified.

3.12.4 Significant Unavoidable Adverse Impacts

The fiscal analysis conducted for this EIS indicates that expected revenues to the City of DuPont would exceed expected costs. Therefore, no significant unavoidable adverse are anticipated.

Chapter 4

ACRONYMS & ABBREVIATIONS

CHAPTER 4
ACRONYMS

ADI	Area of Direct Impacts
AV	Assessed Value
B&O	Business and Occupation Taxes
BMPs	Best Management Practices
CAP	Cleanup Action Plan
CFS	Cubic Feet Per Seconds
CP	Community Park
DAHP	Washington Department of Archaeology and Historic Preservation
DEIS	Draft Environmental Impact Statement
DMC	DuPont Municipal Code
DNR	Department of Natural Resources
DS	Determination of Significance
EIS	Environmental Impact Statement
ESA	Endangered Species Act
GHAs	Geologically Hazardous Areas
GMA	Growth Management Act
I-5	Interstate-5
JBLM	Joint Base Lewis McChord
KVPs	Key Viewpoints
MRP	Manufacturing and Research Park
NDA	Nisqually Delta Association
NGVD	National Geodetic Vertical Datum
NRHP	National Register of Historic Places
O&M	Operations and Maintenance
Qgog	Vashon-Age Recessional Sand and Gravel
Qob	Olympia Beds
Qpog	Pre-Olympia Glacial Deposits
Qvr	Vashon Recessional Outwash
Qvs	Steilacoom Gravel
R-4	Residential
RCW	Revised Code of Washington
REET	Real Estate Excise Tax
RFEGs	Regional Enhancement Groups
RR	Residential Reserve
SEPA	State Environmental Policy Act
SHPO	State Historic Preservation Office
SPSSEG	South Puget Sound Salmon Enhancement Group
SWPPP	Stormwater Pollution Prevention Plan

TRS	Taxable Retail Sales
TSP	Tacoma Smelter Plume
USFW	United States Fish and Wildlife Service
USGS	United States Geological Survey
VCP	Voluntary Cleanup Program
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WEC	Washington Environmental Council
WHR	Washington Heritage Register
WISAARD	Washington Information System of Archaeological & Architectural Records Data

Chapter 5

REFERENCES

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REFERENCES

Anchor QEA. Fisheries Technical Report, June 2023.

Anchor QEA. Floodplain Habitat Assessment & Mitigation Report, November 2020.

Anchor QEA. Landmark Tree Inventory Report, August 2021.

Anchor QEA. Parking Narrative, November 17, 2020.

Anchor QEA. Plants and Animals Technical Report, June 2023.

Aspect Consulting. Earth and Water Resources Report, May 18, 2023.

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Aspect Consulting. South Parcel Monitoring Plan, November 22, 2017.

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City of DuPont Municipal Code Mineral Resource Overlay (DMC 25.60).

City of DuPont Municipal Code Residential Reserve (DMC 25.20).

ECONorthwest. Fiscal Condition Assessment, February 28, 2024.

Environmental Caucus. 2011 Settlement Agreement for DuPont Mine, Restoration of Sequalitchew Creek Watershed and Preservation of Puget Sound Shorelands and Adjacent Open Space, 2011.

ESA. Visual Impact Analysis, December 2022.

Heffron Transportation. Traffic Impact Assessment, July 18, 2022.

Historical Research Associates. Cultural Resources Desktop Analysis, November 2, 2022.

Ramboll Corporation. Air Quality Assessment, September 27, 2022.

Ramboll Corporation. Noise Study, September 27, 2022.

Washington Department of Ecology State Environmental Policy Act (WAC 197-11).

Washington Department of Natural Resources Surface Mining Act (RCW 78.44).

Washington Information System for Archaeological and Architectural Records Data (WISAARD).

Appendices

The following Draft EIS appendices are provided as separate files:

A. Distribution List
B. Earth and Water Resources Report, Aspect Consulting, May 2023
C. Air Quality Assessment, Ramboll Corporation, September 2022
D. Stormwater Management Report, Aspect Consulting, February 2021
E. Groundwater Model Update, Aspect Consulting, June 2017
F. South Parcel Monitoring Plan, Aspect Consulting, November 2017
G. Fisheries Technical Report, Anchor QEA, June 2023
H. Plants & Animals Technical Report, Anchor QEA, June 2023
I. Landmarks Tree Inventory, Anchor QEA, August 2021
J. Floodplain Habitat Assessment & Mitigation Report, Anchor QEA, November 2020
K. Noise Study, Ramboll Corporation, September 2022
L. Visual Impact Analysis, ESA, December 2022
M. Cultural Resources Desktop Analysis, November 2022
N. Traffic Impact Assessment, Heffron Transportation, July 2022
O. Parking Narrative, Anchor QEA, November 2020
P. Fiscal Condition Assessment, ECONorthwest, February 2024

Appendix A

Distribution List

Pioneer Aggregates Distribution List 2024		
	Contact Name and/or Agency	**Email Address/Street Address**
1	WA St. Dept of Archaeology & Historic Preservation	SEPA@dahp.wa.gov
2	Anne Fritzel, AICP WA St. Dept of Commerce	Anne.fritzel@commerce.wa.gov
3	WA St. Dept. of Ecology	Separegister@ecy.wa.gov
4	Donna Joblonski Shorelands & Envionmental Assistance SWRO WA St. Dept of Ecology	dmca461@ecy.wa.gov
5	Jerome Lambiotte SWRO Toxic Cleanup Program Section Manager WA St Dept of Ecology	Jerome.lambiotte@ecy.wa.gov
6	Marian Abbett Tacoma Smelter Plume Unit Supervisor Toxic Cleanup Program-SWRO WA St. Dept of Ecology	marian.abbett@ecy.wa.gov
7	Diana Ison Tacoma Smelter Plume Technical Assistance Coordinator Toxic Cleanup Program-SWRO WA St. Dept of Ecology	Diana.Ison@ecy.wa.gov
8	Eli Newby WA St. Dept of Ecology NPDES Permit Inspector-Water Quality Program	Eli.newby@ecy.wa.gov
9	Zachary Meyer Wetlands/Shorelands Specialist WA St. Dept of Ecology-SW Regional Office Shorelands & Environmental Assistance	Zmey461@ecy.wa.gov
10	Mike Gallagher WA St Dept of Ecolotgy	mike.gallagher@ecy.wa.gov
11	Maria Sandercock WA St Dept of Ecology	MARI461@ECY.WA.GOV
12	Bobbak Talebi SW Regional Director WA St Dept of Ecology	bobbak.talebi@ecy.wa.gov
13	WA St. Dept of Health	SEPA.reviewteam@doh.wa.gov
14	Portia Leigh Area Habitat Biologist WA St Dept of Fish & Wildlife (WDFW)	Portial.leigh@dfw.wa.gov
15	WA St Dept of Fish & Wildlife (WDFW) SEPA	R6SSplanning@dfw.wa.gov

16	Michele Culver Regional Director WA St Dept of Fish & Wildlife(WDFW)	Teammontesano@dfw.wa.gov
17	WA St. Dept of Natural Resources SEPA Center	SEPACENTER@dnr.wa.gov
18	WA St Dept of Natural Resources South Puget Sound Region	Southpuget.region@dnr.wa.gov
19	Ana Shafer Assistant Director of Surface Mine Reclamation Washington Geological Survey WA St Dept of Natural Resources	ana.shafer@dnr.wa.gov
20	Casey Hanell WA St Geologist and Director WA Geolotcial Survey WA St Dept of Natural Resources	casey.hanell@dnr.wa.gov
21	Kate Tackett Regional Surface Mine Inspector WA St Dept of Natural Resources	Kate.tackett@dnr.wa.gov
22	Nicole Damer Plan Reviewer Surface Mine Reclamation Program WA St Dept of Natural Resources	Nicole.damer@dnr.wa.gov
23	Rian Skov Chief Reclamation Geologist Surface Mine Reclamation Program WA St Dept of Natural Resources	rian.skov@dnr.wa.gov
24	WA St Dept of Social & Health Services Land & Bldg Div	PO Box 45848 Olympia, WA 98504-5848
25	Robert J. Hubenthal WA St Dept of Social & Health Services	hubenbj@dshs.wa.gov
26	WA St Dept of Transportation Olympic Region	OR-SEPA-REVIEW@wsdot.wa.gov
27	WA St Parks and Recreation Commission	Planning@parks.wa.gov
28	Nick Tealer Environmental Planner Puget Sound Partnership	Nick.tealer@psp.wa.gov
29	Puget Sound Clean Air Agency	SEPA@pscleanair.org
30	Alex Funderburg Project Manager BNSF Railway	605 Puyallup Ave Tacoma, WA 98421
31	Ms. Jaimie Wharton Chief, Environmental Division Compliance Branch JBLM	jaimie.l.wharton.civ@army.mil

32	William C. Britton Environmental Project Review Clerk/Key Control Manager Environmental Division, Directorate of Public Works JBLM	William.c.britton.civ@mail.mil
33	Halie N. Endicott Corps Project Manager for Western Pierce County US Army of Corps	Halie.N.Endicott@usace.army.mil
34	Chalres Markham Director of Public Works JBLM	Charles.s.markham2.civ@mail.mil
35	David Fullmer JBLM	David.j.fullmer4.civ@mail.mil
36	Sarah Montero JBLM	sarah.c.montero.civ@mail.mil
37	John Richardson JBLM	John.f.richardson1.civ@army.mil
38	Cynthia Trout Environmental Div Chief Public Works JBLM	cynthia.k.trout.civ@mail.mil
39	DuPont Post Office Attn: Postmaster	1313 Thompson Circle DuPont, WA 98327
40	National Marine Fisheries Service Northwest Regional Office	7600 Sand Point Way NE Seattle, WA 98115-0070
41	Glynnis Nakai Nisqually Nat'l Wildlife Refuge	Glynnis_Nakai@fws.gov
42	Sean Gaffney Planning Manager Environmental Office-Pierce County	Sean.gaffney@piercecountywa.gov
43	Adonis Clark Pierce Co. PALS	aclark@co.pierce.wa.us
44	Deland Hand Pierce Co Assessor/Treasurer-Commercial	Delane.hand@piercecountywa.gov
45	Taran Bedi, P.E. Engineering Supervisor Planning & Publice Works, Sewer Div Pierce Co. Environmental Services Bldg	Taran.bedi@pierceountywa.gov
46	John Graves FEMA	John.Graves1@dhs.gov
47	Lakewood Community & Economic Development Planning	planning@cityoflakewood.us
48	Tanner Fuller Planner Steilacoom Community Development	Tanner.fuller@ci.steilacoom.wa.us

49	Terri Hebert Admin Secretary for Capial Projects Clover Park School District	Thebert@cloverpark.k12.wa.us
50	Shawn Lewis Assistant Superintendent Steilacoom Historical School District	shlewis@steilacoom.k12.wa.us
51	Lemay	Cust2180@wcnx.org
52	David P. Brown Municipal Liaison Manager PSE	david.p.brown@pse.com
53	Krystal Kyer Pierce Co. Planning a& Public Works	Krystal.kyer@piercecountywa.gov
54	Debbie Germer Sr. TDM Planner-Sustainable Resources Pierce Co. Public Works	Debbie.germer@piercecountywa.gov
55	Windy Kruse Planner, Planning & Programming Sect. Planning & Public Works Pierce Co. Envionmental Services Bldg	Windy.kruse@piercecoutnywa.gov
56	Sara Bird Tacoma Pierce County Health Dept	SEPA@tpchd.org
57	Kirk Kirkland Tahoma Audubon Society	Kirkkirkland9@gmail.com
58	Joe Cushman Nisqually Indian Tribe	Cushman.joe@nisqually-nsn.gov
59	Annette Bullchild Nisqually Tribal Historic Preservation Office Nisqually Indian Tribe	Bullchild.annette@nisqually-nsn.gov
60	Brad Beach Nisqually Tribal Historic Preservation Office Nisqually Indian Tribe	Beach.brad@nisqually-nsn.gov
61	David Troutt Natural Resources Director Nisqually Natural Resources	troutt.david@nisqually-nsn.gov
62	Jeremy "badoldman" Perkuhn Nisqually Tribal Historic Preservation Office Nisqually Indian Tribe	badoldman.jp@nisqually-nsn.gov
63	George Walter Environmental Program Supervisor Nisqually Natural Resources	walter.geroge@nisqually-nsn.gov
64	James Gordon Natural Resources Dept Cowlitz Indian Tribe	jgordon@cowlitz.org
65	Cowlitz Indian Tribe Permit Review	Permitreview@cowlitz.org
66	Elizabeth Sanchey Yakama Nation	Elizabeth_sanchey@yakama.com

67	Emily Griffith Assistant Director NWL Association	Emily.griffith@agynbyte.com
68	Shirley Ely Director NWL Association	Shirley.ely@agynbyte.com
69	Brian Chestnut Attorney - Represented Nisqually Delta Assoc Ziontz Chestnut (Per Letter from Ziontz Chestnut 8-1-2023)	bchestnut@ziontzchestnut.com
70	Nisqually Delta Association Ed Kenney (per Letter from Ziontz Chestnut 8-1-2023)	baldhillssolar@gmail.com
71	Pete Stoltz Manager-Permitting & Government Affairs CalPortland	Pstoltz@calportland.com
72	Rich Schipanski Manager, Planning and Environmental Review EA Engineering, Science and Technology, Inc.,PBC	Rschipanski@eaest.com
73	Don Russell	Krdr1@juno.com
74	Sam thayer	Samthayer1958@gmail.com
75	Hannah Thornton	Hannahsyd92@gmail.com
76	Maria Gudaitis	mariagudaitis@gmail.com
77	Kate Walsh	3mcwals@gmail.com
78	Renee Buck	rbuckccwc@gmail.com
79	Scott Stugelmeyer	stugie@gmx.com
80	Denny Glenn	Denny.glenn@outlook.com
81	Lee Chase	Leeandchrischase@gmail.com
82	Vicki Keys	vickikeys@comcast.net
83	Judy Norris	piebaldsatil@gmail.com
84	Beth Elliott	Bethelliott1953@gmail.com
85	Kazuko Donahue	kazuko-donahue@comcast.net
86	Mike Brown	Bluemax36@gmail.com
87	Christi Glenn	christiglenn@hotmail.com
88	Shawna Gasak	sgask@hotmail.com
89	Penny & Roy Coffey	Pcoffey1@comcast.net
90	Mike & Nanette Winkler	Winkler4@comcast.net
91	Maame Bassaw	Mbassaw64@gmail.com
92	Karen Nolan	fraukln@yahoo.com
93	Heather Muir	Heather.e.muir@outlook.com
94	Amy Marlow	amyhullmarlow@gmail.com
95	Ronald Forbes	Duke.forbes@comcast.net
96	Elizabeth Bundt	efuray@hotmail.com
97	Jessica Hillsbery	mrshillsbery@gmail.com
98	William Noland	William.noland1977@gmail.com
99	Todd Merritt	tmerritt@rshughes.com
100	Cary Harlow	cebchar@gmail.com

101	Lara Behnert	larabehnert@gmail.com
102	Krista Novak	kristamnovak@yahoo.com
103	Cara Mitchell	caraemitch@gmail.com
104	Robin Barrow	barpow1@msn.com
105	Eric & Jen Chandler	e_jchandler@comcast.net
106	Nicole Slattery	redekops@aol.com
107	John Colvin	jpcolvin327@gmail.com
108	State Rep. Mari Leavitt	mari.leavitt@leg.wa.gov
109	State Rep Andrew Barkis	andrew.barkis@leg.wa.gov
110	State Rep Kelly Chambers	kelly.chambers@leg.wa.gov
111	State Rep Jake Fey	jake.fey@leg.wa.gov
112	Mayor Dick Muri	dick.muri@ci.steilacoom.wa.us
113	Derek Booth	dbooth@stillwatersci.com
114	Midy Roberts	mindy@wecprotects.org
115	Councilmember Tom Wargo	councilmember4@dupontwa.gov
116	Councilmember Kevin Ballard	kballard@dupontwa.gov

Appendix B

Earth and Water Resources Report

EARTH AND WATER RESOURCES REPORT

Pioneer Aggregates South Parcel Project

Prepared for: CalPortland

Project No. 040001-018 • May 18, 2023 FINAL REV. 1

Aspect CONSULTING

earth + water

EARTH AND WATER RESOURCES REPORT

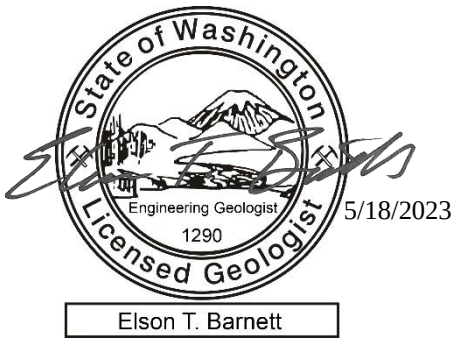
Pioneer Aggregates South Parcel Project

Prepared For: CalPortland

Project No. 040001-018 • May 18, 2023 FINAL REV. 1

Aspect Consulting, LLC

5/18/2023



5/18/2023

Owen G. Reese, PE
Principal Water Resources Engineer
oreese@aspectconsulting.com

Elson T. "Chip" Barnett, LEG
Senior Engineering Geologist
ebarnett@aspectconsulting.com

Peter Bannister, PE
Senior Associate Water Resources Engineer
pbannister@aspectconsulting.com

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1 Introduction

Glacier Northwest, Inc. dba CalPortland is seeking regulatory approvals for the Pioneer Aggregates South Parcel Project ("South Parcel Project"), which proposes to extend sand and gravel mine operations to the southeast of existing activities at the Pioneer Aggregates Mine in DuPont, Washington. Figure 1 provides an overview map of the South Parcel Project.

This document evaluates the environmental conditions and potential impacts of the South Parcel Project, and potential alternative actions, on earth and water resources. These analyses are being conducted as a component of the State Environmental Policy Act (SEPA) evaluation for the South Parcel Project.

The report is divided into three main sections: Geology, Groundwater, and Surface Water. The Geology section summarizes the geologic conditions and geologic hazards, and analyzes the stability of the existing and proposed slopes. The Groundwater and Surface Water sections describe the existing systems, identify the effects of mining on water resources, and provide preliminary design concepts for stormwater and erosion controls.

1.1 Description of the Proposed Action

Consistent with the 2012 Settlement Agreement (discussed further below), the South Parcel Project (Proposed Action) includes horizontal expansion of mining into approximately 188 acres previously undisturbed by mining, and vertical expansion of approximately 125 acres where re-mining would deepen a portion of the existing mine. The South Parcel Project would extend mining at the current rate for approximately 14 additional years.

The proposed South Parcel Project activities would be focused southeast of the existing Pioneer Aggregates Mine in the City of DuPont (City), southwestern Pierce County, sections 22, 23, and 26, Township 19 North, Range 1 East of the Willamette Meridian. The South Parcel Project is bordered to the north and west by the existing Pioneer Aggregates mine; to the east by industrial/distribution facilities including Amazon, Dania, Pier 1 Imports, and FedEx; and to the south by Sequalitchew Creek and the Creekside Village residential development. The South Parcel Project would occur on lands owned by Weyerhaeuser Company and leased to CalPortland.

The South Parcel Project includes mining within areas previously undisturbed by mining (termed the "Expansion Area") and mining deeper within a portion of existing mine, referred to as the "Re-Mine Area." The Expansion Area is approximately 188 acres and is comprised of three subareas, shown on Figure 2. The Kettle Area is a 10.8-acre previously undisturbed area that includes the Kettle Wetland. The 9.2-acre Buffer Strip is a strip of vegetation that was retained along the inside of the originally permitted mine bordering the South Parcel. The South Parcel is 167.5 acres located southeast of the

original mine and inside the Mineral Resource Overlay in the City's adopted Comprehensive Plan.

The Re-Mine Area consists of 125 acres in the southeastern portion of the existing mine where groundwater limits the depth of current mining activities.

The South Parcel Project was developed consistent with a 2012 Settlement Agreement between CalPortland, the City of DuPont, the Washington State Department of Ecology (Ecology), and a coalition of environmental groups collectively referred to as the Environmental Caucus. The Settlement Agreement describes a process for a Restoration Plan for the Sequalitchew Creek watershed to be permitted and implemented contemporaneously with mining of the South Parcel. The Restoration Plan is designed "to help restore and enhance the Sequalitchew Creek watershed, including flows along the entire length of the Creek." The Restoration Plan is not intended solely as mitigation for the South Parcel Project, and the benefits of implementing would more than mitigate for the impacts of the mine. The Restoration Plan is described in Section 4.4.3.

1.1.1 Existing Mine

CalPortland's original sand and gravel mine was permitted in 1996 (355 acres). As provided under the Settlement Agreement, CalPortland applied for permits in 2013 for the North Parcel Mine Expansion to allow mining of approximately 142 acres within the North Parcel. Following the publication of a Final EIS in June 2013, the North Parcel mining expansion was permitted in 2014.

Activities at the existing site include mining and reclamation, processing, transport of sand and gravel, and manufacturing of concrete. The processing area is located adjacent to the mine site on a 52-acre parcel owned by Glacier Northwest (Glacier). Sand and gravel is removed from the mine by bulldozers and wheel loaders and transferred to the processing area by conveyor belts. At the processing facility, the material from the mine is crushed, washed, and separated into different size gradations. Aggregate products are stored in stockpiles in the processing area for distribution.

After completion of the production process, the majority (approximately 80 percent) of the finished aggregate products are transported from the plant area by conveyors and placed onto barges at Glacier's dock and barge-loading facility at Tatsolo Point. The remainder (approximately 20 percent) is sold as aggregate or used to make concrete on-site; in both cases it is transported by truck.

Water used to wash gravel during processing is recycled through a clarifying process to remove silt and clay. This fine material is run through a belt press to remove excess water, transported by truck, and then placed in holding cells in the mine, where it is allowed to dry for up to 3 years.

After drying, fines may be used to raise the floor of the mine by placing the material in cells separated by rock curtains to facilitate drainage. The material is placed in approximately 6-inch lifts and compacted to a material dry density of 90 percent (ASTM D1557) or greater. Once filled to the desired height with fines from the belt press in this manner, a gravel cap of not less than 10 feet is placed over the compacted fines to mitigate potential for settlement and facilitate drainage.

1.1.2 South Parcel Project

The proposed South Parcel Project includes expansion of the mine footprint by approximately 188 acres and extension of the existing rate of mining for an additional approximate 14-year period (depending on market conditions), increasing the available sand and gravel resources by 30 to 40 million tons. The Expansion Area is located within a Mineral Resource Overlay applied by the City's Comprehensive Plan. The purpose of the overlay is to conserve mineral resources of long-term commercial significance, as required by the Growth Management Act.

The South Parcel Project would involve six primary activities: logging, clearing and topsoil removal, groundwater management, mining, processing and transport, and reclamation. These activities would overlap, with multiple actions occurring in different portions of the mine at any one time. For example, while active mining is occurring in one portion of the mine, earlier-mined areas may be reclaimed, and other areas to be mined next could be cleared and having topsoil stockpiled.

The following sections provide descriptions of each of the primary activities involved in mining sand and gravel.

1.1.2.1 Logging

Timber was last logged from the South Parcel several decades ago, but tree cutting would still be needed prior to clearing and mining in the Expansion Area. A substantial portion of the proposed mining would occur within previously reclaimed areas of the existing mine (i.e., the Re-Mine Area) or in previously unmined areas where Scot’s broom shrub dominates the landscape. The Expansion Area would be logged at a single time prior to initiating mining.

1.1.2.2 Clearing and Topsoil Removal

Prior to mining, excavators would remove stumps and vegetation. This material would then be processed through a portable tub grinder and used to amend topsoil for use in reclamation. Clearing and topsoil removal would occur in the mine area, in segments as mining advances into the Expansion Area, over the life of the project.

The Expansion Area is located downwind of the former Asarco copper smelter and refinery in Ruston, Washington. Airborne pollution emitted from the former smelter has resulted in a 1,000-square-mile, area-wide plume of arsenic- and lead-contaminated soil known as the Tacoma Smelter Plume (TSP). Surficial soils in the Expansion Area that have been undisturbed since the mid-1980s may contain arsenic and lead at concentrations above cleanup levels. These soils would be cleaned up under an approved plan developed in consultation with Ecology through the Voluntary Cleanup Program (VCP). The plan incorporates the same process that is being successfully implemented on the North Parcel.

1.1.2.3 Groundwater Management

An existing aquifer is present in the sands and gravels to be mined under the South Parcel Project. Wells would be installed and pumped in advance of mining to intercept groundwater and dry out the gravels for mining. The mining plan is designed to minimize the amount of time that active dewatering by pumping wells is required.

Mining under the South Parcel Project would proceed slowly from the north to the south over a period of 5 to 8 years, extracting gravel to create a broad trough along the eastern property boundary. Once mining of each section of trough is completed, the adjacent wells can be turned off, allowing groundwater to passively seep from the stable mine slope and flow by gravity to an infiltration facility on the floor of the existing mine. After mining the trough along the perimeter, gravel would be extracted from the interior area over an approximately 6- to 9-year period.

A dewatering plan has been developed and is described in detail in the Monitoring Plan (Aspect, 2017a). The dewatering plan involves four steps, occurring over very different time scales. The four steps are:

The initial step is a 60-day pumping test that is completely reversible (i.e., no gravel would be extracted during the test). The results of that test would be analyzed to confirm predictions from the groundwater drawdown model and used to adjust the dewatering plan (well spacing, well screening, etc.) as necessary prior to commencing the next phase. Depending on seasonal timing, the Kettle Wetland (described in Section 4.1.2.1) may be dewatered during the pumping test, but the water level would return after completion of the test. Total duration that Kettle Wetland levels may be dewatered is less than 120 days.

The second step involves installing and pumping additional dewatering wells to lower water levels in the first mine segment in preparation for mining. This step would last about 6 months and functions as a greatly expanded pumping test. As with the initial step, it is also completely reversible. Groundwater observations during pumping would be compared to model predictions to confirm that actual changes in groundwater are within the range predicted during project planning, when potential impacts from the project are evaluated. This step would confirm model predictions before any gravel is removed from the Expansion Area. The Kettle Wetland would be dewatered shortly after commencing this dewatering step and would remain dewatered through the duration of this step, estimated at 180 days.

The third step – active dewatering during mining – involves mining the trough described above. Additional dewatering wells would be installed and pumped as mining progresses. Mining would begin at the location farthest from the Edmond Marsh and Sequalitchew Creek and proceed slowly south. Completing the trough would require 5 to 8 years depending on market conditions and the success in meeting predicted groundwater levels. The potential impact on groundwater levels builds slowly over time as wells are added and mining progresses to the south. This allows ample opportunity to monitor, confirm model predictions, and adapt to the conditions observed before mining proceeds into each dewatered segment.

The Kettle Wetland would be removed in the early mining of this dewatering step. The wetland soils and seed bank would be used in construction of the mitigation wetland, as described in the Wetland Mitigation Plan (Anchor QEA, 2021).

The final step – passive dewatering – begins when mining of the trough described above is complete and the last dewatering well is turned off. Passive dewatering represents the groundwater condition that would continue in perpetuity. Groundwater, no longer intercepted by wells, would form seeps at the toe of the eastern mine slope. It would flow by gravity through a conveyance ditch to newly created wetlands on the bottom of the

existing mine and eventually to an infiltration pond. Once this step has begun, further mining activities in the interior of the South Parcel would not affect groundwater outside the footprint of the mine.

In each of the four steps, water generated from dewatering would be conveyed to the floor of the existing mine and infiltrated. Water from the northern portion of the dewatering system would be routed directly to an infiltration pond located in the northern portion of the original mine parcel. Water from the southern portion of the dewatering system would be routed to a constructed mitigation wetland in the southwest corner of the existing mine, then flow north to the same infiltration pond.

1.1.2.4 Mining

The method of mining for the South Parcel Project would be identical to that currently used in the permitted mine area. A bulldozer would push excavated material from the top of the mine face to two front-end loaders working on the mine floor. The front-end loaders would scoop up the sand and gravel and dump it into portable hoppers that feed conveyors leading to the processing area.

The mine face of each sequence area would be a maximum of 80 feet high and would decrease as mine activities progress. During reclamation, the graded side slopes and mine areas would be revegetated and stabilized in accordance with the mine reclamation plan.

A conveyor would start at the north end of the Expansion Area and would be extended south as mining progresses. The conveyor is comprised of a 48-inch-wide rubberized belt supported by a series of rollers, called idlers, mounted on steel-framed segments that support the conveyor about 5 feet off the ground.

As mentioned above, clearing of the Expansion Area would occur in sequences lasting approximately 1 year, in coordination with mining and construction activities. Mass clearing of the site would not occur.

A 20-foot-high noise berm would be constructed along the southern boundary of the South Parcel behind retained vegetation to reduce potential noise associated with mining for adjacent land uses. The berm would be constructed prior to clearing in the adjacent portion of the South Parcel.

The project would directly impact an approximately 1.78-acre Kettle Wetland located within the existing mine just west of the South Parcel. The Kettle Wetland would be impacted by dewatering in preparation for mining, then removed during the initial phases of mining of the South Parcel Project. Impacts to the Kettle Wetland would be mitigated by creation of a larger wetland, referred to in this report as the constructed mitigation wetland, within the existing mine. Detailed analysis of the wetland impacts and mitigation are described in the Wetland Mitigation Plan (Anchor QEA, 2021).

1.1.2.5 Processing and Transport

Material mined under the South Parcel Project would be conveyed from the mine to the existing processing facility and processed in the same general manner as at present. The material extracted under the South Parcel Project is anticipated to have a higher moisture content and fines content than the aggregate currently being extracted. As a result, there

may be minor adjustments to some of the equipment used in the processing area, but the overall process and most of the equipment would remain unchanged.

Water is used to wash the raw material conveyed from the mine to remove silt and clay. Sand and gravel smaller than 1.5 inches pass through a screening and classifying process that separates and conveys the material to a series of stockpiles sorted by size and stacked on the south side of the processing plant. Stones larger than 1.5 inches are crushed, sorted by size, and conveyed to a series of crushed-rock stockpiles sorted by size north of the processing plant. Screening equipment, rock crushers, and other processing equipment are located between the stockpiles of sorted rock products. Custom blended rock products are also made to customer specifications.

More than 95 percent of water used to process the mined material is recycled through a treatment system where silt and clay is removed so the water can be reused to process more raw material from the mine.

The mode and extent of transporting aggregate products from the site would not change relative to existing operations. Approximately 80 percent of the product would be loaded onto barges at the existing dock at Tatsolo Point and transported to the Puget Sound regional market by barges. Approximately 20 percent of the product would be transported to the local market by truck. Some material would continue to be incorporated into concrete at the existing on-site concrete batch plant serving the local market.

1.1.2.6 Reclamation

As mining progresses, completed mine segments would be reclaimed. The reclamation plan would be reviewed by the Washington State Department of Natural Resources (DNR) for consistency with the Surface Mining Act (RCW 78.44). In general, reclamation would consist of regrading, replacement of topsoil, and revegetation. Glacier is in the process of preparing an application to revise the existing reclamation plan incorporated into the surface mining permit. DNR cannot approve the revised reclamation plan until after the City's permits are issued. The proposed reclamation plan would be similar to the plan approved by DNR for the existing mine.

A summary of the change in land uses that would occur as a result of the South Parcel Project mine reclamation is presented in Table 1. As shown in Table 1, the primary change occurring as a result of the South Parcel Project is the conversion of existing wooded areas into areas reclaimed as forest and as grass. Generally, the steeper slope areas would be reclaimed as forest and flat and gently sloping areas would be reclaimed as grass lands to support future redevelopment. This is true for areas within the South Parcel as well as the Kettle Area, Buffer Area, and the Re-Mine Area.

1.1.2.7 Estimated Volume and Extraction Rates

Estimated mining quantities are shown in Table 2. Based on past market demand, material would be extracted at an average rate of approximately 2.8 million cubic yards per year. An estimated 30 to 40 million cubic yards of material would be extracted as part of the South Parcel Project, which would extend the life of the current operation by about 14 years. The actual extraction rate and life of the mine would depend on the market demand for materials.

Table 2. Estimated Annual Quantities and Timing of Aggregate Mining

Timing	Existing Mine[1]	South Parcel Project
Years 1 through 14	1.4 million cy	1.4 million cy
Years 15 through 19	0	2.8 million cy

Notes: cy = cubic yards. [1] Existing mine includes North Parcel.

1.2 Description of No Action Alternative

This document also evaluates the No Action alternative, which is required by SEPA. No Action can be interpreted in two ways. It could mean that nothing happens on the site, which would essentially continue existing conditions. "No action" is also commonly interpreted to mean that the City would take no action on the mining proposal, but that does not necessarily mean that nothing would happen on the subject site. Although the South Parcel property would not be mined, it could be developed consistent with existing land use and zoning designations. Development potential under applicable zoning is described below.

Portions of the South Parcel are zoned for Manufacturing and Research Park (MRP; 136.2 acres), Residential-4 (R-4; 16.1 acres), Residential Reserve (RR; 22.3 acres), and Open Space (3.8 acres) uses. The MRP zoned areas are currently subject to restrictive covenants related to the Former DuPont Works Cleanup Site, which restrict use of the property to industrial uses. Remediation and rezoning are considered speculative, however, and would not be consistent with a "No Action" scenario.

The extent of development could vary considerably depending on zoning/density, site planning, economic considerations, and numerous site-specific, project-specific, and regulatory requirements including setbacks, open space, and the presence of critical areas. The following is intended to be a general estimate of the possible intensity of development for purposes of analysis only and is based primarily on zoned density and permitted site coverage. The development scenario for the South Parcel is reflected in Table 1. Development estimates are based on assumptions of building and parking areas as a percentage of developable area and do not represent a specific, or detailed, development proposal.

Areas zoned MRP would be available for development of up to 112 acres of light manufacturing and research park. Buildings may be up to 65 to 70 feet tall, and there are no maximum lot coverage requirements other than necessary to meet required setback (25 feet on the front property line, 15 feet on the sides and rear) and landscaping (20 percent of lot area) requirements. This zoned area could yield approximately 109 acres of impervious area at up to 80 percent lot coverage. The areas of the South Parcel zoned R-4 could be developed at a density of up to 4.5 single-family residences per gross acre[1], resulting in a total of approximately 76 residences and 69 percent impervious coverage[2]. An additional four single-family residences could be developed in the smaller portion

[1] "Gross acre" means land designated for residential purposes in the comprehensive plan, inclusive of related streets and neighborhood parks. DMC 25.10.040.
[2] Impervious area estimates for residential development are based on the density based impervious surface coefficient (ISCs) published by California's Environmental Protection Agency (2010).

zoned for Residential Reserve density (one dwelling unit per 5 gross acres) and 34 percent impervious coverage.

There would be no changes in the use of the areas of the South Parcel zoned for Open Space; these areas are currently the naturally vegetated slope of the Sequalitchew Creek ravine and the Sequalitchew Creek pedestrian trail.

A summary of the parcels, zoning, and development potential of the South Parcel is presented in Table 3 and illustrated on Figure 3.

Table 3. Parcels, Zoning, and Potential Development for No Action Alternative

Parcel No.	Zoning	Parcel Area (in acres)	Potential Development
0119262015	MRP	21.0	16.8 acres MRP
	OS	3.7	None
	Total	24.7	16.8 acres MRP
0119262016	MRP	34.0	27.3 acres MRP
0119233016	MRP	19.9	16.0 acres MRP
0119233017	MRP	20.1	16.3 acres MRP
0119233014	MRP	20.3	16.3 acres MRP
0119233015	MRP	20.3	16.4 acres MRP
0119233011	R-4	16.0	72 residences
	R-R	21.9	4 residences
	Total	38.0	76 residences

There would be no change in use of the areas within the existing mine under the No Action alternative scenario; however, once the existing mine is reclaimed it would likely be redeveloped according to its underlying zoning, similar to the South Parcel.

The Kettle Wetland within the existing mine would remain intact, the buffers would remain vegetated, and mining operations would continue in other portions of the existing mine.

2 Geology and Slope Stability

Geologic and geotechnical analyses were performed to determine geologic conditions beneath the existing ground surface of the Proposed Action. These analyses were completed to evaluate the stability of proposed cut slopes and identify areas prone to geologic hazards, such as slope failure or seismically induced soil liquefaction. The analyses rely on geologic investigations conducted over a period of more than 30 years, notably including over 109 borings completed in the late 1980s to facilitate planning of the initial Pioneer Aggregates mine.

Mining of the South Parcel Project would extract sand and gravel from a thick deposit Vashon Recessional Outwash (Qgog) deposit, including the Steilacoom Gravel (Qvs) subunit. These deposits are consistent with the existing mine to the west and north. The planned mining proposed for the South Parcel Project would result in a reduction in groundwater seepage and springs that are observed within the north Sequalitchew Creek ravine slope that will result in making the slopes more stable. Slope stability analyses results indicate proposed mining cut slopes would be relatively stable for static and seismic conditions.

The following Sections 2.1 through 2.6 have been developed using key references that include the Geotechnical Engineering Report (Aspect, 2021a), Critical Areas Report (Anchor and Aspect, 2021), and Groundwater Model Update Report (Aspect, 2017b). A summary of the key data and our analyses are presented below.

2.1 Affected Environment

2.1.1 Topography and Landform Geography

The South Parcel Project includes the Expansion Area, which is previously undisturbed by mining, and the Re-Mine Area, which is a portion of the existing mine that would be mined deeper. Existing topography of both areas is shown on Figure 4. The Expansion Area is generally flat at an elevation of approximately 200 feet.[3] The Re-Mine Area has a rolling slope toward the west down to the floor of the existing mine (western boundary of the expansion). The slopes to the west within the Re-Mine Area vary between a grade of 10 percent to 70 percent locally.

The Sequalitchew Creek ravine is located south and southwest of the South Parcel Project; this ravine forms most of the southern boundary of the existing mine. The ravine deepens as it approaches Puget Sound to a maximum depth of 175 feet below the plateau elevation. Slopes along the northern side of the Sequalitchew Creek Ravine range from approximately 30 percent to 75 percent. A narrow-gauge railroad associated with the former E.I. DuPont de Nemours Company munitions facility was constructed on a bench cut in the northern slope of the ravine; it has since been converted to a public trail.

[3] Elevation relative to the National Geodetic Datum of 1929 (NGVD 29). Unless otherwise noted, all elevations in this report are relative to NGVD 29.

2.1.2 Regional Tectonic Setting

The South Parcel Project lies within the Puget Sound Lowland, between the Cascade and Olympic Mountain ranges. The Cascade and Olympic Mountains and the Puget Sound Lowland result from tectonic forces acting on the oceanic plates and continental plates that constitute the landmass of western North America. Higher-density offshore oceanic plates are being subducted (pulled under) beneath the lower density and more buoyant North American continental plate. The interaction of the oceanic and continental plates puts generally compressive stress on the margins of the plates.

Over the past tens of millions of years, these east-to-west oriented compressive stresses have resulted in uplift of the Olympic and Cascade Mountains, along with volcanism that has further increased the height of the Cascades. The tectonic forces that resulted in uplift of the Cascades and Olympics have also resulted in creation of a basin that lies below the Puget Lowland. Subsidence of the Puget Lowland allowed thick sedimentary sequences to collect in the basin for the last 35 million years. More recently, the sediments in the Puget Lowland have been subjected to north-to-south compressive stresses that have folded and faulted them and created a series of basins and uplifts within the Puget Lowland. These basins extend from the Chehalis area to the Fraser lowland which extends north of the Canadian border.

Tectonic forces that created these lowlands, mountain ranges, and basins remain active today and result in the moderate-size earthquakes that are frequently felt throughout the region as well as infrequent large earthquakes.

2.1.3 Regional Geology and Geologic History

Geologic nomenclature in this report is primarily based on Borden and Troost (2001) and Walsh et al. (2003a and 2003b), which provide the most recent comprehensive regional understanding of Pleistocene stratigraphy in the south-central Puget Lowland. We also reference other nomenclature where previous studies use a different name for the same or similar geologic units.

The most recent ice-sheet glaciation of the Puget Lowland is termed the Vashon Stade of the Fraser Glaciation. Global and regional scientific observations indicate that there were many cooler climatic periods prior to the Vashon glaciation that produced ice-sheet glaciations, and geologists have identified deposits from a number of these pre-Vashon glacial and nonglacial periods in the Puget Lowland (Borden and Troost, 2001).

During the southward advance of the Vashon ice sheet, ice blocked the normal northward drainage of water from the Puget Sound Lowland, creating a pro-glacial lake into which silt, clay, and fine sand were deposited. As the Vashon ice sheet advanced farther southward, meltwater streams and rivers filled the remaining low areas with a blanket of sand and gravel that extended throughout the lowland. These subglacial troughs are visible today as the major waterways of Puget Sound, Hood Canal, Lake Washington, and Lake Sammamish, and many of the broad river valley bottoms in the Puget Lowland. A discontinuous layer of basal till (commonly described as lodgment till in older studies) was deposited where the glacial ice sheet contacted previously deposited sediment.

The Vashon ice sheet was short-lived in the lowland and the glacial ice appears to have stagnated abruptly. Sediment that was entrained on or within the ice was deposited on the

landscape when the ice melted. These deposits are called ablation till and are found largely intact where they were deposited on the uplands. Ablation till deposited in low areas was reworked by meltwater streams that flowed from the melting glaciers to form recessional outwash. In places, the deposits were influenced by shifting ice margins creating highly variable ice contact deposits, which contain both water-worked sands and gravels, and interbeds and lenses of silt and clay and till-like deposits.

These recessional sand and gravel deposits and interbedded ice contact deposits are collectively identified as Vashon Recessional Outwash (Qvr) on the geologic map and profiles. The recessional outwash generally consists of clean (containing very little silt and clay) sand and gravel, or sand and gravel with variable amounts of silt and interbeds and lenses of silty sands and gravels.

As the glaciers melted and receded, a lobe of ice blocked the northward drainage of the Puyallup valley, creating Glacial Lake Puyallup. A prominent late recessional gravelly outwash member called the Steilacoom Gravel is interpreted to have formed when a series of ice dam bursts (jokulhlaups) released the glacially impounded water in Glacial Lake Puyallup (Troost, 2007; and Troost and Sofield, 2011). Floodwaters spilled and transported coarse-grained sediments into a broad outwash plain in the Sequalitchew Creek area. These coarse-grained deposits created thick deltas where the outburst channels flowed into a lower elevation lake (Glacial Lake Russell) that had formed behind the remaining Vashon glacial ice.

Glacial Lake Russell (which is now partially occupied by modern Puget Sound) was deep and had steep sided walls in the area of the South Parcel, similar to those of the modern coastal bluffs. The contact between the sediments exposed in the former walls of Glacial Lake Russell and the overlying late glacial delta and flood deposits derived from Glacial Lake Puyallup is similarly steep and exhibits a marked change in soil types. The contact is called the “Olympia Beds Truncation” (referred to as the “Kitsap cutoff” in some older reports). The location of the Olympia Beds Truncation (Figure 6) is a key geologic and hydrologic feature at the South Parcel Project.

2.1.4 Site Geology

Geologic units of glacial and nonglacial origin were deposited at the South Parcel Project vicinity before, during, and after the Vashon glaciation. The understanding of site geologic conditions was further informed through the boring and monitoring well explorations that are shown on Figure 5 and presented in Appendix A of the Geotechnical Engineering Report (Aspect 2021a). A regional geologic map is shown on Figure 6 and a surficial geologic map of the South Parcel Project is provided on Figure 7. Well and boring logs were used to develop a cross section shown on Figure 8 that provides greater detail and shows the extent of the geologic units. Key well and boring logs are included in Appendix A.

The surface geology of the South Parcel Project area consists primarily of Vashon-age recessional sand and gravel (Qgog) that includes the Steilacoom Gravel (Qvs). The recessional glacial unit is underlain by older Vashon-age glacial deposits that may locally consist of glacial till (very dense consolidated diamict typically comprised of very dense

silty sand with gravel), pre-Vashon nonglacial deposits, and pre-Vashon glacial deposits – all comprised primarily of sand and gravel.

The uppermost pre-Vashon non-glacial sequence at the South Parcel Project area is identified as the Olympia beds. These nonglacial deposits are generally marked by an increase in silt, organics, and wood fragments and are observed in borings. They are termed the Olympia beds since being age-dated by Troost (Borden and Troost, 2001). Strata now known as Olympia beds were previously included within the informally named Kitsap formation (Walters and Kimmel, 1968).

Older unnamed glacial and nonglacial deposits lie below the Olympia beds. These are identified as pre-Olympia nonglacial deposits (Qpon) and a pre-Olympia glacial deposits (Qpog).

Steilacoom Gravel, which is comprised of the late-glacial delta and flood deposits, is a member of the Vashon Recessional Outwash unit and is identified as Qgog on the Project Geologic Map (Figure 7). The proposed mining of the South Parcel Project will occur within the Steilacoom Gravel and is the same geologic unit currently being mined in the existing mine area.

After the end of the Vashon glaciation, nonglacial conditions resumed in the South Parcel Project area. Post-glacial geologic units deposited in the area included beach and shallow marine deposits, colluvium on slopes, and alluvium in drainage bottoms. Topsoil developed on soils in stable and forested uplands areas.

2.1.4.1 Site Reconnaissance and Subsurface Explorations

A site reconnaissance was conducted on November 1, 2019, and later on December 21, 2021. The reconnaissance focused on examining the areas on the north slope of the Sequalitchew Creek ravine for indications of springs, seepage, and instability. Slopes within the existing pit were also evaluated for seeps and springs, and the general nature of the soils exposed in natural and mined excavations. Springs encountered within the Sequalitchew Creek ravine are shown on Figure 7. Natural and mined slope angles were measured and the behavior of historical mine slopes on the active and reclaimed mine slopes in the vicinity was examined. We also looked for evidence of concentrated surface water on the uplands of the Expansion Area and made general observations of surficial soil types.

Field observations were noted on a topographic map, and locations of specific features were recorded with a field GPS for plotting on topographic base maps. Results of the reconnaissance (including observations of hydrology, geology, and slope stability) are incorporated in subsequent sections and figures of this report.

Figure 5 shows the locations of existing subsurface explorations at the site from previous reports and investigation efforts, which were used to inform this study. No subsurface explorations were conducted specifically for this study; logs of previous borings and wells are provided in Appendix A as well as in the Geotechnical Engineering Report (Aspect, 2021a).

2.1.4.2 South Parcel Project Subsurface Conditions

Subsurface conditions for the South Parcel Project were inferred from review of the existing soil boring and well logs, published geologic data and maps, and our geological reconnaissance. Based on the available information, the inferred geologic units at the site are described below.

Topsoil

Topsoil, including up to several inches of forest duff (organic debris), is present in the South Parcel Project area. The duff layer is primarily present within upland forested areas. The South Parcel Project is vegetated with conifer and deciduous trees that will be cleared. The Re-Mine Area has been previously cleared and is vegetated with shrubs and grasses. Undisturbed, native topsoil is generally not present in the Re-Mine Area; however, topsoil has been placed over portions of the Re-Mine Area as a component of mine reclamation.

Steilacoom Gravel subunit of Vashon Recessional Outwash

The majority of near-surface Vashon recessional outwash in the area is composed of the Steilacoom Gravel subunit (Qvs) of the Vashon Recessional Outwash (Qgog) deposit. Soils from the Steilacoom Gravel account for most, if not all, of the soils that will be excavated during mining operations. This soil consists of sandy gravel and gravelly sand with minor amounts of silt, ranging between 2 and 6 percent. Where exposed in the adjacent working mine slopes and on road cuts in the active areas of the existing mine, this unit often has a relatively open matrix between gravel clasts. In other areas, the interstices are filled with sand.

This unit has not been glacially overridden and is anticipated to be medium dense at the surface, grading to dense at depth. Like most outwash deposits, Steilacoom Gravel possesses a minor degree of cohesion apparently resulting from silt and clay binding and slight iron oxide cementation at the grain contacts. This cohesion gives it a good intermediate-term standup time that is exhibited by the near vertical temporary cuts up to 70 feet high in the active area of the existing mine.

2.1.4.3 Olympia Beds

The Olympia Bed (Qob) deposits were observed below the Steilacoom Gravel. This unit is generally composed of interbedded lacustrine (lake sediments) and fluvial (river and stream sediments) deposits. Lacustrine deposits consist of silt and clay. The fluvial deposits consist primarily of sand but may contain oxidized gravelly lenses and layers. Interbed thickness of this unit ranges from inches up to about 10 feet. Some organic silt and peat layers that were deposited in wetlands and bogs are also generally present in this unit. The Olympia Bed unit has been overridden by the Vashon ice sheet and is generally very dense to hard in its natural state. Where exposed to seepage or weathering, its surface degrades and loosens.

The Olympia Bed deposits generally are considerably finer grained than the Vashon deposits above and can perch groundwater. Seepage has been noted at the top of the Olympia Bed unit where exposed in the road cut and natural ravine slopes along Sequalitchew Creek. If a lacustrine bed perches groundwater and is intersected by the surface of the slope, it could result in seepage onto the slope.

The contact between the top of the Olympia Beds and the overlying outwash deposits is understood through an extensive exploration conducted in the 1980s during initial geologic and groundwater studies for the Pioneer Aggregates mine (see Figure 5). Those borings generally encountered the Olympia Beds at 80 to 140 feet below the ground surface.[4] None of the borings encountered the Olympia Beds near the ground surface.

2.1.5 Hydrogeology

Surficial soils in the South Parcel Project area are generally highly transmissive to water. Stormwater will tend to infiltrate into the natural soil surface rather than collect as runoff. The Steilacoom Gravel is generally highly transmissive to groundwater flow and stormwater will infiltrate until it encounters the regional groundwater table, or until it encounters a silty interbed that locally perches groundwater. Additional information on groundwater presence within the Steilacoom Gravel is provided in Section 3.

2.1.6 Geologically Hazardous Areas

Geologically hazardous areas (GHAs) are areas "susceptible to erosion, sliding, or other potentially hazardous geological events" as described in Section 25.105.030 of the DuPont Municipal Code (DMC). The DMC defines four types of GHAs:

- Landslide Hazard Areas
- Steep Slopes
- Erosion Hazard Areas
- Seismic Hazard Areas

Aspect evaluated the presence of GHAs within the South Parcel Project and in surrounding areas as a component of the Critical Areas Report (Anchor and Aspect, 2021). This section summarizes the findings of that report.

GHAs were delineated based on our regional and local geologic knowledge of the area, reconnaissance of the South Parcel, review of published documents, and experience with similar mine sites operating elsewhere, and with reference to DMC.

A key criterion for identifying GHAs is the slope angle. Slopes greater than 15 percent can be Landslide Hazard Areas and Steep Slopes if they also have a geologic contact with a permeable unit overlying a relatively impermeable unit and presence of groundwater seeps or springs. Slopes of 40 percent or greater are GHAs unless they are comprised of competent bedrock or are a properly engineered slope. Slope angles at the South Parcel Project were evaluated using publicly available Light Detection and Ranging (LiDAR) topographic data. There are also other criteria defined in the DMC, but they are generally less applicable to conditions within the South Parcel Project area.

[4] Olympia Beds are found between 87 to 139 feet below the ground surface in the borings closest to Edmond Marsh. Several of the borings closest to the marsh did not encounter the Olympia Beds at their completion depths of 65 to 103 feet. These borings are located in the southeast corner of the South Parcel and in the southern portion of the parcel now occupied by the Amazon Fulfillment Center. In 2002, a boring was completed in the western end of Edmond Marsh and encountered the Olympia Beds at a depth of 84 feet. Boring logs for these explorations are provided in Appendix A.

Although not considered a GHA, aquifer recharge areas used for potable water are included in the list of critical areas in DMC 25.105.030.055, with regulations and performance standards for development within an aquifer recharge area defined in DMC 25.105.050(4). An Aquifer Recharge Area, as defined by the DMC, is not present within the South Parcel Project because the aquifers underlying the project area are not used for potable water.

2.1.6.1 Evaluation of Existing Conditions

This section assesses existing conditions within the South Parcel Project as well as two nearby areas: the Sequalitchew Creek ravine and the reclaimed slopes of the existing mine. The nearby areas would not be modified or impacted by the South Parcel Project, but were evaluated because their soils, geology, and other conditions are similar to those in the South Parcel Project and as such are a good predictor of the performance of the proposed conditions.

Expansion Area

Existing conditions in the Expansion Area do not meet the definition of GHAs (Figure 9). Topography is generally characterized by level ground or gentle slopes, typically inclined at gradients less than 15 percent that do not fall under the GHA criteria.

Aspect observed areas interpreted as old rail grade cut and fill slopes steeper than 40 percent that locally exceed more the 10 feet of vertical relief in the southeast portion of the South Parcel. These do not qualify as GHAs because they do not intersect a geologic contact with relatively impermeable sediment or bedrock and do not have spring or groundwater seepage (DMC 25.105.030.345) and they are stable constructed slopes that have historically performed well.

There are no channels, channel-forming processes, or areas subject to coastal erosion within the Expansion Area so there are no erosion hazard areas as defined by the City.

The existing Expansion Area does not include soils on slopes greater than 40 percent that are expected to be seasonally or perpetually saturated that pose a specific risk of settlement, movement, or liquefaction for seismic hazard areas as defined by the City.

Re-Mine Area

Existing conditions in the Re-Mine Area do not meet the definition of GHAs, although there are areas with slopes steeper than 15 percent (Figure 9). The topography of the Re-Mine Area generally consists of a gentle slope to the northwest descending toward the floor of the existing mine. Steeper slopes are present to the northwest of the Kettle Wetland, where the slope is greater than 40 percent, and along the westernmost portion of the Re-Mine Area, where it typically varies between 15 to 40 percent. Some of the steeper slopes shown on Figure 9 within the Re-Mine Area represent temporary stockpiles or fill placement.

The areas of steeper slopes within the Re-Mine Area do not qualify as GHAs as they are either temporary slopes within an active mine, or were designed and approved by a qualified professional experienced with the site, and are thus exempted from being a GHA.

There are no channels, channel-forming processes, or areas subject to coastal erosion within the Re-Mine Area, so there are no erosion hazard areas as defined by the City.

The Re-Mine Area does not contain seismic hazard areas because the soils on slopes greater than 40 percent are not expected to be seasonally or perpetually saturated and do not pose a specific risk of settlement, movement, or liquefaction.

Existing Mine

The existing mine includes constructed slopes on the south and west sides that have been graded to their final configuration and reclaimed with topsoil and planting. The west slope is about 175 feet high and is smoothly graded at about 30 percent up to 50 percent, as shown on Figure 9. The subsurface soil under the topsoil of the west slope is sand and gravel with a trace of fines. The slope has been planted with grasses and conifer trees.

The west slope has a slope gradient of greater than 40 percent with a vertical relief greater than 10 feet, but it does not meet GHA criteria because it was designed and approved by a qualified professional experienced with the site, and thus is exempted from being a GHA.

During the reconnaissance of the west slope on November 1, 2019, Aspect observed no indication of past or imminent slope failure, landsliding, or erosion. There are no concave or convex topographic features that would suggest slumping or calving, and there are no areas of exposed soil. The vegetation shows no evidence of disturbance from slope instability or erosion.

There are no channels, channel-forming processes, or areas subject to coastal erosion within the existing mine so there are no erosion hazard areas as defined by the City.

The existing mine does not contain seismic hazard areas because the soils on slopes greater than 40 percent are not expected to be seasonally or perpetually saturated and do not pose a specific risk of settlement, movement, or liquefaction.

Sequalitchew Creek Ravine

The Sequalitchew Creek ravine lies outside of the South Parcel Project area, along the southern boundary of the existing mine and the South Parcel. A small portion of the Sequalitchew Creek ravine is located within the South Parcel property boundary, but outside the proposed mining area. The ravine runs westward for about 1.5 miles down to the creek confluence with Puget Sound. The majority of the ravine is outside of the South Parcel. The slopes on the northern side of the ravine range from approximately 30 percent to 75 percent.

The north slope of the Sequalitchew Creek ravine includes a bench cut for a former railroad grade that ran down the full length of the ravine. The railroad grade has been redeveloped into the Sequalitchew Creek Trail, surfaced with asphalt on the upper portion and crushed rock lower down.

Perennial groundwater seeps from the ravine's north slope at several locations, as shown on Figure 9. On the eastern two-thirds of the ravine, the subsurface soil in the upper part of the slope (from the top of the ravine at approximate elevation 200 feet down to about elevation 110 feet) is permeable sand and gravel with minor silt; below approximately elevation 110 feet, the soil is silty and relatively impermeable. In the western third of the

ravine, the subsurface soil is permeable sand and gravel for the entire height of the ravine valley wall.

The channel of Sequalitchew Creek is relatively confined channel formed by historically higher flows (see Section 4). It currently experiences limited flow and thus has limited channel-forming processes. We observed no indication of an active channel migration zone from our reconnaissance or aerial photograph review.

The existing Sequalitchew Creek ravine does include areas with soils on slopes greater than 40 percent that are expected to be seasonally or perpetually saturated that pose a specific risk of settlement, movement, or liquefaction for seismic hazards as defined by the City.

Based on the slope steepness, the presence of the seeps, and the contact between permeable and impermeable soils, the north slope or the Sequalitchew Creek ravine qualifies as a Landslide Hazard Area, Steep Slope, and Seismic Hazard under DMC GHA criteria. The slope is identified by the DNR (Mickelson et al. 2017) as susceptible to shallow landslides.

2.2 Effects of the Proposed Action

2.2.1 Changes in Topography

2.2.1.1 South Parcel Project

Topography within the Expansion Area would be significantly altered as a result of mining as illustrated in the comparison between Figures 9 and 10. The slopes on the eastern edge of the South Parcel would be about 80 to 120 ft tall and would be inclined at 3H:1V (33 percent). Benches would be excavated in the southeast corner of the Expansion Area. The bottom surface of the Expansion Area would generally follow the contours of the top of the Olympia Beds. A thin layer of gravel, several feet thick, would likely be left on top of the Olympia Beds to provide a stable working surface.

Within the Re-Mine Area, topography would also significantly change as the current rolling slopes would be mined down to the Olympia Beds. As with the Expansion Area, a working surface of gravel would be left atop the Olympia Beds. Slopes within the Re-Mine Area would be inclined at 3H:1V (horizontal:vertical; 33 percent), where groundwater is expected to emanate from the toe of the slope and 2H:1V (50 percent), where the slopes are anticipated to be dry.

The proposed finished slopes would be less steep than other areas that have been mined and reclaimed to the west. As observed during the site visit within the reclaimed mine areas, the slopes steeper than 40 percent (up to 50 percent) and the slopes along the Sequalitchew Creek Trail exceeding 60 percent are all performing well. The soils are fairly homogenous across the active mine area and Re-Mine Area, and are expected to perform similarly in general.

2.2.1.2 Existing Mine

There would be no change to the topography of the slopes of the existing mine as a result of the South Parcel Project. However, these slopes may be modified under the current permits as mining activity continues and have already been evaluated for potential

impacts. Changes to the existing slopes under the current permits are not evaluated in this report.

A constructed mitigation wetland has been proposed near the toe of the west slope at the base of area where mining has already been completed, as shown on Figure 10. The constructed wetland slopes will be at gradients less than 15 percent.

Other minor changes within the existing mine include the construction of stormwater conveyance, treatment and infiltration facilities, and groundwater conveyance and infiltration facilities.

2.2.1.3 Sequalitchew Creek Ravine

Topography in the Sequalitchew Creek ravine will not be altered as a result of mining activities (compare Figures 9 and 10).

The dewatering and grading associated with the South Parcel Project will reduce groundwater flow toward the steep slopes of Sequalitchew Creek ravine along the east portion of the South Parcel. The proposed mine expansion will also route groundwater that would potentially flow toward the creek instead toward the mined areas. Ultimately, this will reduce the potential for landsides and slope failures within the Sequalitchew Creek ravine. The seeps and springs identified on Figure 9 are expected to be reduced or dewatered in their entirety, which may reduce the level of landslide hazard susceptibility within the ravine.

2.2.2 Slope Stability

Aspect completed a geotechnical analysis to evaluate the stability of the proposed cut slopes of the South Parcel Project, as documented in the Geotechnical Engineering Report (Aspect, 2021a). This section summarizes the findings of that report.

The static and seismic stability of proposed slopes was analyzed using the two-dimensional, limit-equilibrium slope stability software program Slide by RocScience and stratigraphy and proposed 3H:1V grading shown on cross section A-A' through D-D'. The locations where stability analyses were performed are shown on Figure 11 and were selected as being representative of critical permanent slope configurations. The slope stability results are presented graphically in Appendix B of the Geotechnical Engineering Report (Aspect, 2021a).

The stability analysis software program performs slope stability computations based on the modeled slope conditions, and calculates a factor of safety (FOS) against slope failure. FOS is defined as:

$$FOS = s/\tau$$

where "s" is the available shear strength of the soil and "τ" is the shear stress generated from gravitational forces acting on the slope mass.

A "just-stable" equilibrium condition would result in a FOS of 1.0, while an unstable condition would result in a FOS less than 1.0, implying failure is imminent or is already occurring.

For static and seismic conditions, FOS of 1.5 and 1.1, respectively, are the recommended minimums for permanent slopes that could affect adjacent structures and property. Soil properties and strength parameters, groundwater and seismic input for the slope stability model are provided in detail in the Geotechnical Engineering Report (Aspect, 2021a).

2.2.2.1 Slope Stability Results

Slope stability results are presented in Table 4 below and also shown on Figure 11. The results are presented graphically in Appendix B in the Geotechnical Engineering Report (Aspect, 2021a).

Table 4. Summary of Factor of Safety Values for Slope Stability Analysis Results

Profile	Static [1]	Seismic [2]
A-A’	2.53	1.19
B-B’	1.69	1.17
C-C’	2.01	1.14
D-D’	2.92	1.30

Notes:
1. Limit equilibrium minimum factor of safety found using Spencer’s method in SLIDE
2. Pseudostatic seismic analysis with a reduced PGA due to wave scattering from Table 2 of Geotechnical Engineering Report (Aspect, 2021a)

The results show acceptable FOS values that exceed 1.5 static and 1.1 for seismic conditions for slope stability for the mined condition within the South Parcel Project area and the adjacent Sequalitchew Creek ravine.

2.2.2.2 Effect of Reclamation of Slopes on Stability

Under a reclamation plan approved by DNR (see Section 1.1.2.6), the mine slopes would be progressively reclaimed over the life of the proposed mine development. Mine slopes will be graded to 3H:1V or flatter where groundwater seepage is expected (i.e., on the eastern and southern slopes of the Expansion Area) or flatter once the slope is no longer being mined. Slopes where groundwater is not anticipated to be present, such as along the southern boundary of the Re-Mine Area, will be graded to 2H:1V.

Backfill is not required to achieve the reclaimed configuration; however, backfill may be used to enhance reclamation and has been done elsewhere within the existing mine to improve vegetation performance. The backfill would consist of retained finer South Parcel material and imported clean fill. The proposed slope angles are flatter than the natural angle of repose of the remaining *in situ* soils and would provide the long-term erosion control and landscape base for planting. After establishment of the vegetation growth, any long-term slope stability impact to earth-related features is expected to be low. The already high stability of newly created slopes will generally increase with establishment of vegetation.

2.2.3 Erosion Potential

Due to their generally coarse-grained nature and good infiltration characteristics, the soils in the South Parcel Project area possess a low erosion risk and are generally not moisture

sensitive. The erosion potential is increased by the removal of vegetation and construction of mine slopes; however, with proper stormwater management techniques in place, even these conditions are unlikely to result in significant erosion of the coarse soils. The main area of the South Parcel Project potentially susceptible to erosion is the placement of loose topsoil for revegetation on the final cut slopes.

The Olympia Beds are finer-grained and more susceptible to erosion; however, they will not be exposed by mine activity. An approximately 10-foot-thick layer of the overlying outwash will be left in place as an operating surface for heavy equipment. This layer will protect against erosion of the Olympia Beds.

The South Parcel Project, together with the existing mine, will be excavated as a closed depression and all surface runoff will drain internally. Therefore, erosion does not have the potential to cause harm to surface water bodies or aquatic resources; however, management of erosion remains important for establishment of vegetation during reclamation, visual appearance of the slopes, and the long-term performance of the infiltration ponds. The proposed activities included in the South Parcel Project (refer to Pioneer Aggregates South Parcel Project Engineering Plan Set; Aspect, 2021b) include erosion control Best Management Practices (BMPs) consistent with Ecology's Sand and Gravel General Permit and City of Dupont requirements as defined in section 25.105.030.25 (DMC, 2021) that will reduce the potential for offsite transport of sediment.

To reduce the risk for erosion impacts to the Sequalitchew Creek ravine slopes south of the South Parcel Project area, and in general accordance with DMC 25.105.070(2), the Geotechnical Engineering Report (Aspect, 2021a) recommended maintaining at least a 50-foot buffer from the top of steep slopes. Consistent with the 2012 Settlement Agreement, the South Parcel Project includes a 100-foot buffer along the top of the slope along the Sequalitchew Creek ravine. The 100-foot buffer provides ample protection for erosion of steep slopes along with other recommended mitigation measures and BMPs in Section 2.4.

The City requires preparation of an erosion control plan per DMC 22.01.180 for all sites disturbing more than 1 acre. The erosion control plan will identify the specific BMPs to be used during and after mining for erosion and sediment control. The existing wheel wash will continue to be operated and maintained in compliance with City and Ecology requirements.

2.2.4 Steep Slope Buffer

The South Parcel Project includes a 100-foot buffer along the top of the Sequalitchew Creek ravine slope (Figure 10). This buffer exceeds that required by the DMC, which requires a 50-foot buffer between proposed development activity and hillslopes of 40 percent (22 degrees or approximately 2.5H:1V). It is also greater than the buffer recommended in the Geotechnical Engineering Report (Aspect, 2021a) and therefore provides greater protection.

2.2.5 Topsoil Removal and Replacement

Topsoil contains fines and organic material that is not suitable for construction aggregate and has physical characteristics that are not compatible with efficient use of the

equipment used to transport and process saleable materials extracted from the mine. Topsoil is also generally the most fertile part of the soil column, containing soil structure, organic matter, and microorganisms beneficial to plants and an essential component for successful reclamation of the mine.

Washington's laws governing Surface Mine Reclamation (RCW 78.44) require the conservation of topsoil as a critical component of reclaiming surface mines for future uses. The Proposed Action includes the steps typically used to conserve topsoil on aggregate mines. Topsoil would be stripped and stockpiled as the mining operation advances into the property, and topsoil would be replaced as the mined areas are reclaimed following extraction.

Past industrial activities have resulted in elevated metals concentrations in portions of the South Parcel. The Former DuPont Works Site is a cleanup site associated with historical explosives and commercial munitions facility that operated from 1909 through 1976 (Hart Crowser, 1994). The primary contaminants are arsenic and lead in surface soils. Cleanup activities were completed in 1993 to address the highest concentrations of lead, generally found along the foundations of the former buildings. Weyerhaeuser entered a Consent Decree with Ecology that required implementation of a restrictive covenant (Weyerhaeuser, 1997) limiting land use on the Former DuPont Works Site to industrial uses, which is the origin of the Manufacturing and Research Park zoning for much of the South Parcel.

In addition, the South Parcel is located within the Tacoma Smelter Plume (TSP) in an area where Ecology predicts concentrations of arsenic in surface soils may range between 40 and 100 parts per million (ppm). Ecology has established cleanup levels for properties within the TSP. The cleanup levels are conservative and support residential use. The cleanup level for arsenic in soil is 20 ppm and the cleanup level for lead in soil is 250 ppm (Ecology, 2012). As a basis for comparison, the United States Environmental Protection Agency (EPA) has established an action level of 230 ppm for arsenic and 500 ppm for lead to guide cleanup decisions in areas near the former smelter. Ecology has pre-approved certain approaches to achieve the established cleanup levels at properties within the TSP. Mixing of impacted surface soils with deeper clean soils is one of the approved approaches under the Final Interim Action Plan (Ecology, 2012).

The proposed mining and reclamation activities would serve as a permanent and final remedy for any lead- and arsenic-impacted soils within the Expansion Area. Under the Proposed Action, topsoil within the Expansion Area would be removed to facilitate extraction, and be conserved and maintained on site to be incorporated into the reclaimed mine landscape and support revegetation and reclamation of mined areas consistent with the anticipated subsequent residential land use identified in the City of DuPont Comprehensive Land Use Plan (City, 2001).

Stripping, stockpiling, and replacement of topsoil would be completed using methods and procedures that are generally the same as those used in the existing mine area, including employment of BMPs to control erosion and fugitive dust. Samples would be collected from stockpiled topsoil for each mine segment and analyzed in accordance with a Cleanup Action Plan developed for the South Parcel Project (Aspect, 2020). If the sample results indicate the topsoil does not contain arsenic in concentrations exceeding 20 ppm

(the conservative cleanup level established by Ecology for the TSP) or lead in concentrations exceeding 250 ppm, then the topsoil would be used in reclamation. If the sample results indicate the topsoil contains arsenic in concentrations equal to or greater than 20 ppm, then clean soil would be mixed with the topsoil to reduce the arsenic concentration. Stockpiled topsoil would not be used for reclamation until sample results confirm the concentrations of arsenic and lead meet cleanup criteria.

2.2.6 Effects on Geologically Hazardous Areas

The effects of the Proposed Action relative to landslide and steep slope hazards, seismic hazards and liquefaction hazards are presented below and as shown on Figure 10. Additional discussion is provided in the Geotechnical Engineering Report (Aspect, 2021a).

2.2.6.1 Landslide and Steep Slope Hazards

Landslide and Steep Slope hazards are not present within the South Parcel Project area but are present nearby in the Sequalitchew Creek ravine. The mined slopes have been designed by a geotechnical engineer and are contoured to drain away from the ravine as shown on Figure 10. The slope stability analysis shows acceptable factor-of-safety values (greater than 1.5) for each of the profiles in the Expansion Area and Re-Mine Area as shown on Figure 11. Thus, the mined slopes will not be Landslide or Steep Slope Hazards.

The Proposed Action locally reduce the expression of seeps and springs that have been observed in the ravine as shown on Figure 9, resulting in an improvement in slope stability. The Sequalitchew Creek ravine slope would also have an FOS greater than 1.5 as shown on Figure 11.

The hazard mitigation recommendations listed below in Section 2.4 are intended to protect landslide and steep slope hazards located outside of, but nearby, the South Parcel Project area.

2.2.6.2 Erosion Hazards

DMC 25.105.050 (3) defines erosion hazards as including coastal erosion zones and channel migration zones (areas along a river or stream where the channel can be reasonably predicted to migrate over time) and coastal erosion zones. Coastal erosion zones are not relevant to the Proposed Action.

The channel migration zone within the Sequalitchew Creek ravine will not be impacted by the Proposed Action. The flows from ravine springs will be reduced by the dewatering process, which will reduce the potential for channel migration.

No adverse impacts are anticipated to erosion hazards from the Proposed Action at the South Parcel or adjacent areas.

2.2.6.3 Seismic Hazards

No adverse impacts are anticipated to seismic hazards from the Proposed Action at the South Parcel or adjacent areas. The slope stability analysis for seismic condition shows acceptable factor-of-safety values (greater than 1.1) for each of the profiles in the Expansion Area, Re-Mine Area, and Sequalitchew Creek ravine.

Topography at the Expansion Area would be permanently altered as a result of mining activities. These changes are illustrated by comparing Figures 9 and 10. The proposed conditions would include finished slopes inclined at 3H:1V (33 percent) toward the interior of the existing mine (Figure 10). A 20-foot-high soil berm would be constructed with side slopes at 2H:1V (50 percent) along the south side of the Expansion Area.

The proposed finished slopes would be less steep than other areas that have been mined and reclaimed to the west. As observed during the site visit within the reclaimed mine areas, the slopes steeper than 40 percent (up to 50 percent) and the slopes along the Sequalitchew Creek Trail exceeding 60 percent are all performing well.

Groundwater is anticipated to seep from the toe of graded slopes in the east portion of the Expansion Area. The presence of seepage on slopes greater than 15 percent (proposed at 33 percent) with a potential underlying contact with lower-permeability Olympia Beds does meet the DMC criteria for landslide hazards and steeps slopes. The approximate locations of the potential Geologically Hazardous Areas are mapped on Figure 10.

In general, the proposed graded slopes of 33 percent are far below the angle of repose for sand and gravel that reduce the risk of active landslide or steep slope hazards. Slope stability analysis and mitigation for this potential hazard is provided in the following sections.

The soils are fairly homogenous across the active mine area and Expansion Area, and are expected to perform similarly in general.

There would be no Seismic Hazard Areas created, as slopes in the Expansion Area will be below the 40-percent threshold.

2.3 Effects of the No Action Alternative

Under the No Action alternative, the individual parcels that comprise the South Parcel would be developed under their existing zoning. Mining and reclamation would continue within the currently permitted footprint of the existing mine. The Kettle Wetland and its buffer would remain undisturbed.

Development of the South Parcel would likely occur over time on one or more individual parcels at a time. As each parcel is developed, it would likely be mostly logged and cleared, then graded and developed consistent with applicable zoning regulations. Logging and clearing along with the development would likely leave only a 50-foot buffer along the top of the Sequalitchew Creek ravine as authorized under the DMC rather than the 100-foot buffer required for the mine under the Settlement Agreement. Topography would be expected to remain relatively flat, with the minor topographic depressions filled to level building sites. Under the existing zoning, a portion of each parcel would need to remain vegetated, either as the existing forest or as landscaped areas.

Clearing would increase the potential for surface erosion during construction; however, standard erosion and sediment control BMPs would be sufficient to avoid adverse impacts. Future development would be required to comply with City of DuPont Sensitive Areas Code, and state and local erosion and sediment control requirements.

Development would also increase the volume of stormwater generated as permeable soils with established vegetation (forest) are replaced with the impervious areas, building roofs and pavement, and landscaped areas. Stormwater would likely be managed through infiltration, which would result in an increased volume of groundwater flow, though the change would likely be minor relative to the groundwater flow in the aquifer.

Individual development of the parcels would not be likely to address the metals-contaminated soils as comprehensively as the Proposed Action. It is more likely that capping would be used as a remedy given the lower cost compared with mixing and consistency with the likely developed condition (e.g., paved parking lots and building footprints). The use of capping as, combined with differences in parcel remediation extent and approach as individual parcels are developed separately, would likely prevent lifting of the restrictive covenants from the Former DuPont Works site and rezoning of the Manufacturing and Research Park area.

2.4 Mitigation Measures

The following mitigation measures have been included in the Proposed Action to reduce impacts on slope stability and erosion:

- Preparation and implementation of a reclamation plan under a Surface Mining Act (RCW 78.44). The reclamation plan would be submitted to DNR for review and approval prior to mining.
- Mining would occur in segments; no mass clearing of the South Parcel would occur.
- Preparation and implementation of an erosion and sediment control plan in accordance with the requirements of DMC 22.01.180 and the Sand and Gravel General Permit, a National Pollution Discharge Elimination System (NPDES) and State Waste Discharge Permit issued by Ecology that regulates stormwater management on aggregate mines. Erosion control features would include stormwater drainage into the interior of the South Parcel and on-site stormwater disposal.
- Maintenance of a vegetated buffer between the mine area and the top of steep slopes in accordance with the City of DuPont's Sensitive Areas Code [DMC 25.105.070(2)].
- Maintain the 100-foot setback from the top of slopes greater than 40 percent within the Sequalitchew Creek ravine, consistent with the conditions for the existing mine and the 1994 and 2012 Settlement Agreements.
- Earthwork for excavation and reclamation would be in accordance with the federal and state statutes of the Mine Safety and Health Act and the Surface Mining Act.
- Topsoil would be stockpiled and used for reclamation of mined areas. Consistent with the approved Reclamation Plan, the Cleanup Action Plan developed for the South Parcel Project (Aspect, 2020) and published Ecology guidance (Ecology,

2012), samples would be collected from stockpiled topsoil to confirm arsenic concentrations meet Ecology standards.

- After application of the topsoil, slopes would be revegetated by planting with trees and grass. When reclamation is complete, heavy equipment would generally not operate on the reclaimed slopes except for construction or maintenance of pedestrian paths, access roads, utilities, or other permitted facilities.
- The South Parcel would be cleared in segments corresponding to the mining plan.
- Internal drainage would be maintained during mining.
- Mine slopes would be track-walked to tamp soils and create surface roughness to encourage infiltration of stormwater on the slope.
- Mine slopes would be reclaimed with soil amendments and vegetation according to the DNR-approved Reclamation Plan.
- The existing wheel wash would continue to be used and maintained for vehicles exiting the mine.
- Settling ponds would be constructed upstream of the infiltration ponds.
- Mine slopes would be periodically inspected and repaired or revegetated to reduce erosion or improve surface stability.

2.5 Cumulative Impacts of Proposed Action and Restoration Plan

Cumulative impacts of the Proposed Action and Restoration Plan are described below.

The Proposed Action will reduce the potential for groundwater seepage and spring flow from the northern slope of the Sequalitchew Creek ravine. This will effectively reduce the potential for slope instability within the Sequalitchew Creek ravine.

Following implementation of the Restoration Plan, we anticipate higher streamflows in the Sequalitchew Creek ravine that could locally impact channel bank stability. This represents the return of channel-forming flows to Sequalitchew Creek and is a desired outcome of implementation of the Restoration Plan.

The return of higher flows is not anticipated to result in instability of the ravine side slopes because the restored flows would be similar to the flows present historically that did not impact global ravine stability. Similar flows were historically present during periods of land use disturbance in the ravine (e.g., during the period of railroad grade construction and initial logging of the ravine slope) and did not result in large-scale slope instability.

2.6 Significant Unavoidable Adverse Impacts

No significant unavoidable adverse impacts to geology and slope stability are anticipated from the Proposed Action. There are two general anticipated impacts described below; however, neither rises to the level of significant unavoidable adverse impacts:

1. Natural deposits of sand and gravel would be removed from a 313-acre area, altering the topography and leaving an irregular-shaped bowl feature where the mine operated.
2. Additional slopes would be created in an area where slopes did not previously exist, thus providing more opportunity for shallow slope instability and erosion. However, proper reclamation and erosion control measures as planned for in the Proposed Action would limit any potential slope instability and erosion impacts.

The first impact (removal of material) is significant and unavoidable, but not adverse. The second impact (creation of slopes) is unavoidable, but with the proposed mitigation is not expected to be a significant adverse impact. Therefore, no significant unavoidable adverse impacts are anticipated.

3 Groundwater

Groundwater conditions were examined to understand its occurrence in the vicinity of the Proposed Action. A groundwater monitoring network was established in 1999 and expanded in 2003 to assess aquifer parameters and water level fluctuations. The well network has been monitored approximately monthly since then, and monthly monitoring is ongoing. Table 5 lists the groundwater monitoring wells and current monitoring status. Figure 5 shows the monitoring well locations within the South Parcel, and Figure 12 shows well locations throughout the watershed. Observed groundwater level elevations are shown in time-series graphs on Figure 13. All available groundwater data were compiled and reviewed for this analysis.

Groundwater saturates the aggregate of the South Parcel Project area to within 20 feet of the ground surface. Under the Proposed Action, mining will require pumping groundwater to dewater the gravels that are currently saturated. Dewatering and removal of the aggregate will result in localized changes in groundwater elevations around the South Parcel. Under the No Action alternative, mining of aggregate above the water table will continue to occur within the existing mine without substantially influencing groundwater levels.

The foundation of the groundwater analysis is a numerical groundwater model (DuPont model) developed specifically for the project (Aspect, 2017b). The DuPont model is based on the conceptual model for the groundwater system developed from extensive analysis of project-specific borings and data, as well as compilation and review of other geologic and hydrogeologic data in the surrounding DuPont area. The hydrostratigraphic units are summarized in Table 6.

The DuPont model represents an update to previous groundwater modeling analysis developed for the South Parcel (CH2M Hill, 2003; Aspect, 2004a; Aspect, 2009a; and Aspect, 2009b). The layout of the numerical groundwater model is mapped on Figure 18. It incorporates proposed revisions to the mining plan, expansion of the model area, inclusion of seasonal and annual variability in climate and groundwater levels, and elements of the United State Geological Survey (USGS) groundwater model for the Chambers-Clover Creek watershed, including model boundary conditions and hydrogeologic layers at depth (Savoca et al., 2010; Johnson et al., 2011). The USGS groundwater model was not fully integrated with the DuPont model because the regional scale of the USGS model does not reflect the more detailed information collected for the South Parcel Project. Specifically, the regional groundwater flow direction in the shallow aquifer of the USGS model does not match local observations, the DuPont model incorporates higher stratigraphic data density in the focus area resulting from the borings and wells installed by CalPortland, and the DuPont model offers more refined wetland and surface water body discretization. The model simulates the groundwater/wetland hydraulic connection as detailed in Sections 4.6.3 and 4.6.4 of the Groundwater Model Update Report (Aspect, 2017b).

The DuPont model was first developed and calibrated to match a complete set of existing conditions measured between 2004 and 2010, and then validated to the monitoring data

collected through 2015. A representative range of wet- and dry-season conditions were observed between 2004 and 2015; observed groundwater levels since 2015 (shown on Figure 13) generally fall within this range. Calibrated aquifer parameter values are summarized in Table 6. A comparison of observed and calculated groundwater levels is provided on Figure 19.

While the groundwater model calibration is good (with calculated water levels generally following observed water levels as shown on Figure 19), model results were further refined to better address disagreement between observed and calculated water levels. Please see the Groundwater Model Update Report (Aspect, 2017b) for details on model calibration, validation, and refinement of model results. The model simulation of existing conditions formed the baseline from which changes in future groundwater levels under proposed scenarios can be measured.

Once the DuPont model was able to reliably reproduce historical conditions, the calibrated and validated model was then used to predict the changes in groundwater levels during four different steps of dewatering during the proposed mining plan. The model-calculated groundwater dewatering rates necessary to achieve the target groundwater levels within the mine are listed by step in Table 7 and based on the entire simulation period. The maximum predicted groundwater level changes for each dewatering step are provided by well in Table 8 and based on the entire simulation period. Details on the model uncertainty and the values in Table 8 are provided in Sections 5.5 and 6.5 the Groundwater Model Update Report (Aspect, 2017b).

3.1 Affected Environment

3.1.1 Primary Data Sources

Groundwater conditions in the area around the South Parcel Project have been extensively studied by Woodward-Clyde Consultants (WWC) (1991), Hart Crowser (1990 and 1991), CH2M Hill (2000 and 2003) and Aspect (2004a, 2004b, 2007, and 2017b), to name a few of the larger studies. These investigations focused primarily on concerns about impacts from Fort Lewis's Landfill 5 (WWC, 1991), water supply for the Pioneer Aggregates operations (Hart Crowser, 1991) and obtaining information on the aquifer system in the vicinity of the South Parcel Project (Aspect reports refenced above).

Borings drilled on 500-foot centers throughout the proposed mining area provide valuable data on stratigraphy and depth to water. These data and studies helped to define the occurrence and characteristics of the groundwater and the aquifers in the area of the South Parcel Project. The USGS published information on groundwater conditions in the Chambers-Clover Creek Watershed (Savoca et al., 2010; Johnson et al., 2011).

3.1.1.1 Well Data Inventory

A total of 22 wells in the vicinity of the South Parcel Project have been monitored to assess groundwater conditions, including previously existing monitoring wells and new wells installed for this project. The locations of the monitoring wells are shown on Figure 12. Table 5 presents the construction information for those wells where available.

3.1.1.2 Water Level Monitoring

Monitoring of groundwater levels began in 2000 with a series of groundwater monitoring wells installed within and around the South Parcel. Groundwater monitoring occurs monthly and the program is ongoing. The wells included in the groundwater monitoring program are listed in Table 5. Figures illustrating the groundwater monitoring data collected through September 2022 at key locations are included in Appendix B.

Groundwater levels in the Vashon Aquifer (detailed in Section 3.1.2) typically fluctuate in response to seasonal precipitation patterns and annual variations in precipitation. Figure 14 maps the groundwater level elevations inferred from observations and calculated using the DuPont model for the May 2010 time period, which represents mid-range water level conditions. Figure 15 maps the range in groundwater level fluctuations, showing both observed ranges at specific wells and model calculated ranges as contours. Groundwater levels in the central marsh area fluctuate over a limited range of 2 to 3 feet, whereas groundwater levels in monitoring well CHMW-3S, on the south end of the South Parcel, fluctuate by more than 10 feet. Monitoring conducted for the adjacent Fort Lewis Landfill 5 and DuPont Works Consent Decree area indicate groundwater level variations on the order of 10 feet (URS, 2000; URS, 2003). Seasonal variability in groundwater levels is inferred to be lower near surface water features (such as Sequalitchew Lake and the wetland complex) and greater near drainage features (such as the Sequalitchew Creek ravine and the Olympia Bed Truncation).

3.1.2 Primary Hydrogeologic Units

The primary hydrogeologic units are described in detail in the Groundwater Model Update Report (Aspect, 2017b) and are summarized in Table 6 and the sections below. Cross-section A-A' showing the sequence of hydrogeologic units on a northwest to southeast alignment is presented on Figure 16. Cross section B-B' on Figure 17 shows the hydrogeologic units on a southwest to northeast alignment crossing the Sequalitchew Creek ravine.

The South Parcel Project area lies within a thick glacial outwash sequence near Puget Sound, just north of the Sequalitchew Creek ravine, and east-southeast of the existing mine. The outwash sequence includes the surficial, coarse-grained Steilacoom Gravel flood deposits, an upper confining unit, and an older Vashon outwash. The outwash sequence overlies the low-permeability Olympia Beds (Qob) interglacial unit. The Sea Level Aquifer is composed of pre-Olympia glacial drift deposits consisting of sand and gravel.

For purposes of developing the numerical groundwater model, the Vashon Aquifer is represented by two principal zones with distinct permeabilities, separated by a relatively lower permeability zone. The upper zone is comprised of the Steilacoom Gravel, which occurs from groundwater surface to an elevation of approximately 180 to 168 feet. At that elevation, there is a lithologic change sometimes indicated by a slightly siltier zone or a slight increase in density during drilling. Below this siltier zone lies the deeper portion of the Vashon Aquifer, comprised of sand and gravel. The deeper outwash zone occurs to the depth of the Olympia Beds, which occurs at an average elevation of 110 to 120 feet.

Beneath the Olympia Beds is the regionally extensive and highly productive Sea Level Aquifer, which occurs throughout the DuPont area between elevations of roughly 50 and -100 feet relative to mean sea level. The Sea Level Aquifer is generally confined beneath the Olympia Beds aquitard and has very limited hydraulic connection with the shallower Vashon Aquifer. West of the Olympia Bed Truncation described below, the Sea Level Aquifer becomes unconfined and its groundwater merges with flow from the Vashon Aquifer in the accumulation of Steilacoom Gravel extending below mean sea level (sometimes referred to as the unconfined Sea Level Aquifer; URS, 2003). Groundwater in the Sea Level Aquifer discharges to Puget Sound via intertidal and subtidal seeps. The Sea Level Aquifer is the City of DuPont's primary water supply source (their Bell Hill wells No. 1 and No. 3 and Hoffman Hill wells No. 1 and No. 2 are completed in it [refer to Section 3.1.5]).

Below the Sea Level Aquifer and underlying aquitard unit is a deeper glacial aquifer unit, sometimes termed the Lakewood Aquifer, in which the City of DuPont's Bell Hill No. 2 well is completed. Below the Lakewood Aquifer, two deeper glacial aquifer units separated by interglacial aquitard units were observed during drilling of CalPortland's 1,000-foot-deep water well (TW-1) for the aggregate processing plant. CalPortland's well is completed in the deepest observed aquifer unit, screened between elevations of -685 and -770 feet (Hart Crowser, 1991).

3.1.2.1 Olympia Bed Truncation

The underlying Olympia Beds are absent west of a line (termed Olympia Bed Truncation) located on the order of 1,500 to 3,000 feet inland from the current Puget Sound shoreline. Steilacoom Gravel extends from ground surface to below sea level west of the Olympia Bed Truncation, where they are in contact with the Sea Level Aquifer.

The occurrence/non-occurrence of the Olympia Beds creates a unique hydrogeologic condition. Groundwater in the outwash east of the Olympia Bed Truncation is held up by the occurrence of the thick, low permeability Olympia Bed deposits. A steep hydraulic gradient occurs where the groundwater drops over this feature within the current mine site. As the groundwater flows westerly over the Olympia Bed Truncation, it drops roughly 160 feet vertically in 800 feet horizontally through the permeable gravels to near sea level. Therefore, the water table is typically found at relatively shallow depths of 15 to 25 feet below ground surface (or approximately 185 to 195 feet elevation) in the South Parcel area. West of the Olympia Bed Truncation, the water table is found at a depth of roughly 190 feet below the former ground surface (or at elevation of approximately 15 feet) in the existing mine.

3.1.2.2 Aquifer Testing

Five pumping tests were conducted in wells located along the east side of the proposed South Parcel mine expansion area to determine hydraulic properties of the outwash aquifer throughout its depth (CH2M Hill, 2000). These testing data, along with studies conducted for Fort Lewis Landfill 5 (WCC, 1991) and the Former DuPont Works site (URS, 2003), provide baseline hydraulic parameters for the Vashon Aquifer used as a starting point in development of the numerical groundwater flow model. Table 6 provides the calibrated aquifer parameters used in groundwater simulations.

3.1.3 Groundwater Elevations and Flow Patterns

Observed groundwater elevations in the South Parcel Project area are shown in timeseries graphs on Figure 13. A map with contours of groundwater level elevations for May 2010, which represents mid-range water levels during a typical transition from the high water levels of winter toward the lower water levels of summer, is shown on Figure 14. Seven other groundwater contour maps representing a range of seasonal high and low water levels and antecedent precipitation conditions are included in Appendix C.

A map showing the seasonal range in groundwater levels during wet and dry seasons is shown on Figure 15. These data show that groundwater levels have been seasonally variable with the range dependent on proximity to the wetland complex, in general.

Groundwater underlying the South Parcel Project area primarily originates from upgradient areas in western Pierce County where precipitation (as rainfall and snow) infiltrates the ground surface and forms aquifers. Infiltration from the Fort Lewis Diversion Canal also offers a continuous groundwater source. Seasonal groundwater sources include the Edmond and Bell/McKay/Hamer marsh complex, in addition to rain falling across the South Parcel Project area. Groundwater drainage features include Sequalitchew Creek, the Diversion Canal, and the wetland complex (seasonally).

The surficial Steilacoom Gravel is highly permeable and are known to rapidly infiltrate precipitation and stormwater; the veneer of topsoil covering the Steilacoom Gravel is finer grained (can contain volcanic ash) and thus has lower infiltration capacity. The gravels form a relatively flat outwash plain in the area, in the center of which is a series of large wetlands—referred to as Bell, McKay, Hamer, and Edmond Marshes (Figure 27). These wetlands occur in areas where large ice blocks, stranded during the glacial flood outbursts, later melted and formed kettle depressions lined with finer-grained, lower-permeability materials. These features store water for a much longer time relative to the rapidly infiltrating gravel outwash around these features. The wetland sediments from throughout the wetland complex were sampled and lab tested for permeability, and these data were used for simulating the wetland areas in the numerical groundwater model.

3.1.3.1 Groundwater Interaction with Wetland Complex and Lakes

Since 2000, monitoring data have been collected to understand the hydraulic connection of the groundwater system with the area wetlands and Sequalitchew Creek system (Appendix B). The monitoring data indicate hydraulic connection between surface water and groundwater through the wetland complex within the upper Sequalitchew Creek drainage. Hydraulic connection is observed by similar water elevations, fluctuations, and time-trends at paired surface water and groundwater monitoring stations. Hydraulic connection is also indicated in the middle reaches of Sequalitchew Creek where springs (groundwater) discharge to the ravine throughout most of the year. Sequalitchew Creek infiltrates water to the groundwater system in its lowermost reaches. Details of the conceptual model for the groundwater/wetland connection are provided in Section 3.2 of the Groundwater Model Update Report (Aspect, 2017b).

In Bell, McKay, and Hamer Marshes, surface water levels are typically higher than groundwater levels indicating an influx of surface water in the wet season from

stormwater generated on Joint Base Lewis-McChord (JBLM). Surface water and groundwater monitoring data from these marshes is shown in Figures B-5a through B-5c in Appendix B. In Bell Marsh (Figure B-5a), the surface water level is similar to, but slightly above groundwater level. In McKay Marsh (Figure B-5b), the surface water level was uniformly higher than groundwater until 2011, then the surface water level tracked closely with groundwater until 2019 when seasonal surface water highs started being lower than groundwater. These changes over time are interpreted as associated with removal of beaver dams at the box culvert connecting McKay Marsh to Hamer Marsh.

The relationship between groundwater and surface water in Hamer Marsh varies within the marsh. There are three groundwater wells near Hamer Marsh: MW-HM-1 on the south, SRC-MW-2 on the east, and MW-SL-1 near the Lake Outlet Area (Figure 12). Groundwater level in MW-SL-1 is 1 to 3 feet lower than the surface water level in Hamer Marsh, indicating that the marsh is recharging groundwater along the northwestern edge. On the southern edge, the groundwater level in MW-HM-1 is typically higher than the surface water level, which would result in groundwater discharge to the marsh. On the eastern side, groundwater in SRC-MW-2 is higher in winter and lower in summer. This complicated pattern in Hamer Marsh is largely driven by Sequalitchew Lake and the Diversion Canal acting as large areas of groundwater discharge.

Throughout Edmond Marsh, there is connection between surface water and groundwater; however, the connection is greater in the more easterly monitoring stations than in the west marsh area. In the central and eastern areas, stations EM-3 and EM-2 are located adjacent to roadways that, during their construction, may have excavated out the peat deposits. In addition, the creation and maintenance of a channel for Sequalitchew Creek through Edmond Marsh during the years when a fish hatchery operated in Sequalitchew Lake likely disturbed or removed portions of the peat deposits. The westernmost station EM-1 has the least amount of hydraulic connection, presumably because the underlying peat materials are still in place.

These monitoring data indicate that an influx of surface water in the wet season fills the wetland area. Beaver dams help to maintain marsh surface water levels higher than groundwater levels beneath the marshes during the wet season. During the dry season, the surface water and groundwater levels drop. In the west end of West Edmond Marsh, the groundwater level drops below the marsh bottom (i.e., it becomes perched) and the marsh completely dries each year by late spring. The west end of West Edmond Marsh is typically perched from May through October or later and is dry for most of that period. This condition is interpreted as affecting the western two-thirds of West Edmond Marsh, as water is present year-round at the staff gage west of Robinson Trail. Beaver activity in West Edmond Marsh likely defines the boundary between the areas to the west that become perched and the areas near Robinson Trail that remain in contact with groundwater year-round.

The monitoring data also indicate that the core wetland areas are generally underlain by fine-grained, low-permeability peat and silt deposits that hold water (Aspect, 2004a). Where these peat deposits occur, the amount and rate of surface water that can leak into the groundwater system due to potential future groundwater drawdown would be limited by the natural low permeability of the underlying silts and peats. In other areas, development has removed the naturally low-permeability soils from historical wetland

areas; the removal of peat and/or the natural heterogeneity of the soil materials can create an avenue for greater hydraulic connection and thus wetland response to groundwater level change.

A group of lakes (e.g., Grant Lake, Pond Lake, Old Fort Lake, and several others) are located a few thousand feet south of Sequalitchew Creek (Figure 12). Monitoring data indicates these are water table lakes whose surfaces fluctuate with the groundwater level.

3.1.4 Groundwater Quality

The unconfined Sea Level Aquifer was tested for water quality in late 1991 by Hart Crowser as part of water supply exploration work for the mine, and by Woodward-Clyde Consultants as part of Landfill 5 monitoring. In 2005, samples were collected from selected wells completed in the Steilacoom Gravel for analysis of nitrate (Aspect, 2005).

The data indicate generally good groundwater quality. Nitrate as nitrogen concentrations were below the primary standard for drinking water (i.e., the Maximum Contaminant Levels–MCLs). Secondary MCLs (based on aesthetics) for drinking water were exceeded for iron and manganese. Hart Crowser (1991) indicated it to be a regional phenomenon as it was seen in other wells in the area.

During permitting of the existing mine, there was a concern about water quality because the mine was downgradient of Landfill 5, a portion of which had been listed as a Superfund Site. Since that time, the landfill was closed in accordance with applicable laws and regulations and removed from the Superfund Site listing in 1992, with a Record of Decision that indicated “no further remedial action required”. During subsequent groundwater quality monitoring conducted in wells located in and around the landfill, iron and manganese generally exceeded secondary drinking water quality standards in several of the downgradient monitoring wells. In 2010, iron and manganese exceeded standards in several of the upgradient monitoring wells as well. No other drinking water standards were exceeded in the monitoring wells downgradient of the landfill (Versar, 2011).

The City of DuPont and the South Parcel are within an area of the Tacoma Smelter Plume for which Ecology has determined the predicted arsenic concentrations (less than 200 ppm) are unlikely to pose a threat to groundwater (Ecology, 2012).

3.1.5 Drinking Water Supplies

There are two significant public water supplies in the general area: the City of DuPont’s and JBLM’s. The characteristics of these water supplies are described below.

3.1.5.1 City of DuPont

The City of DuPont uses six wells for its municipal water supply. The closest water supply wells to the South Parcel Project are Bell Hill Wells No. 1, No. 2, and No. 3, located on Bell Hill roughly 1 mile south-southeast (regionally upgradient) of the South Parcel. The Bell Hill No. 1 and No. 3 wells are completed in the deep confined Sea Level Aquifer beneath the Olympia Beds. The Bell Hill No. 2 well is completed in a still-deeper confined aquifer. The City’s Hoffman Hill wells No. 1 and No. 2 are located more than 1 mile southwest of the South Parcel and are also completed in the Sea Level Aquifer. Each of the City’s water supply wells withdraw groundwater from deep confined aquifers that

are hydraulically isolated from surface influence and are at locations hydraulically upgradient (Bell Hill) or cross-gradient (Hoffman Hill) of the Proposed Action.

The City of DuPont holds water right authorizations to withdraw up to 5,390 gallons per minute (gpm), and 3,360 acre-feet per year. In 2020, the City's actual water production was 1,359 acre-feet. The City has a pending water right application with a priority date of December 15, 2004, on file with Ecology. The proposed source for the new water right is two future wells to be situated near Center Drive within the NW ¼ NE ¼ of Section 35, T. 19 N., R. 1 E.W.M. and/or the SE ¼ SW ¼ of Section 26, T. 19 N., 1 E.W.M. These locations in the general vicinity of Grant Lake or Pond Lake, respectively. The wells will withdraw water from the Sea Level Aquifer. As with the existing wells, the City's proposed new wells will be constructed in a unit that is hydraulically isolated from surface influence and upgradient.

The City has additionally filed an Application for Change of Water Right (G2-GWC 170@2) requesting that a portion of Water Right Certificate 170 be transferred to the Hoffman Hill wells. This change would result in an increase of 450 gpm, and 320 acre-feet of water that could be produced from the Hoffman sources.

3.1.5.2 Joint Base Lewis-McChord

JBLM receives most of its water supply from Sequalitchew Springs (see Section 3.1.6.1), which are reported to yield as much as 9,000gpm, or approximately 20 cubic feet per second. Other portions of JBLM are supplied by groundwater wells that range widely in depth and are completed in all three of the area's major aquifer.

JBLM's legal access to water is embedded in the base's federal status as a military base, as such it is allowed to access water for the base's primary purposes which includes the drinking water system that serves its population. Sequalitchew Springs generally provides more flow that needed by JBLM for water supply.

3.1.6 Springs

There are three identified sets of springs in the general vicinity of the South Parcel Project, including Sequalitchew Springs at the east end of Sequalitchew Lake (on JBLM), springs along the Sequalitchew Creek ravine, and intertidal springs observed along the shoreline of Puget Sound. Each set of springs is described below.

3.1.6.1 Sequalitchew Springs

The Sequalitchew Springs are located on the eastern shore of Sequalitchew Lake, just west of American Lake and are formed where the water table between American Lake and Sequalitchew Lake intersects ground surface. American Lake is maintained at an elevation of approximately 224 feet through an overflow channel near Sequalitchew Springs, and Sequalitchew Lake is maintained at an elevation of approximately 211 feet controlled by a weir at the west end of the lake.

As mentioned above, Sequalitchew Springs are the principal water supply for JBLM. Most of the time the springs provide more flow than needed by JBLM for water supply, resulting in surface water outflow from Sequalitchew Lake passing over the Diversion Weir and into the Diversion Canal. There are periods, typically in dry summers, when spring flow is fully consumed by JBLM and no water flows over the Diversion Weir. The periods occurred approximately 7.7 percent of the time during the monitoring period as

described in Section 4.5.3.1. The DuPont model tracks overflow from Sequalitchew Springs.

3.1.6.2 Springs in Sequalitchew Creek Ravine

Groundwater discharges from the Vashon Aquifer as springs in the Sequalitchew Creek ravine below elevations of approximately 195 feet down to the top elevation of the Olympia Bed deposits at elevation between approximately 100 to 120 feet, which spans a creek reach of approximately 0.7 miles. These springs provide baseflow to Sequalitchew Creek. Based on stream gaging data, this groundwater discharge to the creek varies between approximately 0.5 cubic feet per second (cfs) in the summer to 1.5 cfs in the winter. Progressing downstream past the Olympia Bed Truncation, Sequalitchew Creek becomes a losing stream as the water table drops through the outwash to near sea level.

3.1.6.3 Intertidal Springs

Springs are located at multiple points along the shoreline of the Nisqually Reach. Two springs are located along the beach just north of the Sequalitchew Creek estuary and directly west of the area of the proposed South Parcel mine development (Figure 27). The largest of these springs, the Large Spring, was reported to flow between 11 and 18 cfs based on monthly data collected by the USGS in 1942. Spot measurements by CH2M HILL in 1999 and 2000 indicated flows of 9.1 and 14.9 cfs, respectively (CH2M HILL, 2001). The makeup of the water (saltwater versus freshwater) discharging from the springs is influenced by tidal stage and season. The sources of freshwater to the intertidal springs are summarized in Table 9. It is estimated that the Vashon Aquifer contributes up to approximately 15 percent of the intertidal spring discharge and the Sea Level Aquifer contributes up to approximately half of the intertidal spring discharge, with the remainder being salt water (Aspect, 2015; Aspect, 2004b).

Table 9. Sources of Water to the Intertidal Springs

Source	Estimated Percentage of Intertidal Spring Flow
Vashon Aquifer	0–2 - 14
Sea Level Aquifer	0–8 - 49
Puget Sound	–6 - 99

3.2 Effects of the Proposed Action

3.2.1 Groundwater Elevations and Flow Patterns

The groundwater table will be significantly lowered in the vicinity of the South Parcel Project area as a result of the dewatering activities included in the Proposed Action. Following calibration and validation, the DuPont model was used to predict decreases in groundwater levels during the four sequential future steps of proposed dewatering and mining activity in the South Parcel. A summary of the model predictions for all four dewatering steps is shown on Figure 20. As described in Section 4.6.5, dewatering Steps

1, 2, and 3 simulated 10, 24, and 66 active dewatering wells, respectively. Step 4 simulated the post-mining condition with pumping terminated and groundwater passively discharging at the toe of the newly mined slope. For direct comparison with baseline model results, predictive models used the same baseline boundary conditions as the validation model, except for pumping at active dewatering wells or drainage at the toe of the newly mined slope.

Model results indicate that pumping rates will equilibrate within 1 month, and water levels will largely equilibrate within 60 days, of a change in pumping rates. Baseline groundwater levels are sensitive to seasonal and longer-term precipitation patterns (e.g., see Figure 9 in the Groundwater Model Update Report [Aspect, 2017a]), and groundwater levels during the four dewatering phases are predicted to likewise remain sensitive to precipitation patterns.

Results of the predictive models are discussed below by dewatering phase, in terms of predicted decreases in groundwater levels compared to baseline conditions. To support the discussion, predicted decreases in groundwater levels are presented in a table, graphs, and maps.

3.2.1.1 Future Mining Step 1: Initial 10-well Dewatering Test

Step 1 dewatering will include 10 active wells located in the northern portion of the South Parcel, as shown on Figure 21. To simulate Step 1, the validated model was modified by adding 10 wells screened across the Steilacoom Gravel and Vashon Recessional Outwash. Wells were simulated to pump up to 1 cfs each unless the available drawdown in the well limited the pumping rate. After the first month of pumping all 10 wells, the combined pumping rate is predicted to be approximately 3.6 cfs, on average, and up to approximately 5.5 cfs during the wet season. See Table 7 for average monthly, overall average, and minimum and maximum dewatering rates.

Groundwater level decreases are predicted to stabilize within approximately 60 days after pumping starts based on model results. During Step 1, the model-predicted decreases in groundwater levels shown on Figure 22 are most evident at monitoring wells CHMW-2S and CHMW-2D, which are the closest monitoring wells to the proposed location of the Step 1 dewatering wells. At more distant monitoring wells, the predicted groundwater level decreases are less than half the observed range in baseline groundwater levels.

Table 8 lists the maximum decrease in groundwater level at each well during Step 1. For the purposes of communicating refined model results, we focus on the values on the left half of Table 8, which are the maximum decreases in groundwater level without including model uncertainty. The maximum groundwater level decrease at CHMW-2D is predicted to be approximately 8.8 feet, which is more than half the range in observed water levels during baseline monitoring. The maximum groundwater level decrease at upgradient monitoring well MW-D-3 (adjacent to the Diversion Canal east of the mine expansion) is predicted to be approximately 1.8 feet. The maximum groundwater level decrease at monitoring wells MW-EM-1D and MW-EM-2D (in Edmond Marsh) is predicted to be approximately 0.5 foot and 0.1 foot, respectively. Note that the maximum predicted groundwater levels changes shown on Figure 22 at individual wells reflect the incorporation of model uncertainty and correspond with the values presented in the righthand columns of Table 8.

During Step 1, little or no effects on wetlands or groundwater discharge to Sequalitchew Creek were predicted by the model (see Figure 21 in the Groundwater Model Update report [Aspect, 2017b]). The overall average wetland infiltration rate is predicted to remain similar to baseline conditions. The predicted average rates of wetland infiltration to groundwater, and discharge from wetland to surface water, are similar to baseline conditions. The timing of net wetland flow (wetland infiltration to groundwater plus discharge from the wetland to surface water) is predicted to be approximately the same as baseline conditions. During Step 1, the JBLM water supply overflow showed no significant change in flow rates compared to baseline conditions.

3.2.1.2 Future Mining Step 2: Active Dewatering in Preparation for Mining

During Step 2, the dewatering well network will be expanded to the south along the South Parcel mine perimeter as well as adding a few wells in the interior as shown on Figure 21. To simulate Step 2, the validated model was modified by adding 24 wells screened across the Steilacoom Gravel and Vashon Recessional outwash. The dewatering wells are arranged in two lines on either side of the initial mine trough, with 19 boundary wells and 5 inner wells. Wells were simulated to pump up to 1 cfs each unless the available drawdown in the well limited the pumping rate. After the first month of pumping all 24 wells, the combined pumping rate is predicted to be approximately 5.2 cfs, on average, and up to approximately 8.8 cfs during the wet season as shown in Table 7.

Groundwater level decreases at upgradient monitoring wells are predicted to stabilize within approximately 60 days after pumping starts based on model results. As shown in Table 8 and on Figure 23, the maximum groundwater level decreases during Step 2 at CHMW-2D and CHMW-1 are predicted to be approximately 45 feet and 5.2 feet, respectively. At this step, monitoring well CHMW-2D will be interior to the dewatering well network. The maximum groundwater level decrease at upgradient monitoring well MW-D-3 is predicted to be approximately 4.3 feet. The maximum groundwater level decreases at MW-EM-1D and MW-EM-2D are predicted to be approximately 1.5 feet and 0.2 feet, respectively. The maximum predicted groundwater levels changes shown on Figure 23 at individual wells reflect the incorporation of model uncertainty and correspond with the values presented in the righthand columns of Table 8.

During Step 2, the predicted overall wetland infiltration rate will be approximately 0.2 cfs greater than baseline conditions, assuming wetland water levels are maintained (see Figure 21 in the Groundwater Model Update Report [Aspect, 2017b]). Most of the predicted changes in infiltration will occur in the East Edmond Marsh area. The predicted timing of net wetland flow will remain approximately the same as baseline conditions. Groundwater discharge to Sequalitchew Creek during Step 2 is predicted to remain similar to baseline conditions. During Step 2, the JBLM water supply overflow showed no significant change in flow rates compared to baseline conditions.

3.2.1.3 Future Mining Step 3: Active Dewatering During Mining

Step 3 dewatering was simulated with 66 active wells along the eastern and southern South Parcel mine boundary, as shown on Figure 21. The dewatering wells are arranged in two lines on either side of the initial mine trough, with 54 boundary wells and 12 interior wells. The combined pumping rate is predicted to be approximately 6.9 cfs, on

average, and up to approximately 12.2 cfs during the wet season as shown in Table 7. It may not be necessary to operate all dewatering wells as the mine trough progresses once an alternative (passive) dewatering system is in place. However, for the purposes of evaluating the maximum effects of dewatering during Step 3, the DuPont model simulated all dewatering wells operating simultaneously as a conservative assumption.

Groundwater level decreases are predicted to stabilize within approximately 60 days after pumping starts, based on model results. The maximum predicted decreases summarized in this paragraph are shown in the Step 3 column on the left side of Table 8. The maximum groundwater level decreases during Step 3 at CHMW-2D, CHMW-1, CHMW-4D, and CHMW-3D are predicted to be approximately 51 feet, 60 feet, 15 feet, and 57 feet, respectively. The maximum groundwater level decreases at MW-EM-1D and MW-EM-2D are predicted to be approximately 5.1 feet and 0.4 feet, respectively. The maximum groundwater level decreases at upgradient monitoring wells MW-D-3 and MW-93-MFS-C-5 are predicted to be approximately 7.7 feet and 4.2 feet, respectively. The groundwater levels during Step 3 are predicted to be approximately 10 to 20 feet above the Olympia Beds along the mine trough. The maximum predicted groundwater levels changes shown on Figure 24 at individual wells reflect the incorporation of model uncertainty and correspond with the values presented in the righthand columns of Table 8.

During Step 3, the predicted overall wetland infiltration rate will be approximately 0.6 cfs greater than baseline conditions, assuming wetland water levels are constant (see Figure 21 in the Groundwater Model Update Report [Aspect, 2017b]). Most of the predicted changes in infiltration will occur in the East Edmond Marsh area. Based on model results, the lower groundwater levels under West Edmond Marsh will reduce groundwater discharge to surface water during Step 3. Groundwater discharge to Sequalitchew Creek during Step 3 is predicted to be 83 percent less than baseline conditions, on average, with the greatest decreases during the dry season. As with Steps 1 and 2, the JBLM water supply overflow showed no significant change in flow rates in Step 3 compared to baseline conditions.

3.2.1.4 Future Mining Step 4: Post-Mining Conditions

During Step 4, pumping from the dewatering well network will cease, and groundwater will emanate from the toe of the mined slope. Groundwater emanating from the southern portion of the slopes will be collected and conveyed to provide the primary water source for a constructed wetland in the southwest corner of the existing mine. Groundwater seeping from the toe of the northern slopes will be collected and conveyed to an infiltration pond on the floor of the existing mine. Overflow from the wetland will flow to this same infiltration pond. The Step 4 ground surface (model top) elevation was modified to reflect the final mine grade to simulate passive groundwater discharge into the mine. The flow rate of groundwater discharging into the mine is predicted to be 6.9 cfs, on average, and up to 13.7 cfs during the wet season. Collected groundwater discharging into the mine will be re-infiltrated in the western portion of the mine area. The re-infiltration of collected groundwater seeping into the mine will recharge the Sea Level Aquifer and will not affect groundwater levels in the Vashon outwash aquifer. As such, re-infiltration was not simulated in the DuPont model.

Groundwater levels within the Vashon aquifer are predicted to recover slightly relative to the active pumping of Step 3. Those changes within the Vashon aquifer are predicted to stabilize within approximately 60 days after pumping stops based on model results. As shown in Table 8, the maximum groundwater level decreases at monitoring wells along the mine trough (CHMW-2D, CHMW-1, CHMW-4D, and CHMW-3S), are predicted to be approximately 32 feet, 30 feet, 14 feet, and 50 feet, respectively. The maximum groundwater level decreases at upgradient monitoring wells MW-D-3 and MW-93-MFS-C-5 are predicted to be approximately 6.6 feet and 3.6 feet, respectively. The maximum groundwater level decreases at MW-EM-1D and MW-EM-2D are predicted to be approximately 4.7 feet and 0.4 feet, respectively (see Figure 25). The maximum predicted groundwater levels changes shown on Figure 25 at individual wells reflect the incorporation of model uncertainty and correspond with the values presented in the righthand columns of Table 8. Figure 20 presents the calculated groundwater level elevations, the monthly ranges in calculated water levels, and the monthly change in calculated water levels. Model uncertainty is graphically presented by the error bars on Figure 20.

During Step 4, the predicted overall wetland infiltration rate will be approximately 0.5 cfs greater than baseline conditions, assuming stream restoration efforts maintain wetland water levels (see Figure 21 in the Groundwater Model Update Report [Aspect, 2017b]). Most of the predicted changes in infiltration will occur in the East Edmond Marsh area. Based on model results, the lower groundwater levels under West Edmond Marsh during Step 4 will reduce groundwater discharge to surface water. Groundwater discharge to Sequalitchew Creek during Step 4 is predicted to be 79 percent less than baseline conditions, on average, with the greatest decreases during the dry season.

During Step 4, the JBLM water supply overflow showed no significant change in flow rates compared to baseline conditions.

3.2.1.5 Comparison of Water Levels during Mining Steps 1 through 4

Figure 20 provides a collection of graphs comparing groundwater levels (elevations) for each dewatering step by monitoring well. The upper graphs on Figure 20 compare time-series of baseline groundwater levels and predicted groundwater levels for each of the four dewatering phases. The lower ends of the whiskers illustrate the minimum groundwater levels including model uncertainty.

The middle graphs on Figure 20 show the ranges in monthly groundwater level elevations for baseline conditions and each of the four dewatering phases. The color bars reflect the potential effects of annual hydrologic variability. The lower ends of the whiskers illustrate the minimum groundwater level including model uncertainty.

The lower graphs on Figure 20 show the range in monthly groundwater levels decrease from baseline for each of the four dewatering steps. The color bars reflect the potential effects of annual hydrologic variability. The lower ends of the whiskers illustrate the minimum groundwater level including model uncertainty.

During Step 3, it likely will not be necessary to continue operating all of dewatering wells as the mine trough progresses. As the passive groundwater conveyance ditches are installed in areas mined earlier, the wells upgradient of these areas can be turned off

allowing groundwater to passively discharge from the toe of the mined slope. However, for the purposes of evaluating the maximum possible effects of dewatering during Step 3, the DuPont model simulated all dewatering wells operating simultaneously as a conservative assumption.

3.2.1.6 Model Uncertainty

The DuPont model validation timeframe was 11 years, including a 6-year calibration timeframe. This is a longer calibration and validation timeframe than typically incorporated in similar groundwater models. By comparison, the USGS model calibration timeframe was 2 years with no validation timeframe.

Model uncertainty for the DuPont model results was calculated as the 95-percent confidence interval using the 1-tailed test and the well-specific standard deviation of residuals from the residual statistics for the entire 11-year model validation period. For predictive model results, the 95-percent confidence interval was increased proportional to the average water level decrease at that location. Additional discussion of model uncertainty is provided in Section 6.5 of the Groundwater Model Update Report (Aspect, 2017b).

Model uncertainty was incorporated into predictions of the minimum groundwater levels for each month in each dewatering Step. These values are shown in Table 10 and are used as thresholds in the Monitoring Plan (Aspect, 2017a) for triggering the adaptive management process during dewatering. A similar approach was also used for calculating the groundwater levels with mining used in the marsh water balances described in Section 4.2.3.2.

3.2.2 Groundwater Quality

Groundwater quality in the South Parcel Project area will not be significantly affected if BMPs are responsibly implemented throughout the Proposed Action. Groundwater quality impacts are rare at properly managed aggregate mining sites. The principal concern relates to the direct access to highly permeable aggregate materials. Current mining permits require that best management practices include implementation of stormwater pollution prevention, spill control and cleanup procedures, frequent monitoring of stormwater quality, and management of operations to minimize the use of materials in the mine that could generate potential contaminants.

3.2.2.1 Dewatering

Dewatering is not anticipated to have an impact on upgradient water quality. Installation, operation, and decommissioning of dewatering wells, pumps, conveyance lines, and supporting infrastructure will be conducted in accordance with the mine plan to protect both surface water and groundwater resources. Dewatering will not introduce new potential sources of groundwater contamination. Engineering controls at nearby JBLM Landfill 5 (including landfill gas collection and treatment from a lined and covered landfill) will not be affected by water level decreases from dewatering. For existing or future upgradient sources, the steeper hydraulic gradient associated with groundwater level declines will accelerate groundwater velocity before the groundwater enters the dewatering system. Groundwater captured by the dewatering system will be thoroughly mixed before being discharged to constructed wetlands or ponds for infiltration.

3.2.2.2 Chemical Spills, Leaks, and Drips within the Mine

Spills, leaks, and drips of chemical products are not typically a significant groundwater quality concern for mining sites like the South Parcel Project because of the limited use of chemicals, and small number of heavy equipment operating in a large area. Petroleum products (diesel fuel, motor oil, and hydraulic fluid) used to operate the mining equipment are the only chemical constituents used within the mining area and mining companies are uniquely able to excavate and contain small spills because heavy equipment is always on site. Thus, in the event of a spill they can quickly excavate contaminated soil and contain it in the bed of a dump truck.

To assess the risk of an accidental fuel spill from a piece of mining equipment, numerical modeling was performed using the EPA Hydrocarbon Spill Screening Model (HSSM). The model was setup to evaluate a reasonable thickness for an unsaturated soil buffer zone that would protect the groundwater should an accidental release of petroleum hydrocarbons occur on the floor of the existing mine. This is a conservative assumption because the mining of the South Parcel Project will occur in areas underlain by the lower permeability Olympia Beds, which are much less conducive to transport of spilled hydrocarbons. The modeling evaluated the migration of light, non-aqueous phase liquids (LNAPL) through the unsaturated zone to the water table. This modeling analysis was conducted for equivalent mining conditions during permitting for the North Parcel mine expansion, and the HSSM model setup and results for that permitting process (Aspect, 2013) are adopted here.

HSSM model results indicate it would take approximately 3 days for a release of 500 gallons of diesel to migrate to a depth of 5 feet below the base of the active aggregate mine. If a scenario existed where the spill was not cleaned up, the modeling indicates the diesel front would reach a depth of 8.5 feet in 30 days, and a depth of 10 feet in 89 days. It is unlikely that a full diesel tank would rupture. In accordance with the mine's Spill Response Plan, required under the Sand and Gravel General NPDES/SWD permit, any spills would be cleaned up immediately so it is unlikely that a spill would go without a cleanup response for more than 1 day.

3.2.3 Drinking Water Supplies

Drinking water supplies identified near the South Parcel Project area will not be significantly affected by the Proposed Action. Figures 22 through 25 show little to no effect on groundwater conditions in the unconfined aquifer at the southwestern model boundary. Based on the proximity of the City of DuPont water supply wells to the model boundary condition, and the completion of those wells in the Sea Level Aquifer, we anticipate no effect of the Proposed Action on groundwater conditions at these water supply wells.

JBLM's water supply at Sequalitchew Springs would also not be affected by the Proposed Action. Figures 22 through 25 show the drawdown effects of dewatering and post-mining condition do not extend to Sequalitchew Springs or its source American Lake. The model calculates a decrease of approximately 0.03 cfs (15 gallons per minute) in overflow from Sequalitchew Springs to Sequalitchew Lake, which is small relative to the 10 cfs outflow (on average) from the lake measured at the Diversion Weir. While

there would be a minor decrease in the overflow volume, the amount withdrawn for water supply would not be affected.

3.2.4 Springs

The predicted effects of the Proposed Action on spring flow in the vicinity of the South Parcel Project vary. The following sections describe the predicted effects on Sequalitchew Springs, the spring along Sequalitchew Creek ravine, and intertidal springs observed along the shoreline.

3.2.4.1 Sequalitchew Springs

As described above, the model predicts no effect of the Proposed Action on the water supply from Sequalitchew Springs. Figures 22 to 25 show the drawdown effects of dewatering and post-mining condition do not extend to the east end of Sequalitchew Lake or the Springs' source, American Lake.

3.2.4.2 Springs in Sequalitchew Creek Ravine

The model predicts that the Proposed Action will decrease flow rates from some of the springs in Sequalitchew Creek ravine. The affected springs in Sequalitchew Creek ravine are those sourced by the Vashon Aquifer where dewatering and the post-mining condition results in lower groundwater levels.

3.2.4.3 Intertidal Springs

The model predicts that the Proposed Action will not have a significant impact on intertidal springs flows because there is no consumptive use of groundwater as water produced during dewatering and the post-mining condition is reinfiltrated within the mine upgradient of these springs. Because the total quantity of groundwater flowing westward from the re-infiltration pond area would not change, the Proposed Action would not markedly change the makeup of water (freshwater versus saltwater) discharging from the intertidal springs, which is controlled primarily by tidal stage and season (Aspect, 2015, included in Appendix D; Aspect, 2004b).

3.3 Effects of the No Action Alternative

Under the No Action alternative, the individual parcels that comprise the South Parcel would most likely be cleared and developed for manufacturing and research and/or residential land use based on existing land use and zoning designations, as detailed in Section 1.2.

Manufacturing and research and residential development would replace vegetated areas with impervious surfaces, which decreases evapotranspiration and increases stormwater runoff. Assuming that all stormwater is infiltrated, given the porous surficial soils, there would be an increase in groundwater recharge. Any water obtained from the City of DuPont water supply and used within the future South Parcel developments for irrigation or other outdoor purposes could also increase recharge.

Risks to groundwater quality in the South Parcel would increase during future development; however, a 10- to 20-foot-thick unsaturated zone of sand and gravel would remain, providing some protection for the aquifer.

3.4 Mitigation Measures

Mitigation measures have been included in the Proposed Action to reduce impacts to groundwater quantity and quality:

- Steps 1 and 2 of the Dewatering Plan are completely reversible and allow for real-world testing of the groundwater model predictions and impacts to groundwater quantity at scale.
- The Dewatering Plan is structured to begin dewatering at the locations furthest from sensitive receptors, then slowly proceed closer only if the changes in groundwater are consistent with predictions.
- The Monitoring Plan details a series of adaptive management actions during each step of dewatering to monitor water levels, assess results by comparing with predictions, and take corrective actions, if necessary. Dewatering would not proceed if impacts to groundwater are not consistent with predictions.
- The Sequalitchew Creek Watershed Restoration Plan would mitigate for the impacts of the Proposed Action on Edmond Marsh and flows in Sequalitchew Creek (see Section 4).
- Re-infiltration of collected groundwater within the floor of the existing mine preserves the flow to the intertidal springs.
- Erosion and sediment controls and stormwater treatment, described in the Geology and Surface Water sections respectively, would protect groundwater quality and long-term performance of the proposed infiltration ponds.
- Revegetation of the proposed mine slopes and floor as a part of reclamation would stabilize soils and reduce effects on quantity and timing of groundwater recharge.

3.5 Significant Unavoidable Adverse Impacts

3.5.1 Groundwater Elevations and Flow Patterns

The unavoidable impact of the Proposed Action's dewatering and post-mining condition is that the groundwater table will be lowered in the vicinity of the South Parcel Project. Edmond Marsh is located closest to the South Parcel Project. At the center of Edmond Marsh, the model-predicted maximum decreases in groundwater levels are 0.52 feet, 0.63 feet, 0.87 feet, and 0.84 feet during mining Steps 1, 2, 3, and 4, respectively. For the entire wetland complex, seepage rates to groundwater will increase 0.0 cfs, 0.2 cfs, 0.6 cfs, and 0.5 cfs during dewatering Steps 1, 2, 3, and 4, respectively, based on DuPont model results.

3.5.2 Groundwater Quality

No significant unavoidable adverse impacts on groundwater quality are anticipated if best management practices are responsibly implemented throughout the Proposed Action. Best management practices include implementing stormwater pollution prevention, spill

control and cleanup procedures, monitoring stormwater quality, and managing operations to minimize the use of materials in the mine that could generate potential contaminants.

3.5.3 Drinking Water Supplies

No significant unavoidable adverse impacts from the Proposed Action to the drinking water supplies of the City of DuPont or JBLM are anticipated, as the wells and springs tapped for supply either withdraw water from a different aquifer or are outside the area that would be affected by dewatering.

3.5.4 Springs

The Proposed Action will cause no significant unavoidable adverse impacts to flows at Sequalitchew Spring or at the intertidal springs. The Proposed Action will cause significant unavoidable adverse impacts to some springs and seeps in the Sequalitchew Creek ravine as the water table is lowered during dewatering and during the post-mining condition.

4 Surface Water and Stormwater

The effects of the South Parcel Project on surface water hydrology were evaluated from three perspectives:

1. The effects within the South Parcel Project resulting from mining activities, which generally focused on stormwater management and changes in the site water balance
2. The effects of mine dewatering on Sequalitchew Creek and the upgradient watershed
3. The cumulative effects of mining and watershed restoration on the creek and marshes.

Within the South Parcel Project area, existing conditions were examined through several site reconnaissance visits, hydrologic modeling, and compilation of other available data sources (climatic data, NPDES discharge data, etc.) Proposed conditions were simulated using the same hydrologic model to simulate the proposed changes in land use and the stormwater management system.

Within the broader Sequalitchew Creek watershed, the understanding of existing conditions is based primarily on monitoring data collected monthly from staff gages, wells, and flow monitoring stations since 2004. These data inform the groundwater analyses discussed in Section 3 as well as a marsh water balance model used to predict effects on the marshes and Sequalitchew Creek. This water balance model is used for predicting the effects of mining alone and the cumulative effects with watershed restoration.

4.1 Affected Environment

4.1.1 Climate

The existing mine and proposed South Parcel Project are located on the eastern shoreline of Puget Sound and experience the mild marine climate typical of the Puget Sound region. Average temperatures are typically in the mid-50s to upper 70s (in degrees Fahrenheit) during the summer months, and mid-30s to upper 40s during the winter months (Figure 26).

Precipitation tends to fall predominantly as rain with occasional snowfall during winter storms. The closest long-term precipitation gage to the North Parcel is Tacoma Public Utilities' McMillin Reservoir station (NCDC COOP ID# 455224) located about 20 miles northeast of the North Parcel. Beginning in January 2013, the McMillin Reservoir weather station became less reliable as measurements were not taken as frequently and there are significant data gaps. After that date, the best available precipitation data is from the Oregon State University's Parameter Regression against Slopes Model (PRISM), which spatially interpolates between weather station observations, accounting for elevation and aspect among other factors. A timeseries of daily precipitation data for the

McMillin Reservoir location was used to extend the precipitation record beyond December 2012.

Average annual precipitation from the combination of the McMillin Reservoir observations and the PRISM timeseries for the same location from 1941 to 2021 was 41.58 inches. Monthly precipitation totals vary from around 6 inches per month in November through January down to around 1 inch per month in July and August, as shown on Figure 26.

The potential for evaporation was estimated using long-term pan evaporation data from the Puyallup 2W Experimental Station (NCDC COOP ID# 456803) from 1931 to 1995. The Puyallup station was one of few long-term evaporation stations in the Puget Sound region until it ceased operations in 1995 and historical data from that station is often used for representing evaporation in the region. Mean annual pan evaporation measured at the Puyallup station was 28.7 inches for the period of record. Applying a pan coefficient of 0.8 (NOAA, 1982), converts the measured pan evaporation into potential evaporation of 23 inches per year.

Precipitation from McMillin Reservoir and potential evaporation based on Puyallup 2W Experimental Station are the key climatic inputs into the hydrologic model used to simulate hydrology within the South Parcel Project and the water balance model used to evaluate the marshes and Sequalitchew Creek under existing and proposed conditions

4.1.2 Surface Water Features

This section provides a description of the surface water features within the South Parcel Project area and existing mine, then within the Sequalitchew Creek watershed.

4.1.2.1 South Parcel Project Area and Existing Mine

The Kettle Wetland is the only notable surface water feature within the South Parcel Project area (Figure 27). Generally, the coarse recessional outwash soils present within the South Parcel and Existing Mine result in rapid infiltration of precipitation, so no surface water features form from rainfall and runoff.

The Kettle Wetland is a 1.78-acre wetland located within a glacial kettle in the Expansion Area, outside of the mining limits of the existing mine. Kettles form during glacial retreat, where glacial meltwater deposits its river-borne sediments around a large block of stranded glacial ice. When the ice block eventually melts, the kettle is left in the former footprint of the ice block as a closed topographic depression. The kettle where the Kettle Wetland formed is deep enough that it encounters the Vashon Aquifer, and the hydrology of the Kettle Wetland is driven by the seasonal fluctuations of the Vashon Aquifer. There are no tributaries or other surface water inputs to the Kettle Wetland. The Kettle Wetland is described in additional detail in the Plants and Animals Technical Report (Anchor QEA, 2022).

No streams or natural drainage channels were identified within the South Parcel Project area during site reconnaissance or on the DNR Forest Practices Application Mapping Tool (DNR, 2022) for the area.

Stormwater drainage features are present within the existing mine, particularly in the area of active backfill on the floor of the existing mine. CalPortland incorporates infiltration

facilities consisting of curtains of coarse rock to infiltrate stormwater and encourage drainage from backfilled areas. Ditches and small infiltration areas are also present in other portions of the existing mine. Generally, precipitation infiltrates within the mine without requiring significant stormwater infrastructure.

A kettle in the southeast corner of the North Parcel is used by CalPortland as an infiltration pond for discharge of treated process water from their water treatment system under Sand and Gravel General Permits #501178 and #501406, which permit discharges from the aggregate wash plant and concrete batch plant, respectively. This kettle is located west of the Olympia Bed truncation and does not encounter groundwater. It is not a wetland and would be dry if not for its use as an infiltration facility.

4.1.2.2 Sequalitchew Creek Watershed

The South Parcel Project is located within the Sequalitchew Creek subbasin of Water Resource Inventory Area (WRIA) 2–Chambers-Clover Watershed. The Sequalitchew Creek watershed is relatively complex because of the interaction between groundwater and surface water. The dominant features of the watershed are flat terrain, coarse outwash soils, and a series of wetlands and lakes that have formed in depressions and areas of lower permeability soils left by the receding glaciers.

Figure 27 presents an overview of the multiple waterbodies and channels located in the Sequalitchew Creek watershed. Geologic cross sections of Edmond Marsh and Bell, McKay, and Hamer Marshes are shown on Figures 28 and 29, respectively. Water surface elevations within the Sequalitchew Creek watershed are primarily understood through a monthly monitoring program that has been ongoing since 2004. Surface water monitoring locations are shown on Figure 12 and are summarized in Table 11.

Sequalitchew Lake is the headwaters of Sequalitchew Creek. Historically, springs at the east end of the lake would flow into the relatively low-gradient channel of Sequalitchew Creek that wandered through Edmond Marsh before entering a steep ravine leading to Puget Sound. Construction of the Diversion Canal (running from north to south as shown on Figure 27) and beaver activity has changed the creek hydrology such that continuous flow from the lake through the marshes to Puget Sound seldom occurs. Currently, a portion of Sequalitchew Creek and the adjacent marsh flow eastward into the Diversion Canal, rather than westward along their historical path.

The Diversion Canal is an engineered channel that conveys stormwater from JBLM through Bell, McKay, and Hamer Marshes before crossing under Sequalitchew Creek via culverts and picking up additional flow from the Sequalitchew Lake Diversion Weir. The Diversion Canal then skirts the perimeter of Fort Lewis Landfill 5 and continues north, where it descends in a concrete-lined channel to reach the Puget Sound near Tatsolo Point.

Bell, McKay, and Hamer Marshes are connected to Edmond Marsh through one culvert and several interpreted subsurface flow pathways. Bell, McKay, and Hamer Marshes are at higher elevations than the other marshes, and the influx of Fort Lewis stormwater encourages shallow subsurface flow to the lower elevation Edmond Marsh.

The waterbodies and channels that comprise the surface water system are discussed in subsequent sections, starting from the headwaters of the watershed and working downstream to Puget Sound.

4.1.2.3 Sequalitchew Lake

Sequalitchew Lake is an approximately 85-acre lake located on JBLM between American Lake and Hamer Marsh and Sequalitchew Creek. The lake is fed by the springs at its eastern end that provide the primary water supply for JBLM (see Section 3.1.5.2). At normal water level of 211.5 feet, Sequalitchew Lake has an average depth of about 6 feet and a maximum depth of 11.5 feet (Western Engineers, 1952).

The Washington State Department of Fish and Wildlife (WDFW) operated a salmon rearing facility in Sequalitchew Lake from 1976 (Mills, 1994) to about 1997 (Anteon, 2003). During this period, approximately 1 to 2.3 million coho salmon were reared in the lake. In spring, the fish would migrate out Sequalitchew Creek to Puget Sound. Mills (1994) noted that beaver dams would occasionally dam Sequalitchew Creek sufficiently to reverse the flow of the creek, similar to recent observations. The beaver dams were removed by hand during the 2- to 4-week period of smolt outmigration. In addition, a "cookie cutter" machine was used on at least two occasions to clear Sequalitchew Creek of thick wetland vegetation through Edmond Marsh.

Sequalitchew Lake has one surface water outlet at its western end, leading to a moderately complex culvert and weir configuration constructed in the 1950s to control the water elevation in Sequalitchew Lake and bypass flow from Hamer Marsh to the Diversion Canal. The flows in this area are controlled by four structures:

- **Sequalitchew Creek culverts:** Four 42-inch-diameter culverts connect the lake outlet with Sequalitchew Creek. These culverts were intended to convey the normal outflow from the lake to Sequalitchew Creek.
- **Diversion Weir:** An 18-foot-wide concrete structure with wooden stop logs that can be raised or lowered to adjust the elevation of the lake. The Diversion Weir was intended to divert water from Sequalitchew Creek to the Diversion Canal during periods of high flow to prevent high water in the lake from affecting the Sequalitchew Springs water supply. The current elevation of the top of the Diversion Weir is about 210.2 feet.
- **Diversion Canal culverts:** Three 48-inch-diameter culverts cross under the four Sequalitchew Creek culverts. These culverts convey the outflow from Hamer Marsh to the Diversion Canal.
- **Beaver Dams:** Beavers have constructed a large dam across Sequalitchew Creek. This dam retains water in the easternmost portion of Edmond Marsh at an elevation typically 1 or more feet higher than the lake. This dam and the higher elevations behind prevent flow from the lake to Sequalitchew Creek. Several other beaver dams in the area also influence water levels.

As originally designed, outflow from Sequalitchew Lake would continue to flow into Sequalitchew Creek and would only overflow to the Diversion Canal if the lake elevation

exceeded 211.15 feet. However, the construction of beaver dams in Sequalitchew Creek has prevented flow from the lake to the creek and instead all of the outflow from the lake is flowing to the Diversion Canal.

Since 2003, flow over the Diversion Weir has been monitored at a flow monitoring station installed immediately upstream of the outlet diversion weir. A hydrograph of measured streamflow at the Diversion Weir gage is presented on Figure 30.

Average monthly flows vary seasonally from a low of 2.4 cfs in September to a high of 21.5 cfs in March. In some drier years (e.g., 2005 and 2015), there are periods with no flow over the weir in late summer and early fall. Peak flows have exceeded 40 cfs on multiple occasions.

4.1.2.4 Bell, McKay, and Hamer Marshes

Bell, McKay, and Hamer Marshes are three naturally occurring marshes that were significantly altered by the construction of the Diversion Canal in the 1950s. The primary surface water outlet of all three marshes is now the Diversion Canal.

Bell Marsh is an approximately 18-acre L-shaped marsh located within the City of DuPont, between Bell Hill, the historic Village of DuPont, and DuPont-Steilacoom Road (Figure 27). Bell Marsh receives stormwater runoff from 1,928 acres of the main cantonment area of JBLM into the marsh (Washington Engineering, 2001). Prior to entering Bell Marsh, the runoff passes through an infiltration pond and water quality treatment facility operated by JBLM to remove sediments and oil and grease and reduce peak flows prior to discharge into the marsh. Washington Engineering (2001) estimated that 4 to 7 percent of the total runoff would be infiltrated with the remainder being discharged into Bell Marsh.

The northwestern tip of Bell Marsh is located approximately 800 feet from the center of Edmond Marsh. The water level in Edmond Marsh is typically 6 to 7 feet lower than that of Bell Marsh, and as Bell Marsh receives a high volume of stormwater inflow, it is likely water infiltrates from Bell Marsh and flows beneath the ground surface into Edmond Marsh.

McKay Marsh is an approximately 37-acre marsh located on JBLM between DuPont-Steilacoom Road and I-5. A series of four small wetlands lead from the eastern portion of Edmond Marsh toward McKay Marsh. Shapiro and Associates (1991) concluded that these four wetlands were "probably hydrologically connected" to Edmond Marsh. Although surface topography suggests that it is unlikely that Edmond and McKay were previously connected, it is possible that subsurface flow from McKay to Edmond occurs along a path indicated by the chain of wetlands.

Hamer Marsh is an approximately 69-acre marsh located on JBLM immediately downstream of McKay Marsh. There are two main inflows to Hamer Marsh: the box culvert from McKay Marsh and a stormwater outfall from JBLM.

The stormwater outfall from JBLM collects runoff from 1,675 acres of JBLM including a portion of main cantonment area and Grays Army Airfield (Washington Engineering,

2001). The inflow to Hamer Marsh passes through a stormwater treatment and infiltration facility before being discharged to the marsh.

The main outflow from Hamer Marsh is the Diversion Canal. There is significant beaver activity in this section of the Diversion Canal with numerous active beaver dams controlling water levels between Hamer Marsh and the Lake Outlet Area. The first of these beaver dams is the primary control of the water level in Hamer Marsh.

A small culvert leading from the western tip of Hamer Marsh to the easternmost portion of East Edmond Marsh provides a secondary outlet. The culvert is set relatively high and is partially obstructed by debris, which only allows flow when the water surface elevation in Hamer Marsh is at higher levels 214 feet.

The area near the small culvert is also of interest from a subsurface connection perspective. In this area, Hamer Marsh is separated from East Edmond Marsh by approximately 125 feet that includes a gravel roadway. The roadway dips right at the location of the small culvert, which is also where the two marshes are closest together. It is suspected that this area may have been a former surface connection between the two marshes that was filled to allow construction of the roadway. A 1940 U.S. Army Corps of Engineers map (Figure A-6 in Appendix A of Aspect 2004a) shows the two marshes connected in this location. The difference in water levels between the marshes is approximately 2 feet, which given the close proximity is enough to allow subsurface flows from Hamer Marsh to Eastern East Edmond Marsh.

The marshes have a seasonal water pattern, with a high wet season water level typically from November through June or July followed by a lower water period through summer. The typical seasonal range in water levels is 2 to 3 feet. Water levels step down from Bell to McKay to Hamer Marsh as summarized in Table 12. The average water level in Bell Marsh is 218.58 feet. McKay Marsh is about 3 feet lower, with an average water level of 215.43 feet. Hamer Marsh is a little over 1 foot lower than McKay Marsh with an average water level of 214.02 feet.

4.1.2.5 Edmond Marsh

Edmond Marsh extends from the outlet of Sequalitchew Lake to about 700 feet east of Center Drive and is located on JBLM and within the City of DuPont. For discussion purposes in this report, Edmond Marsh is divided into three segments:

- Eastern East Edmond Marsh is located on JBLM east of DuPont-Steilacoom Road.
- East Edmond Marsh is located in DuPont between the Robinson Trail and DuPont-Steilacoom Road.
- West Edmond Marsh is located in DuPont west of the Robinson Trail.

Eastern East Edmond Marsh

Eastern East Edmond Marsh is approximately 32 acres in size and has an open channel through the center of the marsh. It is bounded by uplands on the north and south and DuPont-Steilacoom Road on the west. The east end of the marsh is the outlet area for Sequalitchew Lake. A large beaver dam separates the marsh from the lake outlet. A series of small beaver dams along an abandoned road grade form the northeast edge of the

marsh. Water flows over these beaver dams into the Diversion Canal, a reversal of the original flows down Sequalitchew Creek to Puget Sound. At the west end, a box culvert under DuPont-Steilacoom Road connects the marsh with East Edmond Marsh and allows flow in either direction through the culvert.

Eastern East Edmond Marsh receives inflow from Hamer Marsh via the 12-inch culvert and potential subsurface connection with Hamer Marsh. It also may receive inflow from East Edmond Marsh through the connecting culvert discussed above. No other inflows are known. With the beaver dam retaining water levels the marsh above the elevation of Sequalitchew Lake, it is not possible for outflow from the lake to enter the marsh.

Water has been observed flowing over the beaver dams on the eastern end of the marsh and into the Diversion Canal. The only other potential surface water outflow is the connecting culvert to East Edmond Marsh. At times, water levels have been higher in East Edmond Marsh, indicating flow back through this culvert toward the Diversion Canal. Water levels in East Edmond Marsh have been lower at other periods, indicating westward flow from the connecting culvert.

The water level in the Eastern East Edmond Marsh is monitored at staff gages behind the beaver dam on the eastern end and at DuPont-Steilacoom Road on the western end. The average water level is about 212.40 feet, with little difference between the two locations. This water level is over 1 foot higher than the average water level in Sequalitchew Lake.

East Edmond Marsh

The East Edmond Marsh segment is approximately 55 acres and includes scrub-shrub and open water habitats between DuPont-Steilacoom Road to the west and Robinson Trail (a public trail built on a former railroad grade) to the west. Sequalitchew Creek follows a meandering channel through East Edmond Marsh that has been previously excavated and cleared. Generally, the channel is more open on the eastern end of the marsh and becomes brushy close to the trail.

Inflows to East Edmond Marsh include the culvert under DuPont-Steilacoom Road, the potential subsurface inflows from Bell Marsh and McKay Marsh described in previous sections, and inflow from a small stormwater system draining a portion of Center Drive where roadside ditches and catch basins convey runoff to a drainage swale that leads directly into the northern boundary of the marsh.

The outflows from East Edmond Marsh are either to West Edmond Marsh through a culvert (often blocked by beavers),through the railroad grade itself, or eastward to through the culvert under DuPont-Steilacoom Road.

A significant beaver dam is located approximately 150 feet east of Robinson Trail and controls the water level in East Edmond Marsh. This beaver dam connects two upland areas and impounds water behind it to the east, forming the western end of a continuous body of water with roughly the same water surface elevation that extends to the east end of Eastern East Edmond Marsh. The beaver dam was breached in 2016 and water levels remained lower for multiple years before returning to similar levels in 2010 to 2011.

Two staff gages are used to monitor water levels in East Edmond Marsh: one on the westside of DuPont-Steilacoom Road (SG-EM-3W), and one located just north of an upland area near Robinson Trail (SG-EM-2E).

Water levels in East Edmond Marsh average 212.39 feet at SG-EM-3W and 212.20 feet at SG-EM-2E, indicating a slight gradient toward the west on average. There is little difference between water levels at the staff gages on the east and west sides of DuPont-Steilacoom Road. The water level in East Edmond Marsh is typically high from November or December through May or June, then declines gradually to a low typically in September before refilling as rains return.

West Edmond Marsh

West Edmond Marsh is an approximately 80-acre wetland bounded by the railroad grade on the east, historic DuPont to the south, and ringed by recent development on the north and west. Sequalitchew Creek follows a relatively straight path along the northern boundary of the marsh.

Multiple beaver dams actively control water levels in West Edmond Marsh and several inactive dams can be found throughout the marsh. The water level steps down typically around a foot at each beaver dam. The most significant of the beaver dams is the westernmost dam, which defines the western extent of the marsh.

Outflow from this beaver dam typically only occurs during the winter months and infiltrates in the broad grassy channels of Sequalitchew Creek on both sides of Center Drive. Outflow from West Edmond Marsh has only been observed flowing under Center Drive on rare occasions and seldom extends to the downstream reaches of Sequalitchew Creek.

West Edmond Marsh receives inflow from East Edmond Marsh through the culvert under Robinson Trail and likely from flow through the trail grade as well. In addition, several stormwater infiltration ponds that infiltrate runoff from the adjacent developments are located near the marsh perimeter. Infiltrated runoff may reach West Edmond Marsh through shallow subsurface pathways. No direct stormwater discharges into West Edmond Marsh are known.

Water levels in West Edmond Marsh are monitored at two locations: SG-EM-2W, which is at the outlet of the culvert under Robinson Trail, and a pair of staff gages (SG-EM-1 and -1A) which are located on the western end behind the westernmost beaver dam. The average water level at SG-EM-2W is 211.35 feet, which is slightly higher than the average water level in Sequalitchew Lake. The average water level at SG-EM-1/1A is 207.91 feet. The seasonal variability in water levels is more amplified in the western portion of West Edmond Marsh, with a typical range of 1 foot or less observed near Robinson Trail and 4 to 5 feet at the westernmost end. The westernmost portion of West Edmond Marsh becomes dry in the summer of most years.

4.1.2.6 Wetland 1D

Wetland 1D is an approximately 2.1-acre wetland, located immediately north of West Edmond Marsh, with no surface water connection between it and Edmond Marsh. Water levels in Wetland 1D have ranged from 208.6 to 211 feet, with a typical seasonal range of

1 to 2 feet. The water levels typically peak in December or January and begin to decline earlier than West Edmond Marsh.

4.1.2.7 Isolated Kettle Wetlands (Pond, Strickland, Grant, Old Fort Lake, and Wetlands #8 through #11)

Isolated wetlands, typically forming in kettles created during the recessional period of the Vashon glaciation, are present in the Sequalitchew Creek watershed. Most notably, a group of kettle lakes and wetlands, including Pond Lake, Strickland Lake, Grant Lake, Old Fort Lake, and Wetlands #8 through #11, lies south of Sequalitchew Creek and west of the historic village of DuPont (Figure 27).

Water level data collected as a component of the stormwater management program for the Northwest Landing development indicate that the southern group of kettle wetlands have large seasonal variations in water levels and most go dry during extended dry periods (Shapiro, 1991; Hart Crowser, 1999; ESM Consulting Engineers, 2004). They also fluctuate similarly to the water table fluctuations, and have been inferred by numerous investigators to be expressions of the water table of the Vashon Aquifer in their respective project areas (WCC, 1991; Hart Crowser, 1999; and URS, 2003).

However, as with the wetlands around Sequalitchew Creek, silts, clays and organics build up over time in the stagnant water leaving a layer of low permeability peat and silty muck soils at the bottom of the pond areas. These accumulating fine-grained materials were observed in the kettle lake wetland bottoms (Newling and Smith, 2004). As such, it is likely that the hydraulic connection between the aquifer and wetland water levels is reduced with some delay in the response time of the surface water to groundwater changes.

A couple of the kettle wetlands are interconnected by culverts, but otherwise, the kettle wetlands do not have outlet drainages. Water leaves the kettle wetlands only through evapotranspiration or infiltration to groundwater.

4.1.2.8 Sequalitchew Creek

Sequalitchew Creek is a 3.3-mile-long creek traveling from the eastern end of East Edmond Marsh through Edmond Marsh and down a steep ravine to Puget Sound. Historically, Sequalitchew Lake was the headwaters of Sequalitchew Creek; however, construction and maintenance of the Diversion Weir restricts the potential flows to the creek, and beaver dams further prevent outflow from the lake to the creek. Through the marshes, the creek is a channel of open water or less dense vegetation, but little flow is present. After leaving the marshes, the creek channel maintains its broad width but becomes dry and grassy. Outflow from West Edmond Marsh typically infiltrates in this grassy reach upstream of Center Drive.

Downstream of the grassy reach is a road grade and culvert near the remains of the wooden dam for the old DuPont Works hydropower facility. Downstream of the culvert, springs from the Vashon Aquifer return flow to Sequalitchew Creek as it begins its descent through a 1.3-mile steep ravine to Puget Sound. Multiple springs are present in the upper half of the ravine (see Figure 7). After the stream crosses through the Olympia Beds and the Kitsap Cutoff midway through the ravine, no more springs are present. Near Puget Sound, the ravine widens and gradient decreases. The creek discharges to Puget

Sound through a 5-foot by 5-foot box culvert under the BNSF railroad grade. Construction of the railroad grade limited the connection of the mouth of the creek to Puget Sound. A brackish marsh is located immediately upstream of the railroad grade.

Currently, streamflow is monitored continuously at two locations in the ravine (Figure 12): the mid-ravine gage (formerly referred to as the "upper gage"), which is located just above the Olympia Beds truncation approximately 3,900 feet upstream of the mouth, and the lower gage located approximately 700 feet upstream of the mouth. The lower gage was installed in 1999 and the mid-ravine gage was installed in 2003.

Average annual streamflow is about 2.8 cfs at the lower gage and 1.6 cfs at the mid-ravine gage over their common period of record (calendar years 2004 to 2021). The hydrograph of measured stream flows (Figure 30) indicates seasonally varying baseflow that ranges from 0.5 cfs in late summer up to around 2.5 cfs in wet winters. Individual storm peaks are present in rainy periods, but the peaks are not particularly flashy. The highest observed daily average flow was 13.8 cfs in December 1999.

Comparison of recent flow monitoring results with earlier gaging efforts in 1977-1978 (Thut et al., 1978) and 1984-1987 (Firth, 1991) indicates that the streamflow is about 75 percent lower now. Those periods correspond with WDFW's use of Sequalitchew Lake for fish rearing, so it is likely that the higher flows in the 1970s and 1980s represent a higher portion of the outflow from Sequalitchew Lake reaching Sequalitchew Creek instead of the Diversion Canal, particularly in winter and spring months. Average monthly flow rates near the mouth of Sequalitchew Creek are shown in Table 13.

4.1.3 Surface Water Quality

4.1.3.1 South Parcel and Existing Mine

The only surface water body within the South Parcel Project area is the Kettle Wetland, which has not been monitored for water quality. Because the hydrology of the Kettle Wetland is driven by the Vashon Aquifer, the water quality is anticipated to be similar to the that of the aquifer, but slightly modified by wetland processes and direct exposure to the atmosphere. Water temperature in the Kettle Wetland can be anticipated to be slightly warmer in summer and slightly cooler in winter. Turbidity is likely marginally higher because of natural processes in the wetland (e.g., disturbance of marsh sediments by biota). Dissolved oxygen (DO) could be higher or lower than in the aquifer depending on the season and balance between of different factors. Exposure to the atmosphere would act to increase DO as would lower winter temperatures and growth of aquatic plants; however, higher summer temperatures, plant respiration, and the decay of organic material would act to lower DO. Regardless, the water quality in the Kettle Wetland is likely quite good.

4.1.3.2 Sequalitchew Creek Watershed

This section reviews the regulatory status and water quality criteria applicable to the natural water bodies within the Sequalitchew Creek watershed, then summarizes existing water quality based on the results of several water quality monitoring programs.

Regulatory Status

Washington State water quality standards for surface waters consist of designated uses and criteria and other provisions (e.g., anti-degradation) to protect those uses. Chapter

173-201A of the Washington Administrative Code (WAC) water quality standards are based on the designated uses (type of aquatic life, recreation, water supply, etc.) of a surface water body.

Sequalitchew Creek and Sequalitchew Lake have a designated aquatic life use of "core summer salmonid habitat" as they are tributary to a marine water designated for "extraordinary aquatic life" per WAC 173-201A-600 (1)(a)(iv). The State Water Quality Standards for core summer salmonid habitat for key parameters are shown in Table 14.

Table 14. State Water Quality Standards Applicable to Sequalitchew Creek and Sequalitchew Lake

Parameter	Criterion	Allowable Change
Temperature (7-DADMax)	16.0 °C	0.3 °C when T >= 16.0 °C, else 28/T+7 Total change not to exceed 2.8 °C
Dissolved Oxygen (1-day minimum)	9.5 mg/L	<0.2 mg/L
Turbidity	NA	5 NTU over background when <= 50 NTU, otherwise 10%.
pH	6.5 to 8.5	< 0.5 within range

Notes:
7-DADMax is the 7-day average of daily maximum temperatures.
T = background temperature unaffected by project.
NTU = nephelometric turbidity units; mg/L = milligrams per liter

Ecology has published supplement spawning/incubation criteria (Ecology, 2011) that modifies the temperature criteria applicable to some fresh water bodies. Sequalitchew Creek and Sequalitchew Lake have not been identified for supplemental temperature criteria.

Sequalitchew Creek and Sequalitchew Lake are not on Ecology's EPA-approved 2012 list of impaired waterways ("303(d) list") for any parameters, nor on the draft 2018 303(d) list that is with EPA for review.

Water Quality Monitoring Results

Surface water quality in the natural waterbodies of the Sequalitchew Creek watershed is primarily understood through four studies and monitoring efforts:

- Ongoing monitoring for CalPortland - monthly monitoring for key aquatic life parameters at the Diversion Weir and upper Sequalitchew Creek.
- Citizen monitoring data collected from 2008 to 2012 by Don Russell – periodic monitoring in and downstream of Edmond Marsh for key aquatic life parameters and select metals and nutrients.
- Surface Water Investigation Report, North Sequalitchew Creek Project (CH2M Hill, 2001) – monitoring of the Diversion Canal and Sequalitchew Creek ravine for a broader suite of parameters.

- Fort Lewis Landfill No. 5 Remedial Investigation/Feasibility Study (WCC, 1991) –monitoring multiple locations in Sequalitchew Creek, isolated wetlands, and intertidal springs for a broader suite of parameters.

At a broad level, water quality in the watershed can be understood by grouping waterbodies in three categories: Sequalitchew Creek, the marshes, and Sequalitchew Lake. A summary of water quality monitoring results is shown in Table 15. These samples were collected by multiple parties and are instantaneous grab samples.

Sequalitchew Creek generally has excellent and very consistent water quality, with cool temperatures (< 15 °C), high dissolved oxygen levels (> 9 milligrams per liter [mg/L]), and low turbidity (< 15 NTU). These results are representative of a steady groundwater input and shaded forest setting. The seasonal variation in temperature is much less in the reaches of Sequalitchew Creek in the ravine than in the marshes or lake. Metals concentrations in Sequalitchew Creek are consistently low.

Water quality in the marshes is more typical of stagnant water bodies exposed to the life cycle of aquatic plants. Dissolved oxygen concentrations are lower (typically < 4 mg/L), pH is slightly acidic (median of 6.5), and temperature highs and lows are more extreme, ranging from 2.7 to 22.2 °C. Turbidity is still low (< 10 NTU). Generally, the individual marshes have similar water quality, although East and West Edmond Marshes have elevated iron concentrations, particularly in the vicinity of the railroad grade trail where groundwater seeps entering the marsh; where concentrations have been measured above 1 mg/L. Concentrations of other metals important as indicators of potential stormwater pollution, such as copper and zinc, have been low, even in marshes receiving direct stormwater inputs.

Water quality in Sequalitchew Lake is generally representative of groundwater, except that temperature is warmer in summer (typically above 20 °C) and cooler in winter (below 6 °C) due to exposure to the atmosphere during the longer retention time in the lake. Dissolved oxygen concentrations are generally high (typically > 9 mg/L). pH is neutral and turbidity is low. Metals have not been measured in the lake, with the exception of one sample analyzed for iron at 0.13 mg/L.

Earlier sampling (CH2M Hill, 2001 and WCC, 1991) for broader suites of parameters did not identify significant or unusual pollutant issues in surface waters of the watershed.

4.2 Effects of the Proposed Action

This section examines the effects of the South Parcel Project on issues with surface water quantity and quality that are typically evaluated in permitting of mine sites.

Gravel mining has the potential to change the hydrology of an area by altering topography, changing the size and shape of drainage basins, removing vegetation, and exposing or placing deposits of lower permeability material. These changes generally result in increased stormwater runoff and a decrease in evapotranspiration. Depending on the stormwater management system used, mining can either increase groundwater recharge (if infiltration facilities are used to discharge stormwater to ground) or decrease groundwater recharge (if detention ponds are used to release stormwater to surface waters).

This section describes the changes in site water balance that would occur with the South Parcel Project and predicts stormwater volumes and peak flow rates, then presents a preliminary design of a stormwater system for the Proposed Action. We then evaluate the effects of the stormwater system on groundwater mounding and water quality.

4.2.1 Site Water Balance

A water balance is an approximate accounting of the hydrologic inputs and outputs from a project area. The inputs can include precipitation (as both rain and snow), groundwater discharge from springs, or surface water inflows from streams or rivers or stormwater run-on. The outflows include evapotranspiration, groundwater recharge, and stormwater runoff or stream flow leaving a site.

Three water balances related to the South Parcel Project have been developed to answer different questions about the surface water and groundwater bodies. The water balances were developed using different modeling techniques and software, and are focused on different water bodies. For clarity, the three water balances are:

1. A groundwater water balance developed as part of the groundwater modeling effort and described in the Groundwater Model Update Report (Aspect, 2017b).
2. A site water balance that focuses on the fate of precipitation falling on the South Parcel Project area, presented in this section, and the changes that would occur with mining. This water balance is primarily focused on stormwater within the mine site.
3. A wetland water balance, presented in Section 4.2.3.2, that was developed in Excel with the focus of predicting changes in water levels in the marshes with mining and restoration.

The site water balance for the South Parcel Project was calculated for existing and proposed conditions using the Western Washington Hydrologic Model (WWHM). WWHM is a complex hydrologic model developed by Clear Creek Systems for Ecology. It simulates watershed hydrology based on land use characteristics and historical meteorologic records. The primary purpose of WWHM is to predict stormwater flows for the design of stormwater management facilities, but it can also provide other elements of the water balance, such as groundwater recharge, evaporation, and changes in soil moisture.

Within Pierce County, WWHM uses a 158-year synthetic precipitation series with a mean annual precipitation of 42 inches per year. Because it is a synthetic precipitation record, the period of record does not represent a specific range of actual years. Evaporation data in WWHM is based on pan evaporation measurements from the Puyallup 2W Experimental Station.

Three scenarios were analyzed representing existing conditions along with the Proposed Action and No Action alternatives. For each scenario, the land use characteristics are entered into WWHM to represent the different soil types, vegetative cover, and slope characteristics created by that scenario. A summary of the land use information entered into WWHM to represent existing and proposed conditions is shown in Table 16.

The existing scenario represents the current state of the South Parcel Project area, which consists of a flat, forested land with coarse surface soils in the South Parcel, the Kettle Wetland and buffer, and the vegetated areas of the eastern slope of the existing mine.

The Proposed Action scenario represents the maximum potential for the South Parcel Project to affect surface hydrology. It assumes that the area has been completely mined to the topography shown on Figure 31, but limited vegetation has regrown. This condition was assumed in the model as a worst case and represents a situation that would never occur because segmental reclamation will be used to limit the amount of time any cleared land is not reclaimed. For the proposed model scenario, the bottom of the mine was modeled as till soils to represent the Olympia Beds, even though in practice a layer of sand and gravel approximately 10 feet thick would be left in place. Mine side slopes were simulated as outwash soils with a lawn cover (the vegetative cover that generates the highest runoff) to represent bare soils during mining, or recently seeded slopes in reclamation.

These three scenarios were analyzed in WWHM, which simulates site hydrology on a 15-minute time step for the 158-year period of record of the synthetic precipitation time series. The results were exported as annual averages for each of the 158 years and an overall average calculated. Annual results are presented in Appendix E and the overall average results are described below.

The water balance distinguishes between direct groundwater recharge and infiltrated stormwater. Direct groundwater recharge is defined as precipitation that infiltrates to groundwater at or near the location it falls, thus providing diffuse recharge. In contrast, infiltrated stormwater occurs where precipitation generates stormwater that is conveyed to an infiltration facility providing focused recharge. Direct groundwater recharge and stormwater infiltration were separated in WWHM using separate points of compliance: direct recharge was calculated as the groundwater generated from the site drainage basins; infiltrated stormwater was calculated as the surface runoff and interflow that infiltrates in the stormwater facilities.

Groundwater inflows at the toe of the mined slope were included in the site water balance by adding an annual average of 6.9 cfs (based on Step 3 results in Table 7) as an inflow and adding a corresponding outflow to the volume of total groundwater recharge to create the groundwater outflow.

Results from the WWHM model indicate that under existing conditions, an average of approximately 744 acre-feet of water (or 44 percent of precipitation) evaporates or is transpired by vegetation (Table 17) on an annual basis and 944 acre-feet (or 56 percent of precipitation) recharges groundwater either as direct groundwater recharge or infiltration of stormwater. WWHM predicts that a very small amount of stormwater runoff (104 acre-feet, or 6 percent of precipitation) is generated under existing conditions. This stormwater is infiltrated within the existing mine.

The Proposed Action would cause a minor reduction in evapotranspiration as the forested South Parcel and Kettle and Buffer Areas are cleared for mining. Under the Proposed Action, 706 acre-feet (or 42 percent of precipitation) would evaporate or be transpired. The reduction in evapotranspiration results in an increase in stormwater volume. Because all stormwater will be infiltrated, the Proposed Action results in increased groundwater

recharge. The Proposed Action would result in 982 acre-feet of groundwater recharge per year from direct recharge and infiltrated stormwater compared to 944 acre-feet under the existing condition, a 3.8 percent increase. The nature of groundwater recharge would shift with less distributed recharge and greater infiltration of stormwater in discrete locations.

4.2.2 Mine Stormwater Management

CalPortland has prepared a Preliminary Stormwater Management Report (Aspect, 2021) documenting the preliminary design of the stormwater management system for the proposed South Parcel Project. This section summarizes the hydrologic calculations used in the preliminary design and the key components of the resulting proposed drainage system.

4.2.2.1 Peak Flows and Volumes

WWHM was also used to predict the peak flow rates and volumes of stormwater generated under the existing conditions and Proposed Action. To analyze stormwater volumes, the South Parcel Project area was divided into three drainage basins—Basins C, D, and E—based on the proposed stormwater facilities and conveyance network (Figure 31).

Basins C and D include about 390 acres of the existing mine and South Parcel Project area. When mining is completed, each basin will include mine side slopes, large areas of rolling terrain where sand and gravel will be excavated exposing the lower-permeability Olympia Beds, and a relatively flat area at elevation 25 to 50 feet in the bottom of the existing mine. These basins will drain to new stormwater management facilities to be located on the floor of the existing mine. These facilities will expand on, and replace, the existing stormwater management system.

Basin E consists of 92.6 acres of the mine side slopes and mitigation wetland which drain to the ditches designed to capture and convey groundwater emanating from the toe of the mined slope once active dewatering has ceased. Basin E was further divided into three subbasins, E1 through E3, to allow for calculation of peak flows for conveyance design purposes. All three subbasins ultimately drain to the same infiltration facility, which also receives intercepted groundwater and overflow from the constructed mitigation wetland. Basin E1 consists of the slopes on the southern and southwestern corner of the mine as well as the mitigation wetland itself. Basin E1 drains to the mitigation wetland, then eventually infiltration pond E. Basin E2 includes the western slopes that will drain to the ditch that conveys outflow from the wetland to the infiltration pond; it also includes infiltration pond E. Basin E3 consists of the eastern slopes that drain to the groundwater capture trench running along the toe of those slopes.

Peak flow output from WWHM is shown in Table 18 and indicates that the South Parcel Project would increase stormwater peak flows relative to existing conditions. For example, the 100-year return period flow could increase from 23.5 cfs to 66.5 cfs in Basin C, and from 20.2 cfs to 94.6 cfs in Basin D. The primary reason that mining activity causes an increase in peak flows is the removal of the porous outwash soils (which do not generate much runoff) down to the level of the Olympia Beds (which are lower permeability and generate more runoff). Peak stormwater flows would be managed

through infiltration, resulting in the increase in groundwater charge described in Section 4.2.1.

4.2.2.2 Proposed Drainage System

As the area is mined, it will expand the closed depression of the existing mine so all stormwater generated within the South Parcel Project area will either infiltrate or evaporate. Stormwater runoff will be collected and conveyed to stormwater ponds in permeable soils on the floor of the existing mine for treatment and infiltration.

Each stormwater pond group will consist of a two-celled lined wetpond designed to remove sediments and provide spill control and an infiltration pond to dispose of stormwater and recharge groundwater. Pond locations and the conceptual drainage patterns are shown on Figure 31.

Two-celled wetponds are proposed as the water quality treatment technology because they are low maintenance, and well suited for removal of suspended solids, which are the primary potential stormwater pollutant at mining operations. The two-celled design improves the sediment removal efficiency and allows for spill control and trapping of floatables in the first cell.

The wetponds were designed to treat 91 percent of the total runoff under developed conditions in accordance with Ecology guidance (Ecology, 2014). Key pond dimensions are shown in Table 19. The ponds were designed to be 7 feet deep, which includes one foot of sediment storage at the bottom of the first cell, and 1 foot of freeboard in both cells.

Table 19. Summary of Proposed Stormwater Water Quality Ponds

Pond	Cell	Depth (feet)	Volume Provided (cubic feet)	Volume Required (cubic feet)
C	1	6	79,704	79,453
	2	7	187,614	185,391
D	1	6	111,816	111,731
	2	7	263,739	260,707

The infiltration ponds were designed to infiltrate all stormwater generated within the mine. Pond E was also designed to infiltrate intercepted groundwater during and after active dewatering. Key dimensions of the infiltration ponds are summarized in Table 20. For preliminary design, the ponds were assumed to be rectangular, with 3H:1V slopes, and a total depth of 5 feet (4 feet of active depth and 1 foot of freeboard).

The infiltration properties of soils in the pond areas were estimated based on grain size data from borings at the location and depth closest to the proposed pond locations following guidance in the *Stormwater Management Manual for Western Washington* (Ecology, 2014). A correction factor of 0.12 was applied to adjust the infiltration rate estimated from grain-size properties to a long-term design infiltration rate. The resulting long-term design infiltration rates were 8.1 to 8.2 inches per hour for all three ponds.

Table 20. Summary of Proposed Infiltration Ponds

Pond	Depth in feet (without freeboard)	Bottom Area (square feet)	Top Area at Max Water Level (square feet)	Side Slopes
C	5	50,762	66,748	3H:1V
D	5	37,655	68,755	3H:1V
E	6	57,807	82,120	3H:1V

The drainage system would be constructed as mining advances according to the following general sequence:

1. During active mining, temporary, often informal, drainage facilities would be used to treat and infiltrate stormwater. During the early stages of each segment, little runoff would be generated as mine side slopes are very pervious, allowing for infiltration. Overtime, the mine bottom would be compacted by equipment traffic, increasing runoff.
2. Permanent drainage facilities would be constructed when mining had reached final grade near the pond location.
3. Drainage facilities would continue to function throughout the life of the mine. CalPortland would be responsible for maintenance of drainage facilities through mining and completion of reclamation.
4. After reclamation of each segment, the drainage facilities would remain on-site and continue to function. Long-term maintenance of the drainage facilities would be the responsibility of the landowner. The volume of runoff entering the drainage facilities would decrease as vegetation planted during reclamation matures.

4.2.2.3 Water Quality

CalPortland would manage water quality for the North Parcel under a Sand and Gravel General Permit issued by Ecology. The Sand and Gravel General Permit combines the protections of an NPDES Permit for surface water discharge and a State Waste Discharge Permit for discharges to groundwater. The existing mine currently operates under two separate Sand and Gravel Permits: permit #501178 covers discharges from the aggregate wash plant, processing area, and mine; and permit #501406 covers discharges from the concrete batch plant. Permit #501178 would be expanded to include the Expansion Area.

Under the Sand and Gravel General Permit, CalPortland would take the following actions:

- Implement a Stormwater Pollution Prevention Plan (SWPPP) specific to the North Parcel
- Implement BMPs to prevent stormwater pollution

- Meet water quality standards for stormwater discharged to any surface water or groundwater through infiltration ponds
- Monitor surface water quality in stormwater ponds at least quarterly
- Monitor process water discharges monthly
- Frequently inspect the facility for erosion and oil sheen

Mines constructed as closed depressions typically have little impact on surface water quality as all water is contained internally. The remaining water quality concerns relate to preventing stormwater contamination that could impact groundwater. Two areas of potential concern are spills from heavy equipment and sediment from erosion. These concerns are managed through implementation of BMPs described in the SWPPP and erosion and sediment control plan.

Spills

Spills, leaks, and drips of chemical products are not typically a significant problem for mining sites like the existing mine because of limited use of chemicals and the small number of pieces of heavy equipment operating in a large area. However, the potential exists that spills, if not quickly cleaned up, could contaminate stormwater and groundwater (either directly or through the infiltration of stormwater).

Petroleum products (diesel fuel, motor oil, and hydraulic fluid) are the primary chemicals used on-site. Chemical storage and equipment maintenance areas are already established in the existing processing area, and would continue to be used.

CalPortland's spill plan, developed under the Sand and Gravel NPDES permit, includes controls to be used on-site that significantly reduce the likelihood that a small spill or leak would impact water quality. Mining companies are uniquely able to respond to excavate and contain small spills because heavy equipment is always on-site. In the event of a spill, they can quickly excavate contaminated soil and contain it in the bed of a dump truck.

In addition, the stormwater system includes spill control devices in the wetponds to prevent floatable contaminants, such as oil or grease, from reaching the infiltration pond. Finally, the mining plan includes a soil buffer above the water table. The 10-foot thickness provides sufficient time for cleanup of a spill before contaminants could reach groundwater, as evaluated in Section 3.2.2.

Erosion

Removal of vegetation and creation of slopes by mining increases the potential for soil erosion. Erosion within the closed depression of the mine would not affect Sequalitchew Creek or Puget Sound, but could affect the constructed wetland or the long-term performance of the stormwater and groundwater infiltration ponds. It could also affect the ability to successfully reclaim mine slopes. Soil erosion is typically managed through a combination of source control BMPs to prevent erosion and treatment BMPs to remove sediments suspended in stormwater.

Source control BMPs, such as segmental clearing and revegetation of slopes, will be the primary technique for preventing soil erosion, and are discussed in Section 2.2.3. The

Proposed Action also includes runoff treatment BMPs as a secondary step to prevent impacts from erosion. Each infiltration pond will be proceeded by a two-cell wetpond to remove sediment and prevent clogging of the infiltration pond. In the long term, erosion and sediment control would be provided through implementation of the Reclamation Plan in accordance with surface mine reclamation permit conditions issued and enforced by DNR.

Topsoil would be stripped and stockpiled for reuse for reclamation on completed mine areas. BMPs (such as surface roughening, mulching, temporary cover, or longer-term vegetative cover) will be used to prevent erosion from stockpiles. These BMPs would also protect against erosion of topsoil potentially containing metals attributable to the former Asarco smelter. Samples would be collected from the stockpiled topsoil to confirm arsenic concentrations meet cleanup levels before the topsoil is placed on mined areas for reclamation. After application of the topsoil, erosion control BMPs such as surface roughening and permanent vegetative cover would be implemented as with any newly created slope. The preceding measures combined with the fact that no stormwater discharge to surface water is proposed or would be authorized for the Proposed Action, eliminate any risk of the topsoil contaminating surface waters.

4.2.3 Sequalitchew Creek Watershed

4.2.3.1 Sequalitchew Lake and Marshes on JBLM

Sequalitchew Lake would not be affected by the South Parcel Project for three reasons:

1. The lake is located well east of the area of appreciable change in groundwater levels (see the 0.5-foot drawdown contours on Figures 22 through 25). Model predictions for all dewatering steps indicate the 0.5-foot drawdown contour would be located west of DuPont-Steilacoom Road.
2. The water level in the lake is controlled by the Diversion Weir and there is typically discharge from the lake throughout the year.
3. The lake is an area of groundwater discharge throughout the year, which means that groundwater levels around the lake are higher than the lake water surface.

There also would be no change in the flow from Sequalitchew Springs as the springs are located at the far eastern end of Sequalitchew Lake.

4.2.3.2 Marsh Water Levels

The effects of mining on wetland hydrology of the Bell-McKay-Hamer and Edmond Marsh complexes were investigated by developing a water balance model of the key wetland areas.

Water Balance Overview

A water balance is a method of accounting for the individual hydrologic processes that add water to, or take water away from, the area being studied. The basic concept of a water balance is that the change in the volume of water in a waterbody over a period of time can be calculated as the difference between the amount of water that entered and left the waterbody during that time. The challenging part of a water balance is quantifying the individual inflows and outflows. For the key elements of the Sequalitchew Creek

watershed surface-water network (i.e., the wetlands), the following individual inflows and outflows need to be quantified:

Inflows:

- Precipitation falling directly on the water surface
- Surface water inflows such as stormwater or creeks
- Shallow subsurface inflows from nearby higher waterbodies
- Groundwater seeping into the marsh

Outflows:

- Evapotranspiration from open water and marsh vegetation
- Surface water outflows
- Shallow subsurface outflows to other nearby lower waterbodies
- Groundwater recharge

The water balance simulated the six main interconnected wetlands, grouping the upper marshes and simulating the lower marshes individually as shown on Figure 32:

- Bell, McKay and Hamer Marshes, with a focus on Hamer Marsh for calibration
- East Edmond Marsh, both east and west of DuPont-Steilacoom Road
- West Edmond Marsh

The water balance simulates the individual hydrologic processes based on fundamental data sources (e.g., measured precipitation and evaporation data) and scientific approaches. Precipitation is based on the PRISM data series for McMillin Reservoir as described in Section 4.1.1.

The primary surface water inflows under existing conditions are the stormwater inputs to Bell and Hamer Marshes from JBLM. These were estimated using WWHM and a correlation between monthly stormwater discharge and monthly precipitation that was developed to extend the stormwater predictions beyond WWHM's period of record. More minor stormwater inputs, including a small portion of Center Drive that drains to East Edmond Marsh, were estimated using a similar approach. Under Restoration Scenarios, the historical record of outflow from Sequalitchew Lake to the Diversion Canal was used as an input to East Edmond Marsh.

Shallow subsurface inflows between the higher marshes (Bell, McKay, and Hamer) and East and West Edmond Marsh were calculated using Darcy's law, which estimates groundwater flow based on the gradient, cross sectional area of the flow path and hydraulic conductivity. Gradient was calculated as the difference in water levels in the marshes divided by the distance between them. Gradient changed monthly and between water balance scenarios based on the water levels predicted by the water balance. Hydraulic conductivity was estimated at 400 feet per day, which is about the lower 25th percentile of the hydraulic conductivities for Steilacoom Gravel used in the DuPont groundwater model (see Table 1 in Aspect, 2017a). The cross-sectional area of the flow

path was estimated based on width of topographic channels at locations where the marshes are closest and a depth of flow equal to the difference in marsh elevations.

Groundwater discharge into a marsh was also calculated with Darcy's law where the vertical gradient is based on the difference in the marsh water level and the underlying groundwater elevation, hydraulic conductivity is based on the marsh sediments, and cross-sectional area is the wetted area of the marsh. Wetted area for each marsh varies based on water level and was estimated from topographic information.

Potential Evapotranspiration (PET) is calculated based on the pan evaporation data from the Puyallup Experimental Station (described in Section 4.1.1) and a pan coefficient of 0.8 to convert pan evaporation to open water evaporation. PET from vegetation assumed a "crop" coefficient of 1.

Surface water outflows were calculated by estimating the hydraulic properties of the structures (typically beaver dams or a culvert) controlling the water level in a marsh. Beaver dams were composite structures, with some leakage occurring through the dam itself according to Darcy's law, and flow over the top as a partially obstructed broad-crested weirs. Weir elevations were modified during calibration of the water balance model to match observed water levels. Only a couple changes over the period of record were used.

Shallow subsurface outflows were calculated using the same approach as shallow subsurface inflows, with the outflow from the upgradient marshes being the same as the inflow to a downgradient marsh.

Groundwater recharge (i.e., flow from a marsh into groundwater) was calculated using the same approach as groundwater discharge into a marsh. Groundwater recharge only occurs when the marsh water level is higher than groundwater. Similarly, groundwater discharge into a marsh only occurs when the marsh water level is lower than groundwater. Thus, groundwater recharge/discharge is calculated as a single term in the water balance, and either occurs as recharge or discharge, but not both, in any given month.

The water balance model simulates wetland hydrology on a monthly time step for the period from March 2003 (the start of the monitoring program) to September 2021 (the end of the most recent water year).

The water balance model was calibrated by qualitative comparison of predicted marsh water levels with the observed water levels from the monitoring period. The water balance model was able to reproduce the seasonal trends in water levels and capture differences between wetter and drier years under existing conditions. Figures 33 and 34 compare the observed water level measurements with the model predictions for existing conditions for Hamer and East Edmond Marsh, and West Edmond Marsh, respectively. For example, the model simulated years where West Edmond Marsh was completely dry in summer versus years where some water remained; however, in some years the period that West Edmond Marsh was dry was underestimated. Generally, the model fit is best for East and West Edmond Marshes and weakest for Hamer Marsh.

The combination of scientific basis for the model construction and good success of the model at simulating existing conditions provides a credible basis for using the model to evaluate the consequences of the mining and restoration projects operating simultaneously.

The primary outputs from the water balance are:

1. Predictions of marsh water levels on a monthly time step
2. An estimate of the losses/gains that occur when the flow from Sequalitchew Lake is directed through the marshes under the Mining and Restoration scenario

Water Balance Scenarios

Following calibration to existing conditions, the model was used to simulate three scenarios:

- **Existing Conditions:** This scenario simulates existing conditions in the marshes using observed groundwater levels from the monitoring network.
- **With Mining – Low Groundwater:** This scenario simulates the effects of the predicted groundwater drawdown at Step 4 (i.e., the long-term condition after active dewatering has ceased). The groundwater levels used are the model results for Step 4.[5] It also subtracts the model uncertainty from the groundwater levels, providing a lower bound estimate of the predicted water levels. Only the groundwater levels beneath the marshes are changed in this scenario.
- **With Mining and Restoration – Low Groundwater:** This scenario and its results are described in the Cumulative Effects discussion in Section 4.5.1.

The marsh water balance model was not used to evaluate a No Action scenario because there is no mechanism by which the No Action alternative would affect marsh water levels.

Marsh Water Balance Results

The water balance indicates that mining, if done without the Restoration Plan, would result in lower water levels in the marshes, with the greatest change occurring in West Edmond Marsh, followed by Hamer Marsh, then East Edmond Marsh. Average monthly water levels for the 19-year period of record for the existing and mining scenarios are shown on Figure 35 and presented in Appendix F, along with results for each individual month. These results are based on the conservatively low estimate of groundwater levels resulting from mining.

On average the water level in West Edmond Marsh would be 1.9 feet lower with mining. Hamer Marsh would be 0.3 feet lower, and East Edmond Marsh would be 0.1 feet lower. The magnitude of the change would vary seasonally. For West Edmond Marsh, the greatest change in water levels would occur during the spring months, when the decrease in water level would be up to almost 3 feet in May. The smallest difference would be

[5] The monthly average of the groundwater model results was for groundwater levels beyond the end of the period of record of the DuPont groundwater model.

0.35 feet in the late summer when West Edmond Marsh is typically dry under existing condition in most, but not all, years.

Conversely, the predicted change in Hamer and East Edmond Marsh water levels, which typically retain water year-round under existing conditions, is greatest in the summer. The average decrease in Hamer Marsh water levels would be over 0.5 feet from June to November, peaking at 0.8 feet in September. The minimum decrease would be about 0.2 feet in March. Hamer Marsh receives a high volume of stormwater input in winter months, which dampens the change. The decrease in East Edmond Marsh water levels ranges from 0.13 feet in June down to 0.005 feet in February.

The water balance model predicts that Hamer Marsh would experience a greater decrease in water level than East Edmond Marsh for two reasons. First, Hamer Marsh and East Edmond Marsh have different water sources and different relationships to the groundwater table. Groundwater levels near Hamer Marsh are typically higher than the marsh by a foot or more through the winter, whereas groundwater levels are typically below the marsh water level at the east and west ends of East Edmond Marsh and similar to the marsh water level in the middle. As a result, Hamer Marsh is more dependent on groundwater inflows, particularly during the dry season. Secondly, the DuPont model uncertainty is greater in the vicinity of Hamer Marsh. Model uncertainty in the vicinity of Hamer Marsh is 0.67 feet compared with 0.18 feet for East Edmond Marsh, which results in a relatively lower groundwater elevation for Hamer Marsh under the With Mining–Low Groundwater scenario since uncertainty is subtracted from the model-predicted groundwater elevation estimates.

4.2.3.3 Sequalitchew Creek Flow

Under existing conditions, the only regularly flowing reach of Sequalitchew Creek occurs in the ravine, where springs provide the primary water source to the creek. The effect of mining on Sequalitchew Creek flows was evaluated by predicting streamflows at two locations in the ravine: the mid-ravine gage (formerly termed the “upper gage”) located approximately 2,500 feet downstream from the top of the ravine and the lower gage, located just before the creek enters the brackish marsh near its mouth.

As described in Section 3.1.6.2, dewatering conducted as part of the South Parcel Project would reduce the flow of springs in the Sequalitchew Creek ravine. The groundwater model results indicate that there would be no observable change in spring flows during the initial 10-well test (Step 1). During preparation for mining/expanded pumping test (Step 2), the reduction in spring flow is predicted to be 9 to 14 percent, with the greater reduction generally occurring in summer months and the smaller reductions occurring in winter.

At the peak of active dewatering during mining (Step 3), the reduction in spring flow would average 83 percent, ranging from 76 percent in January up to 86 percent in summer. Spring flow would return slightly in the ravine after active dewatering has ceased. The predicted reduction in Step 4 is an average of 79 percent, varying from 73 percent in January to 86 percent in summer (Aspect, 2017b). Reductions in spring flow are assumed to result in a 1:1 reduction in streamflow.

The effect of these reductions on flow in Sequalitchew Creek was accounted for by scaling the average daily flow records from the mid-ravine gage record by the corresponding monthly percent reductions in spring flow. This analysis conservatively overestimates the impact of mining on streamflows, particularly during winter months, as the entire flow in the creek is assumed to result from a spring source and was scaled down accordingly. The hydrograph indicates that surface and stormwater contribute a portion of the flows in Sequalitchew Creek during rainy periods. These inflows would not be affected by mining, but nonetheless were scaled down in this analysis.

The resulting hydrograph of predicted flows in Sequalitchew Creek at the mid-ravine gage if mining were to occur without mitigation is shown on Figure 36. This hydrograph represents long-term conditions after the cessation of active dewatering (Step 4). The average flow in Sequalitchew Creek would be reduced from 1.6 cfs to 0.34 cfs.

4.2.3.4 Isolated Lake and Wetland Water Levels

Wetland 1D and the isolated kettle water bodies, such as Old Fort Lake, Pond Lake, and the similar lakes and wetlands located farther south, would potentially be affected by the change in groundwater levels associated with mining. The effects on these water bodies would vary depending on the proximity to the South Parcel Project.

Surface water levels in Wetland 1D and the isolated kettle wetlands have generally been identified as fluctuating with the groundwater system. Since these wetlands do not have surface water outlets, for simplicity sake, the change in surface water levels in them can conservatively be assumed to be comparable to the decline in groundwater level. In actuality, lower permeability sediments in the water bodies will likely dampen and delay the magnitude of the change in groundwater levels.

Wetland 1D is the closest isolated water body to the South Parcel Project. The groundwater model predicts that groundwater levels beneath Wetland 1D would decrease by about 3 feet in the long term (Figure 25). The surface water level in Wetland 1D is, thus, expected to be lowered by about 3 feet with the Proposed Action. The change in water levels would be negligible in Step 1 of dewatering, about 1 foot in Step 2, and about 3 feet in Step 3 (see Figures 22 to 24, respectively).

There is also the potential for aquifer drawdown to extend south to the isolated kettle wetlands. For the long term/post-mining dewatering scenario (Step 4), the groundwater model predicts about 2 feet of aquifer drawdown beneath Pond Lake decreasing to closer to 1 foot near Wetlands #8 through #11. Old Fort Lake would experience about 0.5 feet of groundwater drawdown. As with Wetland 1D, these changes in groundwater levels are expected to result in essentially equivalent changes in surface water levels in the water bodies.

Figure 37 presents the hydrographs for Pond Lake and Old Fort Lake illustrating the existing water levels and predictions with the Proposed Action. Pond Lake typically dries up in spring and summer. With the Proposed Action, Pond Lake would go dry earlier and refill later in some years depending on the amount of rainfall in that particular year. In addition, the high water levels would be lowered by the change in groundwater. Old Fort Lake retains water year-round. With the Proposed Action, its water level would be lowered by the change in groundwater levels, predicted to be 0.5 feet or less in the long

term. Because of the large natural fluctuation, the analysis indicates the predicted change will be effectively masked by natural variability.

4.3 Effects of the No Action Alternative

Under the No Action alternative, the South Parcel could be developed for a manufacturing and research park or residential land use based on existing zoning. There would be no changes to use of the existing mine under the No Action alternative; the Kettle Wetland and Buffer Area would remain intact.

If built out under existing zoning, the No Action alternative would result in creation of a substantial amount of impervious area within the South Parcel from roads and building roofs. Presumably, given the extremely porous soils, all stormwater from this development would be managed with infiltration. The land use characteristics for the No Action alternative are shown in Table 16.

A water balance was developed for the No Action alternative using WWHM similar to the approach described in Section 4.2.1. Results from the water balance are shown in Table 17. The water balance indicates that the No Action alternative would reduce evapotranspiration by about 25 percent relative to existing conditions (i.e., from 744 to 595 acre-feet per year) as forest is replaced with impervious areas and landscaping. Precipitation that is not evaporated or transpired either recharges groundwater directly or generates stormwater. Because all stormwater is assumed to be infiltrated, the total groundwater recharge increases from 944 acre-feet per year under existing conditions to 1,093 acre-feet per year with the No Action alternative. This is also higher than recharge that would occur under the Proposed Action. As with the Proposed Action, the nature of the groundwater recharge would shift from broadly distributed recharge under existing conditions to focused infiltration in discrete locations.

Potential impacts to stormwater quality include increased sediment during construction or land disturbing activity and potential contamination from future uses. Standard source control measures (construction BMPs, education efforts, proper storage, etc.) would reduce the potential for impacting stormwater quality. All stormwater generated would likely be infiltrated. The large separation between the land surface and the aquifer would provide significant protection for the aquifer. That separation would likely be reduced, but not eliminated, under any future mining actions.

4.4 Mitigation Measures

This section describes the mitigation measures included in the Proposed Action to mitigate impacts to surface water and stormwater. The mitigation measures are presented in three subsections:

- **Mine Best Management Practices**–Describes the BMPs used within the mine to manage stormwater and prevent erosion.
- **Monitoring Plan**–Summarizes the monitoring and adaptive management plan developed to ensure that the impacts of dewatering on groundwater levels are consistent with the model predictions.

- **Sequalitchew Creek Watershed Restoration Plan**–Provides an overview of the restoration plan that more than mitigates for the impacts to surface water of the Proposed Action through watershed-wide action to restore flows in Sequalitchew Creek from Sequalitchew Lake to Puget Sound.

4.4.1 Mine Best Management Practices

The following mitigation measures within the mine area are included in the Proposed Action:

- The mine area would be excavated as a closed depression, preventing off-site runoff of stormwater.
- Mine stormwater would be infiltrated in ponds located on the mine bottom.
- A minimum vertical separation of at least 5 feet would be maintained between the pond bottom and the seasonal high groundwater table.
- Water quality treatment facilities would be provided upstream of the infiltration ponds to protect their long-term infiltration capacity.
- The proposed stormwater management system must comply with Ecology and City of DuPont stormwater regulations.
- A Reclamation Plan, pursuant to the Surface Mining Act (RCW 78.44), would be prepared and implemented. The Reclamation Plan would be submitted to DNR for review and approval prior to issuing a revised surface mine reclamation permit required for mining. Implementation of the reclamation plan is guaranteed by posting of financial security required by RCW 78.44.
- An erosion and sediment control plan would be prepared and implemented in accordance with the requirements of DMC 22.01.180.
- Compliance with the NPDES Sand and Gravel General Permit would continue. Required actions include preparation and implementation of a SWPPP, erosion and sediment controls, monitoring, compliance with effluent limits, and specific BMPs for industrial activities. These actions would be subject to inspection and review by Ecology as required by the Sand and Gravel General Permit.

4.4.2 Monitoring Plan

The South Parcel Monitoring Plan (Monitoring Plan; Aspect, 2017a) defines the groundwater monitoring program and adaptive management plan aimed at ensuring that the actual changes in groundwater levels during dewatering are consistent with predicted values. The Monitoring Plan is part of the Proposed Action.

The overall goal of the Monitoring Plan, as specified in the 2011 Settlement Agreement, is to *"…include a series of monitoring actions to allow a comparison of predicted and actual changes in groundwater draw-down levels, and a process for the Parties to meet and confer if groundwater monitoring results do not meet the criteria provided in the Monitoring Plan."*

The Monitoring Plan articulates a series of goals, objectives, and performance thresholds. Goals are the overarching principles behind the Monitoring Plan. Objectives identify specific, measurable elements that are undertaken to meet the goals of a project. The performance threshold defines the measure of success used to assess whether an objective is met. Failure to meet a performance threshold will trigger the adaptive management process and require iterative additional actions until it is met.

The goals, objectives and performance thresholds of the Monitoring Plan for the South Parcel Project are:

Goal 1. Maintain groundwater at or above predicted levels beneath Edmond Marsh and Sequalitchew Creek.

- **Objective 1A.** Groundwater levels at monitoring wells near Edmond Marsh and Sequalitchew Creek are at or above predicted levels.
- **Performance Threshold.** Monthly groundwater level measurements are at or above target levels established for each step of the dewatering process at each well and for each month of the year, based on statistical analysis of groundwater model predictions over a range of historical climate conditions. Initial target levels are included in Appendix A of the Monitoring Plan.

Goal 2. Maintain groundwater conditions conducive to safe and efficient mining and processing of the South Parcel aggregates.

- **Objective 2A**. Moisture content of mined aggregate is at appropriately low levels for safe and efficient mining and processing.

Groundwater levels will be monitored during dewatering. The monitoring network will include 18 of the existing monitoring wells and the proposed new dewatering wells and observation wells to be installed as a component of the Proposed Action. The existing monitoring wells are located throughout the Sequalitchew Creek watershed as shown on Figure 12 and include wells in DuPont and on JBLM, near each of the major marshes, and on the South Parcel itself. Water level monitoring will vary during the different dewatering steps but will generally consist of continuous monitoring in the wells on the South Parcel and the closest marsh wells, and monthly or twice monthly manual measurements in the remaining wells.

The groundwater levels observed during dewatering will be compared with predicted groundwater elevations for the appropriate dewatering step. The Monitoring Plan defines the predicted groundwater levels at each well during each month of the year for each dewatering step in Appendix A of the Monitoring Plan. The predictions were developed from the DuPont model results for the maximum decrease in water level for the relevant dewatering step plus an estimate of model uncertainty. As such they represent a conservatively low set of groundwater levels on which to base the assessment of environmental impacts to surface water bodies. As long as actual groundwater levels remain above these thresholds during mining, reviewers can be confident that impacts to surface water will be less than or equal to what was predicted.

The Monitoring Plan (Aspect, 2017a) also defines an adaptive management process for the key parties to follow throughout the dewatering and mining. The process is based on five steps:

A. Assess – Information is compiled from monitoring data, geologic investigations, groundwater modeling, and other available sources. The compiled information is used to identify issues, refine objectives, and screen potential alternative approaches. Predictions of the potential effects of the action on groundwater levels are developed.

B. Design – Based on the results of the assessment stage, design of the Proposed Action proceeds. Design will result in a specific plan of action, and supporting evaluations to ensure that the anticipated results are consistent with the identified objectives, the Monitoring Plan, and prior environmental assessments. Predictions of groundwater levels are refined as the design evolves. Analyses conducted during the design stage could result in an iterative process of assessment and design. Any required permitting is also included in the design stage.

C. Implement & Monitor – The approved plan is put into action, concurrently with monitoring focused on key indicators tied to the identified objectives. Monitoring data indicating conditions worse than forecasted are acted on rapidly, moving into the evaluation and adjustment stages.

D. Evaluate – Monitoring data are evaluated relative to the objectives and forecasted results developed in the assessment and design stages. Differences between forecasts and results are identified and the causes for those differences investigated.

E. Adjust – Information learned in previous steps is used to adjust the actions, if necessary. The Monitoring Plan provides an initial identification of potential adjustments in each dewatering step, but additional adjustments could be developed to fit specific situations.

The adaptive management process is iterative and would repeat until the South Parcel Project is completed. If an adjustment is identified, the process would begin again from the assessment and design stages, followed by implementation of the adjustment and associated monitoring, then evaluation and further response (if necessary). If an adjustment is not necessary, then the process still repeats. In this case, the assessment and design stages would largely rely on the previously approved plans, but there is still potential for more minor refinements based on the information learned.

Throughout the adaptive management process, status updates, monitoring data, and final reports will be shared. If adjustments are unsuccessful in meeting predicted groundwater levels, the Monitoring Plan defines the Meet and Confer process required under the 2011 Settlement Agreement for determining the appropriate additional steps.

The adaptive management process is a little different during each step of the dewatering process, as, for example, Steps 1 and 2 are completely reversible and more limited in extent than the later steps. The Detailed Adaptive Management Plan section of the Monitoring Plan outlines the specifics of how adaptive management would be implemented during each step of the mining and dewatering process.

4.4.3 Sequalitchew Creek Watershed Restoration Plan

The Sequalitchew Creek Watershed Restoration Plan (Restoration Plan; 2018) was developed as a component of the 2011 Settlement Agreement to restore flows and ecological functions in Sequalitchew Creek and Edmond Marsh. The Settlement Agreement articulates five required components of the Restoration Plan:

1. Improvement of gradients so water discharges from Hamer and Bell Marshes flow into Edmond Marsh rather than into the diversion canal.
2. Improvements to create significant flows from Sequalitchew Lake into the Edmond Marsh complex to support a functional creek ecosystem, and provide for the passage of migratory fish in the Sequalitchew Creek system. To achieve this goal, the Parties to the 2011 Settlement Agreement will consider, at minimum, modification of the diversion canal flood control structure and gradients.
3. Rehabilitation of Edmond Marsh by removal of sufficient fill and other flow impediments to provide the hydraulic gradients and capacity necessary to achieve and maintain adequate flows through the Marsh.
4. Rehabilitation of Sequalitchew Creek below Edmond Marsh to reduce seepage, improve fish habitat, and help restore year-round flows.
5. Active management of beaver activities to maintain the hydraulic gradients that provide flows through Hamer, Bell, and Edmond Marshes.

Through a public process, led by the South Puget Sound Salmon Enhancement Group (SPSSEG) followed by work with the Environmental Caucus and CalPortland, the required components were honed into 12 specific restoration elements, listed in Table 21 for elements within the City of DuPont and Table 22 for elements on JBLM. The locations of Restoration Plan elements throughout the watershed are shown on Figure 38.

The elements of the Restoration Plan can be grouped into five categories of actions:

1. Regulatory Actions
2. Flow Restoration
3. Flow Maintenance and Enhancement
4. Habitat Restoration

Regulatory actions are a precursor to implementation of the Restoration Plan, involving updates to the City of DuPont's critical areas ordinance to support the restoration activities. This element has been completed in June 2021 through the City's update to the Critical Areas code (Ordinance 21-1094).

The next three categories directly align with the objectives of the Restoration Plan. Restoring flows would primarily occur through beaver management and modifications in the lake outlet area to seasonally raise the Sequalitchew Lake level and remove potential channel obstructions. Flow maintenance and enhancement involves removal of channel constrictions (e.g., replacing a portion of the trail that bisects Edmond Marsh with a pedestrian bridge) to reduce the potential for ongoing beaver obstructions and evaluation

of Hamer Marsh as a potential source of additional water. Habitat restoration would remove several potential barriers to fish passage and restore or enhance aquatic habitat in important portions of the watershed.

4.5 Cumulative Effects of Proposed Action and Restoration Plan

This section describes the cumulative effects of the Proposed Action and implementation of the related Restoration Plan on surface water bodies in the Sequalitchew Creek watershed. The effects of the Proposed Action alone were previously described in Section 4.2.

4.5.1 Marsh Water Levels

The cumulative effects of Mining and Restoration scenario on marsh water levels were estimated using the water balance model described in Section 4.2.3.2. The water balance model was run with an additional scenario representing the combination of mining and implementation of the Restoration Plan and includes the following:

- **Low Groundwater Levels** – The Mining and Restoration scenario uses the estimates of groundwater levels for Step 4 that incorporate uncertainty (i.e., are conservatively low) described in Section 3.2.1.
- **Beaver Management** – Consistent with element 2.B of the Restoration Plan, flexible levelers are installed with the goal of maintaining marsh water levels at the following targets, recommended in SPSSEG (2014). For the model run, these elevations are assumed to represent fixed spillways throughout the year:
  - East Edmond Marsh, east of DuPont-Steilacoom Road = 210.5 feet
  - East Edmond Marsh, west of DuPont-Steilacoom Road = 209 feet
  - West Edmond Marsh = 206.5 feet
- **Sequalitchew Lake** – The monthly observed outflows from the lake are routed into Eastern East Edmond Marsh.
- **Hamer Marsh Weir** – Consistent with element 3.E of the Restoration Plan, a weir is installed in the main outlet of Hamer Marsh. Prior documents are not specific about the target elevation of the weir, so it was assumed to be at elevation 215 feet, which is about 0.5 feet higher than winter water levels at the start of the monitoring period and about the same as later winter water levels.
- **Hamer Marsh Culvert to Edmond Marsh** – Since replacing the Hamer Marsh culvert connecting to Edmond Marsh is a contingent action, depending on a study of water quality in Hamer Marsh, it was assumed not to be replaced. No additional surface water flow was assumed to be routed from Hamer Marsh to Edmond Marsh.
- **Dry Reach** – Consistent with element 3.G of the Restoration Plan, infiltration of flowing water into the channel bottom of the normally dry reach was assumed to be zero, either through natural or constructed lining of this reach.

Results from the marsh water balance analysis of the with Mining and Restoration – Low Groundwater scenario are included in Appendix F.

Marsh Water Levels with Mining and Restoration

The water balance model predicts that the water levels in East and West Edmond Marshes would generally be controlled at their restoration target elevations (see Figure 35) under the Mining and Restoration scenario. These elevations are significantly lower than the current water levels in these marshes. The decrease in marsh water levels is primarily influenced by beaver management under the Restoration Plan aimed at achieving water levels necessary to ensure east-to-west flow through the marsh system into Sequalitchew Creek. The changes in water surface elevations in the marshes are necessary to allow for flow from Sequalitchew Lake to reach Sequalitchew Creek ravine. Currently, the water levels in East Edmond Marsh are higher than the typical lake level of about 210.5 to 211.5 feet, preventing any outflow from the lake from reaching the marshes.

Generally, there would be little variation in marsh water levels, as there would almost always be more than enough flow from Sequalitchew Lake to keep the wetlands full to their target elevations. However, there are several summers during the simulation period when water levels in Edmond Marsh would dip below the target elevations for a month or more. These events are visible on Figure 35 as the slight dips in July and August below the relatively constant elevation line. The hydraulic gradient through the marshes would always be maintained, however, as the water level in East Edmond never dips below the water level in East Edmond Marsh.

The target water levels of the Mining and Restoration scenario achieve a difference in water surface elevations of 4 to 5 feet between the lake (typically 210.5 to 211.5 feet) and West Edmond Marsh (target elevation 206.5 feet). Over the 8,700-foot flow path through the marshes, these water levels would result in a hydraulic gradient of 0.0006 feet per foot. This is a very low gradient; however, one or more broad (20+ feet), shallow (< 2 feet) channels at this gradient would have sufficient capacity to convey the peak outflows from Sequalitchew Lake. Flow velocities in this system would be low (<1 foot per second).

The water balance may overestimate the change in marsh water levels because it treats large areas of the marsh as single, contiguous water body with the same elevation. When implementing the Restoration Plan, the restoration managers could adaptively manage wetland water levels through the use of flexible levelers and other beaver management devices at more locations throughout the marshes, creating smaller steps in water level. In addition, beaver ponds off the main channel through the marshes from Sequalitchew Lake could be maintained at higher elevations without impeding flow along the channel.

Gains/Losses in the Marshes

Under the Mining and Restoration scenario, the outflow from Sequalitchew Lake would once again enter the marshes, given that the barriers to flow have been removed or lowered to provide a positive gradient to the Sequalitchew Creek ravine. As water travels through the marshes, it would still be subject to potential gains from precipitation, stormwater inflows, or discharge from groundwater, as wells as losses to evapotranspiration or infiltration to groundwater.

Gains and losses to flow from Sequalitchew Lake as it passes through the marshes varies throughout the year. In most months (September to June), the marsh system would add to the flow, as shown in Table 23. In drier months (July and August), the gain would be negligible, or some flow would be lost in the wetlands (up to 3 percent) to evapotranspiration or infiltration. Losses during the drier months balanced with gains during the winter result in an average annual increase in flow of 12 percent. Summertime losses are also important because they occur at times when less water is present in the system and so highlight periods of net reduction in flow through the marsh system.

Table 23. Average Gains/Losses in Wetlands with Proposed Action and Restoration Plan

Month	Average Inflow from Sequalitchew Lake in cfs	Average Outflow to Sequalitchew Creek in cfs	Gain (+) or Loss (-)	
			in cfs	Percent
January	15.8	18.5	2.7	17%
February	19.8	22.0	2.2	11%
March	22.2	24.3	2.1	10%
April	20.4	21.9	1.6	8%
May	13.4	14.6	1.2	9%
June	7.7	8.5	0.8	10%
July	3.4	3.5	0.0	1%
August	2.5	2.4	-0.1	-3%
September	2.2	2.4	0.2	10%
October	3.7	4.7	1.0	26%
November	7.1	8.8	1.7	25%
December	11.0	13.2	2.2	20%
Average	10.75	12.05	1.3	12%

Note: cfs = cubic feet per second

4.5.2 Edmond Marsh Water Quality

The proposed mining and restoration projects would affect water quality in East Edmond and West Edmond Marsh through flushing with a high volume of water with better quality than the water in the marshes under existing conditions. The anticipated changes were evaluated qualitatively by comparing the water quality conditions in the outflow from Sequalitchew Lake with water quality conditions in the marshes.

The residence time in the wetlands would reduce significantly, decreasing from weeks to months under existing conditions to days with the Mining and Restoration scenario. As a result, the water quality in the wetlands would be dominated by the input from Sequalitchew Lake. Dissolved oxygen would be higher and the pH slightly more neutral. Temperature and turbidity have been about the same between the lake and the marshes, so little change would be anticipated.

It is anticipated that the elevated iron concentrations observed in the center of Edmond Marsh would be resolved through flushing and dilution with Sequalitchew Lake water. The iron concentration in the outflow from Sequalitchew Lake has been measured on only one occasion (at 0.13 mg/L), well below the elevated levels of 3 to 5 mg/L observed in Edmond Marsh near the railroad trail bridge and related seeps. Iron concentrations in

the marshes receiving flow from Sequalitchew Lake could be expected to have iron concentrations near, but slightly above, the concentration in the lake.

Iron is necessary for aquatic life but can be toxic at higher concentrations. There is no state water quality criterion for iron in surface waters, but British Columbia has established a water quality guideline for total iron of 1 mg/L in surface water (Phippen et al, 2008). As the iron concentration in Sequalitchew Lake outflow is nearly an order of magnitude lower that this criterion, the iron concentration in the Edmond Marsh during and after mining and restoration is anticipated to be well below 1 mg/L.

4.5.3 Sequalitchew Creek Streamflow

The cumulative effects of the Proposed Action and Restoration Plan were predicted for two reaches of Sequalitchew Creek: the normally dry reach between the outlet of West Edmond Marsh and the top of the ravine, and the upper portion of the ravine.

4.5.3.1 Dry Reach

Under existing conditions, the reach of Sequalitchew Creek between the outlet of West Edmond Marsh and the top of the ravine experiences no consistent flow passing through the entire reach. This occurs because there is little outflow from West Edmond Marsh and the bottom of the channel in this reach is above the groundwater levels and has been disturbed by prior human activity, so any outflow readily infiltrates into the coarse native soils.

Together, the Proposed Action and Restoration Plan are predicted to result in an average flow of 12.6 cfs in the dry reach. The flow would vary seasonally from a monthly average of 2.5 cfs in August to 25.7 cfs in March as shown on Figure 39. Peak flows could be as high as 65 cfs if all water is routed through the wetlands during peak flow events. To avoid flooding during peak flows, JBLM may seek to continue to route a portion of peak flows to the Diversion Canal. The results presented here do not account for the diversion of peak flows.

With the Proposed Action and Restoration, there would be some periods when water would not flow from West Edmond Marsh or in the dry reach. Water balance model results, based on hydrologic conditions observed over the 19-year period of record, indicate that water would not flow through the dry reach due to dry conditions on 401 days (or 7.7 percent of the time). These dry periods were predicted to last for multiple weeks to several months and occurred in five of the 19 years simulated by the model (2004, 2005, 2015, 2017, and 2018). These reflect periods in the historical record when there was no flow over the Diversion Canal weir.

Streamflow in the dry reach was calculated by adjusting the daily average outflows from Sequalitchew Lake from 2003 to 2021 by the estimates of the gains or losses that would occur in the wetlands based on the results of the water balance model. The dry reach was assumed to have a sealed bed under restored conditions (either naturally or through contingent restoration actions), so no gains or losses were assumed to occur within the dry reach.

The predictions of streamflow in the dry reach are subject to uncertainty resulting from several sources including: (1) the historical measurement of streamflow at the Diversion

Weir, (2) the estimates of gains and losses from the water balance model, and (3) the temporal effects of streamflow routing as water travels through the marshes. The uncertainty associated with streamflow measurement at the weir is anticipated to be low (<10 percent) as weirs provide a reliable hydraulic section for streamflow measurement. However, as the outflow from Sequalitchew Creek is by far the largest factor affecting streamflow in Sequalitchew Creek, once the Restoration Plan is implemented even low uncertainty in the flow measurement can be important.

Uncertainty in the water balance stems from multiple factors including the application of precipitation and evaporation historical observations to the project site; challenges in estimating hydraulic conductivity throughout a large, submerged area; errors with estimating the storage-surface area-elevation relationships of the marshes; changing hydraulic controls over time through beaver activity, difficulties estimating parameters like the hydraulic conductivity of beaver dams or the locations where shallow subsurface flow between marshes may occur; and uncertainties in the estimates of groundwater levels with mining (see discussion in Section 3.2.1.6).

To reduce the potential impact of these uncertainties, several conservative assumptions (i.e., assumptions which overestimate losses in the marshes, or otherwise underestimate flow through the marshes) were used:

1. Low Groundwater Levels – The groundwater levels subtract the estimate of model uncertainty, resulting in a low estimate of groundwater levels and thus higher losses from the marshes. In addition, no additional surface water flow was assumed to come from Hamer Marsh under the Restoration Plan.

2. Restoration of Surface Flows from Hamer Marsh Not Included – Additional surface water flow from Hamer Marsh was not included in the With Mining and Restoration – Low Groundwater scenario because it is a contingent element. If this element is implement, and initial indications are that JBLM plans to route surface water outflows from Hamer Marsh to Eastern East Edmond Marsh, additional flow would pass through the marshes and benefit Sequalitchew Creek.

Finally, these predictions do not account for the effects of storage in the wetlands as flow from Sequalitchew Lake is routed through them. This uncertainty only affects the With Mining and Restoration – Low Groundwater scenario. The effects of storage will likely be beneficial to streamflow by attenuating flows and spreading it over multiple days, which in some cases may reduce the number of days of periods without flow in the Dry Reach.

4.5.3.2 Upper Sequalitchew Creek Ravine

Streamflow passing through the dry reach of Sequalitchew Creek would continue into the top of the Sequalitchew Creek ravine. In this reach groundwater discharges from the ravine springs, augmenting flow in the creek. The dewatering component of the Proposed Action would significantly decrease the flow from the springs as described in Sections 3.2.4.2 and 4.2.3.3, but there would continue to be some spring discharge to the creek.

Streamflow in Sequalitchew Creek with the Proposed Action and Restoration Plan can be predicted by starting with the flows in Sequalitchew Creek from the dry reach (see Section 4.5.3.1) and adding the predicted flows in upper Sequalitchew Creek with the

Proposed Action alone. The Restoration Plan would have no effect on the ravine spring flows.

The annual average flow in upper Sequalitchew Creek ravine would be 12.9 cfs and the monthly average would vary from a low of 2.5 cfs in August to a high of 26.3 cfs in March. The resulting hydrograph of predicted flows in the upper Sequalitchew Creek ravine with the Proposed Action and Restoration Plan is shown on Figure 40.

There would be periods when the cumulative effects of the Proposed Action and Restoration Plan are predicted to result in a reduction in flows at the mid-ravine gage when compared with the observed existing condition. Post-project flows are predicted to be lower during 45 periods, lasting a total of 475 days over the 19 years evaluated, or about 10 percent of the time. During 24 of those days, there would be no flow at the mid-ravine gage. Under observed existing conditions, there were 7 days with no measurable flow at the gage.

The median duration of a period when flows would be lower with the Proposed Action and Restoration Plan (hereafter referred to as a "lower flow event") would be 3 days, but there were 7 lower flow events lasting more than 2 weeks long. The longer events occurred in 6 of the 19 years simulated (2004, 2005, 2015, 2016, 2017, and 2018). The longest single lower flow event was 98 days ending in October 2017. However, lower flow events dominated the summer and fall of 2005, when there were four lower flow events between July 20 and December 23 lasting a total of 134 days. Lower flow events occurred most commonly in July, August, September, and October, but occasionally occurred in all months except March. The average streamflow during lower flow events was 0.83 cfs under existing conditions and would be 0.44 cfs with the Proposed Action and Restoration Plan. The decrease in streamflow during lower flow events ranged from less than 0.1 cfs up to 1.6 cfs.

Streamflow in the lower reach of Sequalitchew Creek can be expected to be similar to the upper reach. Once Sequalitchew Creek crosses the truncation of the Olympia Beds, neither the Proposed Action nor the Restoration Plan would affect the spring discharge to the creek nor infiltration from the creek to groundwater. Flows in the lower ravine reach are higher than in the upper ravine reach as gains from stormwater and spring discharge exceed losses to infiltration. This condition can be expected to continue, though the magnitude of the gains will be minor relative to the restored flow.

4.5.4 Sequalitchew Creek Water Quality

The Mining and Restoration projects would affect stream temperature in the Sequalitchew Creek ravine by introducing a large quantity of water of different temperature. The effects would vary seasonally as the volume of water from Sequalitchew Lake, and its associated temperature varies. In summer, the outflow from Sequalitchew Lake is warmer than Sequalitchew Creek; in winter, it is colder.

The change in stream temperature was evaluated quantitatively by using a linear mixing equation to calculate average monthly temperatures based on observed temperature data and predicted streamflows from the outflow from the marshes and the groundwater discharge from the ravine springs. Generally, the outflow from Sequalitchew Lake has

higher summer temperatures and lower winter temperatures due to exposure to the atmosphere.

The outflow from the marshes was represented by the monthly average flow rates from West Edmond Marsh from the water balance and the observed temperature data for Sequalitchew Lake plus an additional 1°C added to conservatively account for warming that may occur in the marshes (even though monitoring data indicate that water temperatures in the marshes are generally similar to lake temperatures). The groundwater discharge to Sequalitchew Creek was based on the estimate of post-mining spring discharges to the ravine and the observed Sequalitchew Creek temperature data.

This analysis is limited by the quality of the available temperature data. Grab samples are representative of the specific time and location they were taken, but do not represent the diurnal temperature variation, or spatial variations within a water body. As such, care should be taken in comparing the results of this analysis with temperature criteria based on multiple day averages of daily maximum temperatures.

Sequalitchew Creek would experience warm temperatures in June, July, and August, with temperatures reaching up to 21°C and cool temperatures in winter, down to 5 to 6°C. The seasonal pattern of average monthly temperatures in Sequalitchew Creek with mining and restoration are shown on Figure 41. The predicted stream temperatures would be considerably warmer than the current spring discharge in the creek for most of the year. The surface water quality criterion for temperature applicable to Sequalitchew Creek is 16°C for the 7-day average of daily maximums. The analysis based on grab samples suggests that this threshold may be exceed from May through September.

The change in stream temperature reflects a return toward historical conditions when the warmer outflow from Sequalitchew Lake would pass through marshes before flowing down the Sequalitchew Creek ravine.

4.6 Significant Unavoidable Adverse Impacts

The Proposed Action in conjunction with the Restoration Plan would result in the following significant, unavoidable adverse impacts to surface waters within the Sequalitchew Creek watershed:

- Water levels in Edmond Marsh would be lower than existing conditions by up to 3 feet. This impact is primarily attributable to the Restoration Plan and is necessary to achieve flow from Sequalitchew Lake to the Sequalitchew Creek ravine. However, the change in water level also includes the impact of changes in groundwater levels from dewatering for mining.
- Water levels in isolated lakes and kettle wetlands would be lower by the amount of the change in groundwater levels from dewatering. The decrease would be 3 feet for Wetland 1D, 2 feet for Pond Lake, 1 foot for Wetlands #8 to #11, and 0.5 feet for Old Fort Lake.
- There would be periods, approximately 10 percent of the time, when flows in Sequalitchew Creek with the Proposed Action and Restoration Plan would be lower than under existing conditions.

- Water temperature in Sequalitchew Creek would be warmer than under existing conditions from April through September and would likely exceed the 7-day average of daily maxima criterion of 16°C in multiple months between May and September.

No significant unavoidable adverse impacts to surface waters are anticipated from direct effects of the Proposed Action (i.e., activities within the mine area acting directly on stormwater or surface water).

5 References

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6 Limitations

Work for this project was performed for the CalPortland (Client), and this report was prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. This report does not represent a legal opinion. No other warranty, expressed or implied, is made.

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TABLES

Table 1. Summary of Existing and Post-Reclamation Land Uses for Proposed Action

Project No. 040001, Pioneer Aggregates South Parcel Project, DuPont, Washington

Land Use	Area [1] in Acres									
	Existing Conditions					Proposed Action - Post-Reclamation				
	Expansion Area			Re-Mine Area	Total	Expansion Area			Re-Mine Area	Total
	South Parcel	Kettle Area	Buffer Strip			South Parcel	Kettle Area	Buffer Strip		
Built Areas										
Buildings	--	--	--	--	0.00	--	--	--	--	0.00
Roads, Access, and Parking	--	--	0.4	9.2	9.55	--	--	--	--	0.00
Processing Areas	--	--	0.2	17.9	18.08	--	--	--	--	0.00
Active Mining	--	--	--	--	0.00	--	--	--	--	0.00
Active Reclamation	--	--	0.2	20.5	20.62	--	--	--	--	0.00
Cleared for Mining	--	--	--	--	0.00	--	--	--	--	0.00
Water Management Ponds	--	--	--	--	0.00	--	--	--	--	0.00
Total Built Areas	0	0	0.8	47.5	48.26	0	0	0.00	0.00	0.00
Natural & Reclaimed Areas										
Areas Reclaimed as Forest	--	--	--	3.3	3.3	29.4	0.6	0.6	35.8	66.3
Areas Reclaimed as Grass	--	--	--	68.5	68.5	138.2	10.2	8.6	89.4	246.4
Wooded Areas	146.2	5.6	7.4	5.8	165.1	--	--	--		0.0
Grass Areas	21.3	--	1.0	0.21	22.5	--	--	--		0.0
Wetland	--	1.8	--		1.8	--	--	--		0.0
Wetland Buffer	--	3.4	--		3.4	--	--	--		0.0
Total Natural & Reclaimed Areas	167.5	10.8	8.4	77.7	264.5	167.5	10.8	9.2	125.2	312.7
Total	167.5	10.8	9.2	125.2	312.7	167.5	10.8	9.2	125.2	312.7

Notes:

-- Indicates no area of this type.

1) Totals may not exactly equal the sum of their components due to rounding.

Table 5. Well Data Inventory

Project No. 040001-I-018, Pioneer Aggregates South Parcel Project, DuPont, Washington

Name	Owner	Installation Date	Easting (ft, WA State Plane South, NAD83)	Northing (ft, WA State Plane South, NAD83)	Measurement Point Elevation (ft, NGVD29)	Ground Surface Elevation (ft, NGVD29)	Total Depth (ft, bgs)	Total Depth Elevation (ft, NGVD 29)	Bottom of screen elevation (ft, NGVD29)	Top of screen elevation (ft, NGVD29)	Monitoring Status
CHMW-1	CalPortland	9/24/1999	1106696.99	656314.27	211.41	209.41	85	124.41	124.91	136.41	Active
CHMW-2D	CalPortland	11/18/1999	1106700.16	658200.38	209	207.2	73	134.2	134.7	146	Active
CHMW-2S	CalPortland	11/19/1999	1106705.29	658216.29	209.39	207.94	43	164.94	165.44	176.39	Active
CHMW-3D	CalPortland	11/5/1999	1105047.94	655341.87	218.35	216	85	131	131.5	140.5	Active
CHMW-3S	CalPortland	11/5/1999	1105040.23	655354.29	218.49	216	40	176	176.5	185.5	Active
CHMW-4D	CalPortland	11/11/1999	1106579.69	654911.11	215.91	214	85	129	129.5	138.5	Active
CHMW-4S	CalPortland	11/23/1999	1106568.15	654917.67	215.765	214	37	177	177.5	186.5	Active
OB-1	CalPortland	2/15/1991	1106246.36	661167.18	210.72	208.72	239.5	-30.78	-20.58	-0.18	Active
MW-BM-1	CalPortland	8/3/2004	1110307.50	651349.59	232.32	229.37	25	204.37	204.37	214.37	Active
MW-93-MFS-C5-3	JBLM	2/23/1993	1108505.09	659437.53	219.32	216.52	30.2	186.32	186.52	196.32	Active
MW-D-3	JBLM	8/5/1996	1108925.35	657457.41	212.47	209.94	24	185.94	185.94	195.94	Active
MW-EM-1D	CalPortland	12/11/2002	1107470.10	653789.74	210.29	207.3	32	175.3	175.3	185.3	Active
MW-EM-1S	CalPortland	12/11/2002	1107470.10	653789.74	210.23	207.3	5	202.3	202.3	204.8	Active
MW-EM-2D	CalPortland	12/2/2002	1109620.41	653048.09	214.2	212.1	50	162.1	162.1	172.1	Active
MW-EM-2S	CalPortland	12/2/2002	1109620.41	653048.09	214.95	212.1	5	207.1	207.1	209.6	Active
MW-EM-3	CalPortland	3/11/2004	1111866.67	653569.41	217.38	214.63	20	194.63	194.63	204.63	Inactive*
MW-HM-1	CalPortland	8/2/2004	1113393.29	652867.84	221.06	217.75	20.3	197.45	197.75	207.45	Active
MW-PL-1	CalPortland	7/26/2006	1106163.60	651040.56	205.51	202.76	4.15	198.61	198.61	201.61	Active
MW-SRC-2	JBLM	NA	1116574.08	653674.67	234.62	232.76					Active
88-2-VD	JBLM	11/17/1988	1111621.47	657093.03	221.74	219.31	49	170.31	181.31	173.74	Inactive
MW-SL-1	CalPortland	3/11/2004	1113520.44	655737.40	217.74	214.94	20.3	194.64	194.94	199.64	Active
MW-WL1D-1	CalPortland	7/26/2006	1108902.03	653804.55	212.31	209.56	3.9	205.66	205.66	208.66	Active

Note:

* EM-3 is temporarily inaccessible due to unknown lock.

Table 6. Summary of Hydrostratigraphic Units and Calibrated Parameter Values

Project No. 040001, Pioneer Aggregates South Parcel Project, DuPont, Washington

Hydrostratigraphic Unit in DuPont Model	Correlated USGS Hydrogeologic Unit and Partial Description	Principal Layers in DuPont Model	Horizontal Hydraulic Conductivity (feet/day)					Vertical Anisotropy (-)	Specific Yield (-)	Specific Storage (1/foot)	for Horizontal Hydraulic Conductivity (feet per day)	
			Max.	75 percentile	Average	25 percentile	Min.	horizontal: vertical			USGS median	Dupont Works RI
Steilacoom Gravel	A1 – "recessional outwash…sand and gravel deposited by large meltwater streams…"	1,2	3,900	1,600	1,100	350	36	2.7	0.07	6.1E-05	933	18
Upper Confining Unit	A2 – "low-permeability unit composed of Vashon till and lesser amounts of ice-contact, moraine and fine-grained glaciolacustrine deposits…"	3	1.61	0.47	0.33	0.16	0.017	1.0	0.07	5.0E-05	18	
Vashon Outwash	A3 – "aquifer composed of Vashon advance outwash…"	4,5	49	11	7.7	2.4	0.27	15.1	0.09	2.7E-05	122	34
Olympia Beds (Qob)	B – "low-permeability unit composed of fine-grained silts and clays deposited during the Olympia interglacial…"	6,7	0.018 (uniform)					10.0	0.09	1.1E-04	21	
Sea Level Aquifer	C – "aquifer composed of pre-Olympia glacial drift deposits consisting of sand and gravel…"	8,9	690 (uniform)					6.3	0.18	6.0E-05	96	63

Notes:

1 USGS reference: Savoca et al., 2010.

2 Dupont Works RI reference: Hart Crowser, 1994.

Table 7. Predicted Groundwater Dewatering Rates by Step

Project No. 040001, Pioneer Aggregates South Parcel Project, DuPont, Washington

Month	Dewatering Pumping Rate in cfs			
	Step 1	Step 2	Step 3	Step 4
January	4.1	6.2	8.2	0
February	3.9	5.7	7.6	0
March	3.9	5.7	7.6	0
April	3.8	5.6	7.4	0
May	3.6	5.3	7.0	0
June	3.4	4.9	6.5	0
July	3.1	4.4	5.8	0
August	3.0	4.2	5.5	0
September	3.0	4.2	5.6	0
October	3.3	4.6	6.0	0
November	4.0	5.9	7.8	0
December	4.1	6.1	8.1	0
Average	3.6	5.2	6.9	0
Minimum	2.6	3.6	4.7	0
Maximum	5.5	8.8	12.2	0

Notes:

1. Monthly values represent average for that month throughout the simulation period.
2. Average row represents the average of all months in the simulation period.
3. Minimum and maximum represent the lowest and highest individual values from the entire simulation period.

Table 8. Well-Specific Maximum Water Level Changes

Project No. 040001, Pioneer Aggregates South Parcel Project, DuPont, Washington

Well	Predictive Model Results													
	Maximum Decrease in Water Level in feet based on Refined Model Results				Calculating Adjustment for Model Uncertainty						Maximum Decrease in Water Level in feet based on Refined Model Results and including Model Uncertainty			
					Standard Deviation	Range in Observed Values	Model Uncertainty in Feet							
	Step 1	Step 2	Step 3	Step 4			Step 1	Step 2	Step 3	Step 4	Step 1	Step 2	Step 3	Step 4
MW-EM-1S	0.50	1.61	5.44	5.00	1.75	7.56	2.39	2.72	3.86	3.73	2.90	4.33	9.29	8.73
MW-EM-1D	0.47	1.51	5.12	4.71	0.98	7.90	1.34	1.50	2.08	2.01	1.81	3.01	7.20	6.72
MW-EM-2S	0.06	0.15	0.35	0.33	0.35	2.39	0.46	0.48	0.52	0.51	0.52	0.63	0.87	0.84
MW-EM-2D	0.07	0.17	0.39	0.36	0.30	2.54	0.39	0.41	0.44	0.43	0.46	0.58	0.83	0.80
MW-EM-3	0.01	0.02	0.02	0.02	0.14	3.00	0.19	0.19	0.19	0.19	0.20	0.21	0.21	0.21
CHMW-1	1.30	5.23	59.79	30.47	0.92	9.48	1.34	1.83	8.62	4.97	2.64	7.06	68.41	35.44
CHMW-2S	7.37	45.45	50.98	29.92	0.71	7.55	1.79	6.37	7.04	4.50	9.17	51.82	58.01	34.43
CHMW-2D	8.80	45.20	50.79	31.76	0.66	6.89	1.91	6.35	7.03	4.71	10.71	51.55	57.83	36.47
CHMW-3S	0.83	3.24	53.86	52.76	1.55	10.80	2.14	2.58	11.87	11.67	2.97	5.82	65.73	64.43
CHMW-3D	0.10	2.70	57.02	50.29	1.51	10.43	1.96	2.44	12.53	11.28	2.05	5.14	69.56	61.57
CHMW-4S	0.95	3.14	14.33	13.79	1.03	9.54	1.45	1.76	3.31	3.23	2.40	4.90	17.64	17.02
CHMW-4D	0.76	2.96	15.03	14.01	0.92	9.40	1.27	1.55	3.06	2.94	2.03	4.51	18.10	16.95
MW-SRC-2	0.29	0.33	0.30	0.34	0.61	6.70	0.82	0.82	0.82	0.82	1.11	1.15	1.12	1.16
MW-D-3	1.79	4.27	7.68	6.55	0.97	7.77	1.54	1.93	2.48	2.30	3.33	6.20	10.16	8.85
MW-93-MFS-C5-3	1.40	2.73	4.21	3.63	1.01	7.26	1.55	1.79	2.05	1.95	2.96	4.52	6.27	5.58
88-2-VD	0.40	0.57	1.41	1.35	0.69	2.85	1.01	1.06	1.31	1.30	1.41	1.63	2.72	2.64
MW-BM-1	0.21	0.35	0.39	0.74	0.46	5.72	0.62	0.63	0.64	0.67	0.83	0.98	1.03	1.41
MW-HM-1	0.25	0.41	0.27	0.41	0.59	5.95	0.78	0.80	0.79	0.80	1.03	1.21	1.05	1.22
MW-PL-1	0.10	0.35	1.10	1.01	1.55	6.04	2.02	2.10	2.34	2.32	2.11	2.45	3.44	3.33

Notes:

1. Model predictions are presented at the typical field-measurement precision (0.01 ft).
2. Refined model results correct for calibration offset.
3. Model uncertainty calculated for 95% lower confidence interval for 1-tailed test.
4. Shaded values indicate forecasted change in water level exceeds half the range in observed values.
5. Calculated water levels may be below bottom of well.

Table 10. Minimum Predicted Groundwater Levels for Each Dewatering Step

Project No. 040001, Pioneer Aggregates South Parcel Project, DuPont, Washington

Step 1 - Initial Pumping Test

Well	Groundwater Elevation in Feet (NGVD 29)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MW-EM-1S	203.6	202.4	202.9	202.2	202.3	201.4	200.4	200.4	199.5	199.5	202.1	202.9
MW-EM-1D	204.6	203.4	203.9	203.2	203.3	202.5	201.5	201.5	200.7	200.7	203.1	203.9
MW-EM-2S	210.6	210.3	210.4	210.3	210.2	210.0	209.7	209.6	209.3	209.5	210.2	210.4
MW-EM-2D	210.8	210.4	210.6	210.5	210.4	210.2	209.8	209.7	209.4	209.6	210.4	210.5
MW-EM-3	212.1	211.9	211.8	211.9	212.0	211.6	211.4	210.8	210.2	210.3	211.5	211.9
MW-SRC-2	213.2	212.4	212.7	212.6	212.8	212.0	211.4	210.2	209.6	210.5	212.3	212.7
MW-BM-1	218.0	217.0	216.6	217.4	217.3	216.6	216.1	213.1	213.3	214.2	216.8	217.4
MW-HM-1	214.2	213.5	213.3	213.8	213.6	212.7	211.8	211.2	210.6	211.1	213.1	213.6
MW-PL-1	200.8	200.1	200.4	200.1	200.0	199.4	198.6	198.7	198.0	197.7	199.6	200.2
CHMW-1	191.3	189.9	190.4	189.6	189.7	189.0	188.1	188.0	187.4	187.5	190.0	190.7
CHMW-2S	184.6	183.3	183.7	183.0	183.0	182.5	181.7	181.6	181.2	181.4	183.5	184.0
CHMW-2D	183.4	181.8	182.4	181.4	181.5	180.8	179.8	179.7	179.3	179.4	182.1	182.7
CHMW-3S	193.3	191.7	192.4	191.3	191.5	190.6	189.6	189.5	188.7	188.8	191.7	192.6
CHMW-3D	193.2	191.5	192.2	191.1	191.3	190.4	189.2	189.1	188.3	188.4	191.5	192.5
CHMW-4S	196.1	194.7	195.3	194.4	194.6	193.7	192.7	192.6	191.9	191.9	194.6	195.5
CHMW-4D	194.3	192.9	193.5	192.6	192.7	191.9	190.9	190.8	190.1	190.1	192.8	193.6
MW-D-3	196.5	195.3	195.7	195.0	195.1	194.6	193.9	193.7	193.3	193.5	195.6	195.9
MW-93-MFS-C5-3	192.3	191.2	191.7	191.0	191.0	190.5	190.0	189.9	189.5	189.8	191.6	191.7

Table 10. Minimum Predicted Groundwater Levels for Each Dewatering Step

Project No. 040001, Pioneer Aggregates South Parcel Project, DuPont, Washington

Step 2 - Preparation for Mining/Expanded Dewatering Test

Well	Groundwater Elevation in Feet (NGVD 29)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MW-EM-1S	202.3	201.1	201.6	200.9	201.1	200.1	199.1	199.2	198.4	198.3	200.8	201.5
MW-EM-1D	203.4	202.3	202.8	202.2	202.3	201.4	200.5	200.5	199.7	199.7	202.0	202.7
MW-EM-2S	210.6	210.2	210.3	210.2	210.1	210.0	209.6	209.5	209.2	209.4	210.1	210.3
MW-EM-2D	210.8	210.4	210.5	210.4	210.3	210.1	209.7	209.6	209.3	209.5	210.3	210.5
MW-EM-3	212.1	211.9	211.8	211.9	212.0	211.6	211.4	210.8	210.2	210.3	211.5	211.9
MW-SRC-2	213.2	212.4	212.6	212.6	212.8	212.0	211.4	210.2	209.5	210.5	212.0	212.7
MW-BM-1	218.0	217.0	216.5	217.3	217.2	216.6	216.1	213.0	213.3	214.1	216.8	217.3
MW-HM-1	214.2	213.4	213.3	213.8	213.6	212.7	211.8	211.2	210.5	211.1	213.0	213.6
MW-PL-1	200.4	199.7	200.1	199.8	199.8	199.1	198.2	198.4	197.7	197.4	199.2	199.8
CHMW-1	187.0	185.7	186.3	185.5	185.6	184.9	184.0	184.0	183.3	183.4	185.8	186.4
CHMW-2S	143.8	141.4	142.2	141.0	141.0	140.1	139.1	138.9	138.3	138.6	141.8	142.9
CHMW-2D	142.5	141.0	141.6	140.7	140.7	140.0	139.1	138.9	138.3	138.5	141.2	141.9
CHMW-3S	190.6	189.0	189.8	188.8	189.0	188.1	187.0	187.0	186.2	186.2	189.0	189.8
CHMW-3D	190.2	188.6	189.4	188.3	188.5	187.5	186.3	186.3	185.4	185.3	188.4	189.3
CHMW-4S	193.7	192.3	193.0	192.1	192.3	191.4	190.4	190.4	189.6	189.6	192.2	193.0
CHMW-4D	191.8	190.5	191.2	190.3	190.5	189.6	188.6	188.6	187.8	187.8	190.4	191.1
MW-D-3	193.7	192.5	193.0	192.3	192.3	191.9	191.2	191.1	190.7	190.9	192.9	193.4
MW-93-MFS-C5-3	190.8	189.8	190.3	189.6	189.6	189.1	188.7	188.5	188.2	188.5	190.2	190.5

Table 10. Minimum Predicted Groundwater Levels for Each Dewatering Step

Project No. 040001, Pioneer Aggregates South Parcel Project, DuPont, Washington

Step 3 - Active Dewatering during Mining

Well	Groundwater Elevation in Feet (NGVD 29)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MW-EM-1S	197.5	196.4	196.9	196.4	196.5	195.6	194.7	194.8	194.1	194.1	196.1	196.8
MW-EM-1D	199.4	198.4	198.9	198.3	198.4	197.6	196.8	196.9	196.2	196.2	198.1	198.7
MW-EM-2S	210.3	210.0	210.1	209.9	209.9	209.7	209.4	209.3	209.0	209.2	209.9	210.0
MW-EM-2D	210.5	210.1	210.3	210.1	210.0	209.8	209.5	209.4	209.1	209.3	210.0	210.2
MW-EM-3	212.1	211.9	211.8	211.9	212.0	211.6	211.4	210.8	210.2	210.3	211.5	211.8
MW-SRC-2	213.2	212.4	212.7	212.6	212.8	212.0	211.4	210.2	209.5	210.5	212.0	212.7
MW-BM-1	217.8	216.8	216.4	217.2	217.1	216.4	215.9	212.8	213.1	213.9	216.7	217.2
MW-HM-1	214.2	213.4	213.3	213.8	213.6	212.7	211.8	211.2	210.4	211.1	213.0	213.6
MW-PL-1	199.4	198.7	199.0	198.8	198.7	198.0	197.1	197.3	196.6	196.2	198.1	198.8
CHMW-1	129.8	129.1	129.4	128.9	128.9	128.5	127.8	127.8	127.3	127.4	129.2	129.5
CHMW-2S	136.0	134.5	135.0	134.1	134.1	133.5	132.9	132.8	132.3	132.5	134.9	135.5
CHMW-2D	135.9	134.7	135.1	134.3	134.2	133.7	133.1	132.9	132.4	132.6	134.9	135.5
CHMW-3S	131.1	128.4	130.3	128.9	129.2	127.9	126.6	127.0	126.2	126.3	129.0	130.2
CHMW-3D	128.3	127.4	127.9	127.6	127.6	126.8	125.8	126.1	125.4	125.1	127.0	127.6
CHMW-4S	181.0	179.7	180.4	179.6	179.7	178.8	177.7	177.8	176.9	176.9	179.5	180.3
CHMW-4D	178.5	177.3	178.0	177.1	177.3	176.4	175.3	175.4	174.5	174.4	177.1	177.8
MW-D-3	189.9	188.6	189.1	188.4	188.4	187.9	187.4	187.3	186.9	187.3	189.1	189.6
MW-93-MFS-C5-3	189.5	188.5	189.0	188.4	188.3	187.9	187.5	187.4	187.2	187.5	189.0	189.3

Table 10. Minimum Predicted Groundwater Levels for Each Dewatering Step

Project No. 040001, Pioneer Aggregates South Parcel Project, DuPont, Washington

Step 4 - Cessation of Active Dewatering

Well	Groundwater Elevation in Feet (NGVD 29)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MW-EM-1S	198.1	197.0	197.6	197.0	197.1	196.2	195.4	195.3	194.8	194.7	196.8	197.4
MW-EM-1D	199.9	198.9	199.4	198.8	199.0	198.2	197.3	197.3	196.7	196.7	198.7	199.3
MW-EM-2S	210.3	210.0	210.1	210.0	209.9	209.7	209.4	209.3	209.0	209.2	209.9	210.1
MW-EM-2D	210.5	210.2	210.3	210.1	210.1	209.9	209.5	209.4	209.1	209.3	210.1	210.2
MW-EM-3	212.1	211.9	211.8	211.9	212.0	211.6	211.4	210.8	210.2	210.3	211.5	211.8
MW-SRC-2	213.2	212.4	212.7	212.6	212.8	212.0	211.4	209.9	209.4	210.4	212.0	212.7
MW-BM-1	217.9	216.9	216.4	217.2	217.1	216.5	216.0	212.3	213.0	213.8	216.7	217.2
MW-HM-1	214.2	213.4	213.3	213.8	213.6	212.7	211.8	211.0	210.3	211.1	213.0	213.6
MW-PL-1	199.5	198.8	199.2	198.9	198.9	198.2	197.3	197.5	196.8	196.4	198.2	198.9
CHMW-1	163.2	162.7	162.9	162.7	162.6	162.4	162.1	162.1	161.8	162.0	162.9	163.1
CHMW-2S	169.3	165.0	168.1	163.2	162.8	158.9	157.1	157.2	156.2	156.9	167.9	168.8
CHMW-2D	160.3	158.5	159.2	158.1	157.9	156.9	155.4	155.5	154.6	155.2	159.1	159.8
CHMW-3S	140.4	140.2	140.3	140.2	140.2	140.0	139.7	139.7	139.5	139.7	140.3	140.3
CHMW-3D	141.9	141.6	141.8	141.6	141.6	141.4	141.1	141.1	140.9	141.0	141.6	141.8
CHMW-4S	183.0	181.9	182.5	181.8	181.9	181.3	180.5	180.5	179.9	180.0	181.9	182.4
CHMW-4D	181.0	180.0	180.6	179.9	180.0	179.4	178.7	178.7	178.2	178.2	180.0	180.5
MW-D-3	191.4	190.2	190.7	190.0	189.9	189.5	188.9	188.8	188.5	188.9	190.7	191.1
MW-93-MFS-C5-3	190.1	189.1	189.5	188.9	188.8	188.4	187.9	187.9	187.6	188.0	189.6	189.9

Table 11. Surface Water Monitoring Station Inventory

Project No. 040001, Pioneer Aggregates South Parcel Project, DuPont, Washington

	Name	Water Body	Equipment Owner	Installation Date	Type of Station	Easting (ft, WA State Plane South, NAD83)	Northing (ft, WA State Plane South, NAD83)	Elevation Reference Point		Monitoring Status
								Elevation (ft, NGVD29)	Description	
Existing	SC-Lower	Sequalitchew Creek	CalPortland	Jul-1999	Flow (Continuous)	1101642.74	657543.91	NA	NA	Active
	SC-MidRavine*	Sequalitchew Creek	CalPortland	Nov-2003	Flow (Continuous)	1103973.25	655338.83	NA	NA	Active
	SG-PL-1	Pond Lake	CalPortland	Nov-2006	Stage	1106120.45	651239.82	201.52	0 ft stage	Active
	SG-WL1D-1	Wetland 1D	CalPortland	Jul-2006	Stage	1108981.52	653867.36	208.69	0 ft stage	Active
	SG-EM-1A	West Edmond Marsh	CalPortland	May-2004	Stage	1107329.98	653655.47	210.98	0 ft stage	Active
	SG-EM-1	West Edmond Marsh	CalPortland	Mar-2004	Stage	1107490.44	653659.66	209.87	3.0 ft mark on gage plate	Active
	SG-EM-2W	West Edmond Marsh	CalPortland	Mar-2004	Stage	1109561.81	653049.07	211.48	3.0 ft mark on gage plate	Active
	SG-EM-2E	East Edmond Marsh	CalPortland	Mar-2004	Stage	1109729.75	653546.46	213.43	2.0 ft mark on gage plate	Active
	SG-EM-3W	East Edmond Marsh	Unknown	Unknown	Stage	1111778.38	653532.65	212.31	33 3/4" mark on gage plate	Active
	SG-EM-3E	Eastern Edmond Marsh	CalPortland	Mar-2004	Stage	1111965.63	653528.97	213.43	3.0 ft mark on gage plate	Active
	SG-SCM-1	Eastern Edmond Marsh	CalPortland	Mar-2004	Stage	1113265.44	655679.85	213.20	3.0 ft mark on gage plate	Inactive*
	Diversion Weir	Sequalitchew Lake Outlet	CalPortland	Jul-1999	Flow (Continuous)	1113401.28	655929.72	NA	NA	Active
	SG Bubbler	Sequalitchew Lake Outlet	CalPortland	Jul-1999	Stage	1113401.28	655929.72	213.43	3.0 ft mark on gage plate	Active
	SG-DC-1	Diversion Canal	CalPortland	Mar-2004	Stage and Flow (Spot)	1111721.14	656276.19	207.15	3.0 ft mark on gage plate	Active
	SG-DC-2	Diversion Canal	CalPortland	Mar-2004	Stage and Flow (Spot)	1108840.82	657413.52	205.80	3.0 ft mark on gage plate	Active
	SG-DC-3	Diversion Canal	CalPortland	Mar-2004	Stage and Flow (Spot)	1108512.74	659518.19	202.60	3.0 ft mark on gage plate	Active
	SG-HM-1	Hamer Marsh	CalPortland	Mar-2004	Stage	1113805.80	654636.68	215.25	3.0 ft mark on gage plate	Active
	SG-MKM-1	McKay Marsh	CalPortland	Mar-2004	Stage	1113599.35	652792.46	216.27	3.0 ft mark on gage plate	Active
	SG-BM-1	Bell Marsh	CalPortland	Aug-2004	Stage	1110518.87	651232.41	215.31	2.0 ft mark on gage plate	Active

Notes:

NA - Not applicable

1) Mid-Ravine gage was formerly known as SC-Upper.

2) Staff gage has been stolen or removed by unknown party.

3) Future monitoring locations are identified in the Monitoring Plan or Reclamation Plan.

Table 12. Surface Water Elevations in Sequalitchew Creek Watershed

Project No. 040001, Pioneer Aggregates South Parcel Project, DuPont, Washington

Water Body	Monitoring Location	Water Surface Elevation in ft NGVD 29		
		Average	Minimum	Maximum
Sequalitchew Lake	SG at Bubbler	211.17	209.51	211.91
Bell Marsh	SG-BM-1	218.58	213.31	219.91
McKay Marsh	SG-MKM-1	215.43	213.27	217.35
Hamer Marsh	SG-HM-1	214.02	211.67	215.58
Eastern East Edmond Marsh	SG-SCM-1	212.44	210.20	213.46
	SG-EM-3E	212.39	211.07	213.54
East Edmond Marsh	SG-EM-3W	212.39	210.44	213.29
	SG-EM-2E	212.10	210.20	212.93
West Edmond Marsh	SG-EM-2W	211.35	209.64	212.14
	SG-EM-1/1A	207.91	205.27	210.22
Pond Lake	SG-PL-1	203.90	201.65	207.36
Wetlands 1D	SG-WL1D-1	209.98	208.63	211.00

Notes:

Period of record varies by location, but most began in March 2004 and include data through January 2022

Table 13. Summary of Surface Water Flows in Sequalitchew Creek

Project No. 040001, Pioneer Aggregates South Parcel Project, DuPont, Washington

Month	Average Flow in cfs				
	Diversion Weir	Mid-Sequalitchew Creek Ravine	Lower Sequalitchew Creek Ravine		
	2003 to 2021	2004 to 2021	1977 to 1978	1984 to 1987	1999 to 2021
January	15.6	2.5	9.7	5.9	4.0
February	19.6	2.6	12.8	8.5	4.2
March	21.5	2.2	12.2	8.7	3.8
April	19.8	2.0	0.7	9.4	3.2
May	12.7	1.6	1.6	7.8	2.7
June	7.4	1.2	1.5	3.7	1.9
July	3.2	0.9	0.2	1.3	1.3
August	2.8	0.8	0.1	1.0	1.1
September	2.4	0.8	0.1	1.0	1.1
October	3.7	0.8	0.1	1.4	1.4
November	7.1	1.3	2.4	3.7	2.6
December	10.9	1.9	10.5	5.1	3.5
Mean Annual Flow	10.5	1.6	4.3	4.8	2.7

Note: cfs = cubic feet per second

Table 15. Summary of Surface Water Quality in Sequalitchew Creek Watershed

Project No. 040001, Pioneer Aggregates South Parcel Project, DuPont, Washington

Location	Temperature in °C			Dissolved Oxygen in mg/L			pH			Turbidity in NTU			Iron in µg/L		
	Median	Range	n	Median	Range	n	Median	Range	n	Median	Range	n	Median	Range	n
Sequalitchew Lake	12.8	3.2 to 26.4	100	9.2	0 to 14.3	99	6.9	5.6 to 8.9	97	3.0	0 to 121	92	130	--	1
Marshes	10.5	2.7 to 22.2	74	4.0	0.0 to 11.3	58	6.5	5.6 to 8.1	72	1.85	0.7 to 7.7	41	409	5 to 5000	35
Sequalitchew Creek	10.8	4 to 16.5	157	10.6	0 to 14.3	152	7.0	4.1 to 8.2	162	1.4	0 to 10.1	136	16	5 to 617	21

Notes:
n = number of samples
mg/L = milligrams per liter
µg/L = micrograms per liter

Table 16. Land Use Scenarios Used in Mine Area Water Balance

Project No. 040001, Pioneer Aggregates South Parcel Project, DuPont, Washington

	Area in Acres												
	Till Lawn			Outwash Forest			Outwash Pasture	Outwash Lawn			Saturated, Forest, Flat	Impervious		
Scenario	Flat	Mod.	Steep	Flat	Mod.	Steep	Flat	Flat	Mod.	Steep		Flat	Steep	Total
Existing Conditions	38.5	0.0	0.0	145.9	10.0	3.3	21.7	60.6	74.0	109.6	1.8	13.6	3.4	482.4
Proposed Action	79.2	193.4	47.0	0.0	0.0	0.0	0.0	25.7	41.5	90.4	4.3	0.0	1.0	482.5
No Action	38.5	0.0	0.0	13.8	10.0	3.3	1.2	94.8	74.0	109.6	1.8	131.9	3.4	482.4

Notes:

The total area represents basins C, D,E which include the disturbed area of the South Parcel Project as well as portions of the existing mine that drain to the proposed stormwater facilities. The same total area was used for each scenario to allow for consistency in comparison between scenarios

Till Lawn is used to represent portions of the floor of the existing mine, as well as the Olympia Beds in the Proposed Action

Outwash Forest is used for the undisturbed South Parcel

Outwash Lawn represents bare and reclaimed mine slopes (prior to tree growth) as well as lawn and landscaping under No Action.

Saturated Forest Flat represents the Kettle Wetland and the constructed mitigation wetland

Impervious areas are used for the main access road in the Proposed Action and paved roads and buildings under No Action.

Table 17. Annual Average Mine Area Water Balance

Project No. 040001, Pioneer Aggregates South Parcel Project, DuPont, Washington

Water Balance Component	Water Quantity in Acre Feet and Percent of Annual Precipitation			Basis for Estimate
	Existing	Proposed Action	No Action	
Water Sources				
Precipitation	1688 (25%)	1688 (25%)	1688 (25%)	WWHM - Pierce County158-year synthetic precipitation series
Run-on/Springs	0 (0%)	4995 (75%)	0 (0%)	Field observations, topography and geology for Existing and No Action; groundwater model for Proposed Action
Groundwater Inflow	4995 (75%)	0 (0%)	4995 (75%)	Groundwater model predictions
Water Losses				
Evapotranspiration	744 (10%)	706 (6%)	595 (8%)	Calculated by balance
Direct Groundwater Recharge	840 (11%)	542 (4%)	648 (8%)	WWHM model results
Infiltrated Stormwater	104 (1%)	440 (3%)	445 (6%)	WWHM model results, assuming all stormwater is infiltrated under development scenarios
Inflitrated Groundwater	0 (0%)	4995 (39%)	0 (0%)	Groundwater model predictions
Total Groundwater Recharge	944 (12%)	5977 (47%)	1093 (14%)	Sum of direct groundwater recharge, infiltrated stormwater, and infiltrated groundwater
Groundwater Outflow	5939 (78%)	5977 (47%)	6088 (78%)	Equal to groundwater inflow + total groundwater recharge

Notes:

1) Quantities presented for precipitatoin, evapotranspiration, direct groundwater recharge and infiltrated stormwater represent the overall average from the 158-year WWHM model runs.

2) Quantities presented for run-on/springs and groundwater inflow are based on the estimated annual average of dewatering water during Step 3 from the DuPont groundwater model.

Table 18. Peak Surface Runoff Flows

Project No. 040001, Pioneer Aggregates South Parcel Project, DuPont, Washington

Recurrence Interval	Annual Exceedance Probability	Peak Flow in cfs								
		Basin C			Basin D			Basin E		
		Existing Conditions	Proposed Action	No Action	Existing Conditions	Proposed Action	No Action	Existing Conditions	Proposed Action	No Action
2 year	0.5	4.3	9.6	8.1	3.6	13.9	39.5	1.7	0.9	7.3
5 year	0.2	7.2	18.4	12.1	6.1	26.9	53.3	3.4	2.5	10.5
10 year	0.1	9.9	26.5	15.4	8.3	38.6	63.4	5.0	4.5	13.0
25 year	0.04	14.2	39.6	20.4	12.1	57.3	77.2	8.0	8.9	16.8
50 year	0.02	18.4	51.9	24.7	15.7	74.4	88.4	11.0	14.2	19.9
100 year	0.01	23.5	66.5	29.7	20.2	94.6	100.2	15.0	22.2	23.4

cfs = cubic feet per second

Table 21. Restoration Plan Elements in City of DuPont

Project No. 040001, Pioneer Aggregates South Parcel Project, DuPont, Washington

Element	Components
1. Regulatory Actions	
A. DuPont CAR	Update the City of DuPont's Critical Areas Regulations - Completed in June 2021
2. Flow Restoration	
B. Beaver Management	Manage beaver and beaver dams Monitor flows and adaptively manage flexible levelers
3. Flow Maintenance and Enhancement	
F. Railroad Trail Bridge	Planning for DuPont Railroad Trail bridge Install DuPont Railroad Trail bridge
G. Losing Reach	Remove trash and invasive vegetation Monitor Losing Reach Seal Losing Reach (?) and restore habitat
4. Habitat Restoration	
H. City Hall Culvert	Replace the culvert near City Hall
I. Center Drive Culvert	Evaluate Center Drive culvert Modify Center Drive culvert (?)
J. Ravine Habitat	Monitor habitat changes after flow restoration *Add large woody debris (LWD) to ravine (?)* *Replace footbridge/remove berm (?)*
L. Southern alignment	Evaluate scope and feasibility of southern alignment Southern alignment implementation (?)

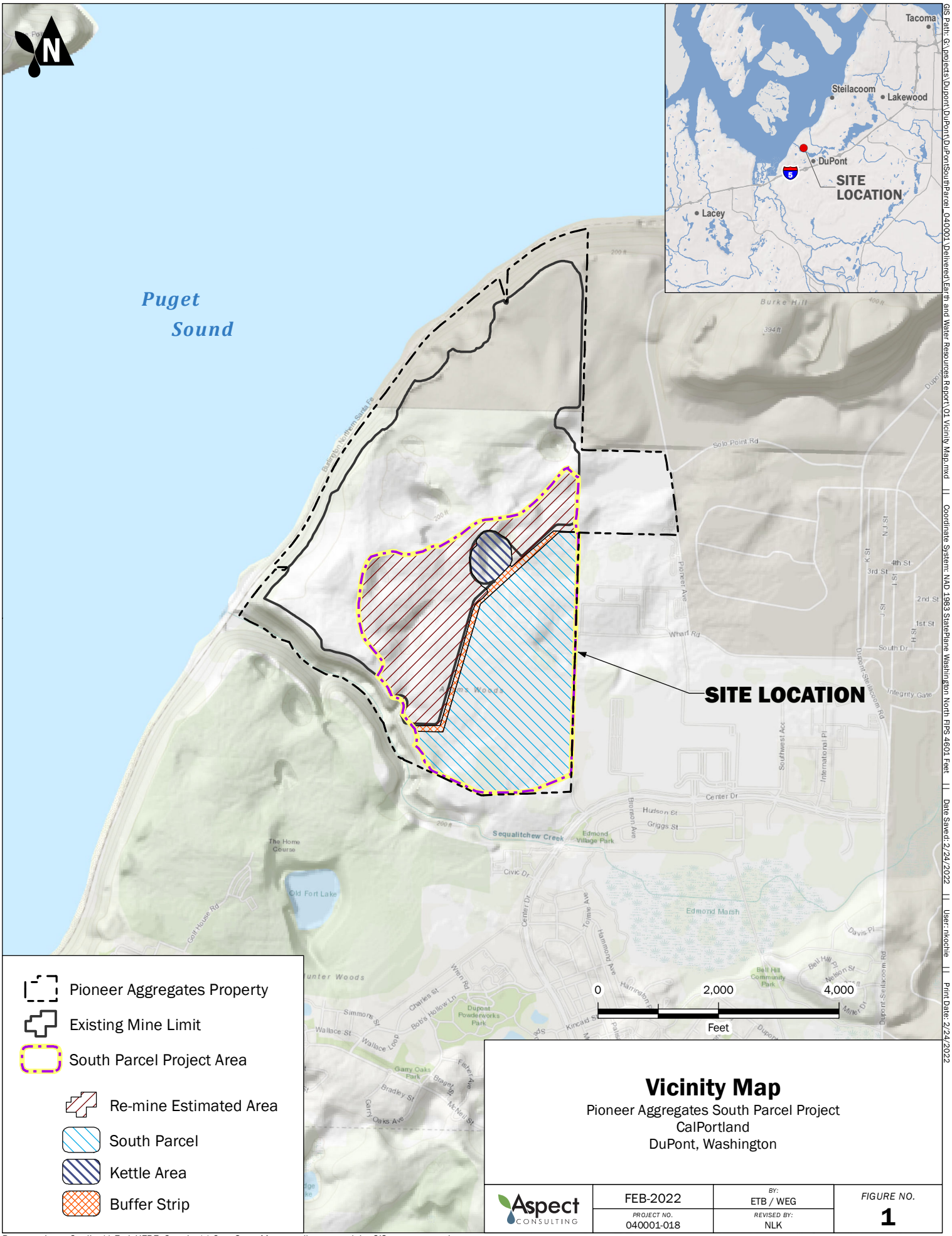
Notes:
(?) = action contingent on prior monitoring/evaluation.
Bold font indicates initial actions.
Underlined font indicates the second stage of actions (following partial restoration of flows).
Italic font indicates the final stage of actions (following full restoration of flow

Table 22. Restoration Plan Elements on JBLM

Project No. 040001, Pioneer Aggregates South Parcel Project, DuPont, Washington

Element	Components
2. Flow Restoration	
B. Beaver Management	Remove dam at east end of Edmond Marsh
	Clear culverrt at DuPont-Steilacoom Road and install beaver exclusion device
C. Adjustment of Sequalitchew Lake Levels	Install an additional stop log in weir or gate valve to allow for seasonal adjustment of lake water level
D. Improvements in Lake Outlet Area (Part 1)	Planning for removal of crossover culverts
	Repair cross-over culverts by replacing the bottom set and replacing the top set with an open channel. Remove some fill to increase channel width and reduce obstructions
3. Flow Maintenance and Enhancement	
E. Hamer Marsh	Install weir at outlet
	Study water quality in Hamer Marsh
	Repair culvert between Hamer Marsh and Edmond Marsh if water quality is adequate
4. Habitat Restoration	
K. Improvements in Lake Outlet Area (Part 2)	Repair Lake Outlet Area by relocating diversion weir a few hundred feet downstream then improving wetland area behind it by removing old weir and secondary weir, extending lower set of cross-over culverts, removing fill, and regrading and planting wetland vegetation.

FIGURES



Vicinity Map

Pioneer Aggregates South Parcel Project
CalPortland
DuPont, Washington

Aspect CONSULTING	FEB-2022	BY: ETB / WEG	FIGURE NO. 1
	PROJECT NO. 040001-018	REVISED BY: NLK	

Basemap Layer Credits || Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

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N

Puget Sound

Infiltration Ponds

Stormwater Treatment Ponds

Processing Area

Proposed Constructed Mitigation Wetland

Existing Mine

Infiltration Pond

Stormwater Treatment Ponds

South Parcel Project

Noise/Visual Screening Berm

Sequalitchew Creek

CENTER DRIVE

- Existing Mine Limit
- Ponds
- South Parcel
- Proposed Constructed Mitigation Wetland
- South Parcel Project Area
- Pierce County Tax Parcel
- 10-ft. Contour
- Proposed Mine 25-ft Contour

Note: Existing topography based on aerial photogrammetric survey conducted on 10/30/2021 by David C. Smith & Associates, Inc. Vertical datum = NGVD29

0 600 1,200
Feet

Project Site Plan

Pioneer Aggregates South Parcel Project
CalPortland
DuPont, Washington

Aspect Consulting	FEB-2022	BY: ETB / WEG	FIGURE NO. 2
	PROJECT NO. 040001-18	REVISED BY: NLK	

No Action Site Plan

Pioneer Aggregates South Parcel Project
CalPortland
DuPont, Washington

Aspect CONSULTING	FEB-2022	BY: ETB / WEG	FIGURE NO. 3
	PROJECT NO. 040001-18	REVISED BY: NLK	

GIS Path: G:\projects\Dupont\DuPont\DuPontSouthParcel_040001\Delivered\Earth and Water Resources Report\03 No Action Site Plan.mxd || Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet || Date Saved: 2/24/2022 || User: nkochie || Print Date: 2/24/2022

Existing Mine Limit
South Parcel
South Parcel Project Area
Pierce County Tax Parcel
20-ft. Contour

Note: Existing topography based on aerial photogrammetric survey conducted on 10/30/2021 by David C. Smith & Associates, Inc. Vertical datum = NGVD29

0 600 1,200
Feet

Existing Topography

Pioneer Aggregates South Parcel Project
CalPortland
DuPont, Washington

Aspect CONSULTING	FEB-2022	BY: ETB / WEG	FIGURE NO. 4
	PROJECT NO. 040001-18	REVISED BY: NLK	

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Puget Sound

0B-1
TW-1
NW013
NW018
NW025
NW023
NW024
WY014
WY018
WY016
WY024
WY022
WY023
WY063
WY010
WY015
WY019
WY020
WY025
WY028
WY061
84-PA-264
WY062
WY009
WY011
WY027
WY021
WY017
WY057
WY087
WY088
WY126
WY127
WY013
WY008
WY012
WY026
WY059
WY058
WY073
WY030
WY089
WY066
WY128
WY005
WY007
WY074
WY078
WY060
WY056
WY072
WY093
WY081
WY083
WY124
CHMW-2S
CHTW-2
TW-2
WY004
WY006
WY075
WY076
WY077
WY079
WY080
WY055
WY064
WY082
WY129
WY039
WY041
WY042
WY045
WY112
WY110
WY071
WY070
WY067
WY068
WY111
WY114
WY040
WY044
WY048
WY047
WY103
WY104
WY117
WY116
WY113
WY043
WY046
WY049
WY101
WY102
WY118
WY122
WY123
TW-1
CHMW-1
WY052
WY100
WY050
WY119
WY121
WY035
WY053
TW-3
WY099
WY105
WY107
WY036
WY037
WY051
CHMW-3S
CHTW-3
CHMW-3D
TW-4S
WY108
WY106
WY120
WY032
CHMW-4S
WY038
TW-4D
CHTW-4D
Sequalitchew Creek

0 500 1,000
Feet

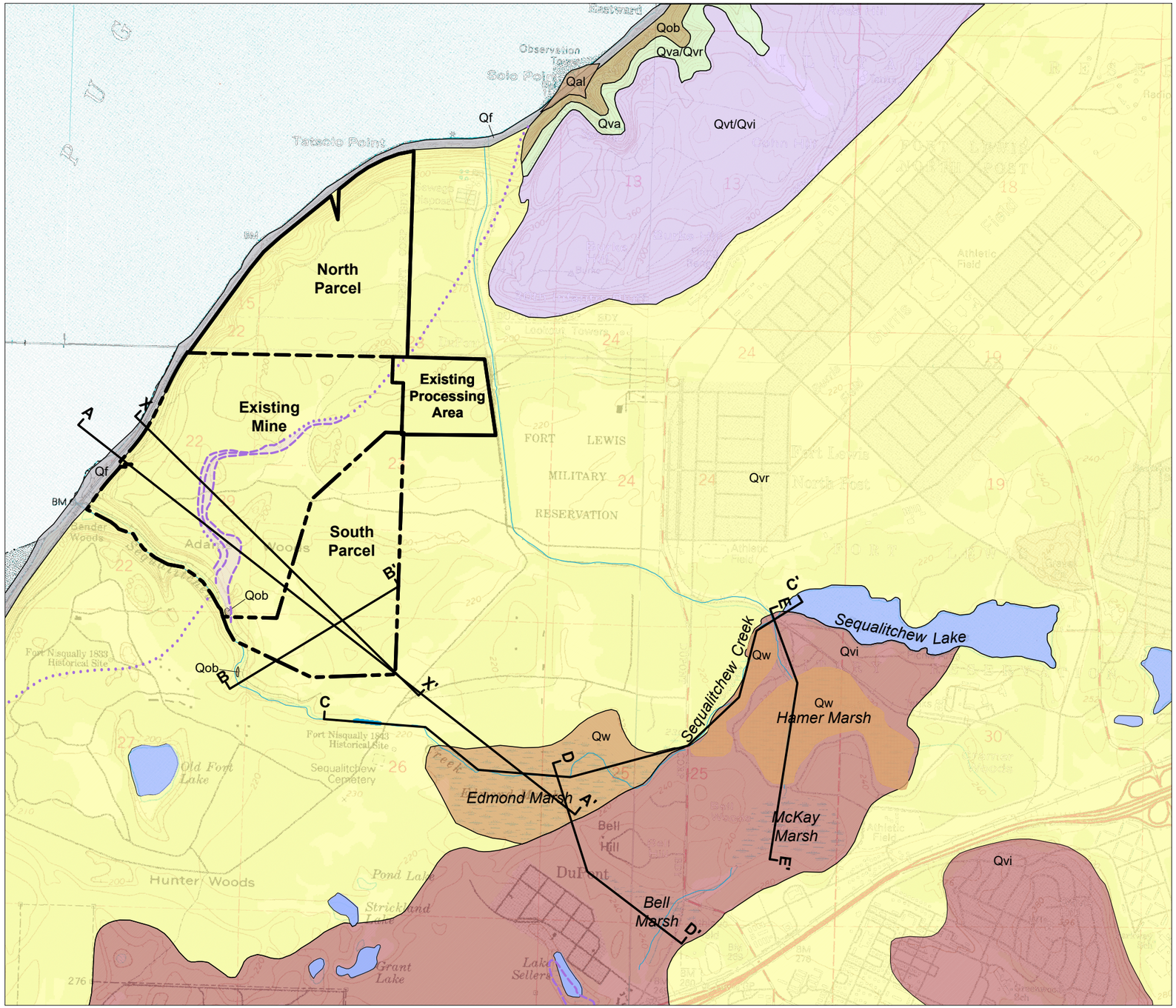
- Boring
- Monitoring Well
- Test Well
- Water Supply Well
- South Parcel Project Area
- South Parcel

Note: Existing topography based on aerial photogrammetric survey conducted on 10/30/2021 by David C. Smith & Associates, Inc.

Site Explorations Map

Earth and Water Resources Report
Pioneer Aggregates South Parcel Project
DuPont, Washington

Aspect Consulting	FEB-2022	BY: ETB / WEG	FIGURE NO. 5
	PROJECT NO. 040001-I-018-02	REVISED BY: ---	



Legend

Qf (Fill)
Artificial fill. Likely consists primarily of crushed rock and rip-rap placed for railroad embankment.

Qw (Wetland Deposits)
Peat, organic-rich muck, silt and clay.

Qal (Recent Alluvium)
Silt, sand, gravel, and peat deposited in stream beds and estuaries, includes some lacustrine and beach deposits.

Qvr (Vashon Recessional Glacial Outwash)
Medium dense to dense, slightly silty to clean sand and gravel. Includes some silty beds. The majority of near-surface Vashon recessional outwash on the Project Site is made up of the Steilacoom Gravel member, which is composed of sandy gravel and gravelly sand, with minor amounts of silt.

Qvi (Ice-Contact Deposits)
Water-worked sands and gravels with interbeds and lenses of silty, till-like deposits.

Qvt/Qvi (Till and Ice Contact Deposits)
Dense to very dense discontinuous layers of silty, sandy, and gravelly basal till. Ice contact deposits contain water-worked sands and gravels with interbeds and lenses of silty, till-like deposits.

Qva (Vashon Advance Glacial Outwash)
Sand and gravel, and lacustrine clay, silt, and sand of northern source, deposited during Vashon glacial advance.

Qob (Olympia Beds)
The Olympia Beds Qob unit is generally composed of interbedded lacustrine silt and clay and fluvial deposits.

Olympia Beds Truncation (Surface Projection)
Approximate surface projection line showing the northwestward lateral subcrop extent of the Olympia Beds unit. Dashed where approximate, dotted where inferred.

Note: Map modified based on subsurface data and geologic interpretation from Walsh, Logan and Polenz 2003; Walsh et al. 2003, Walters and Kimmel, 1968, and Troost, Booth, and Borden, in review.

N

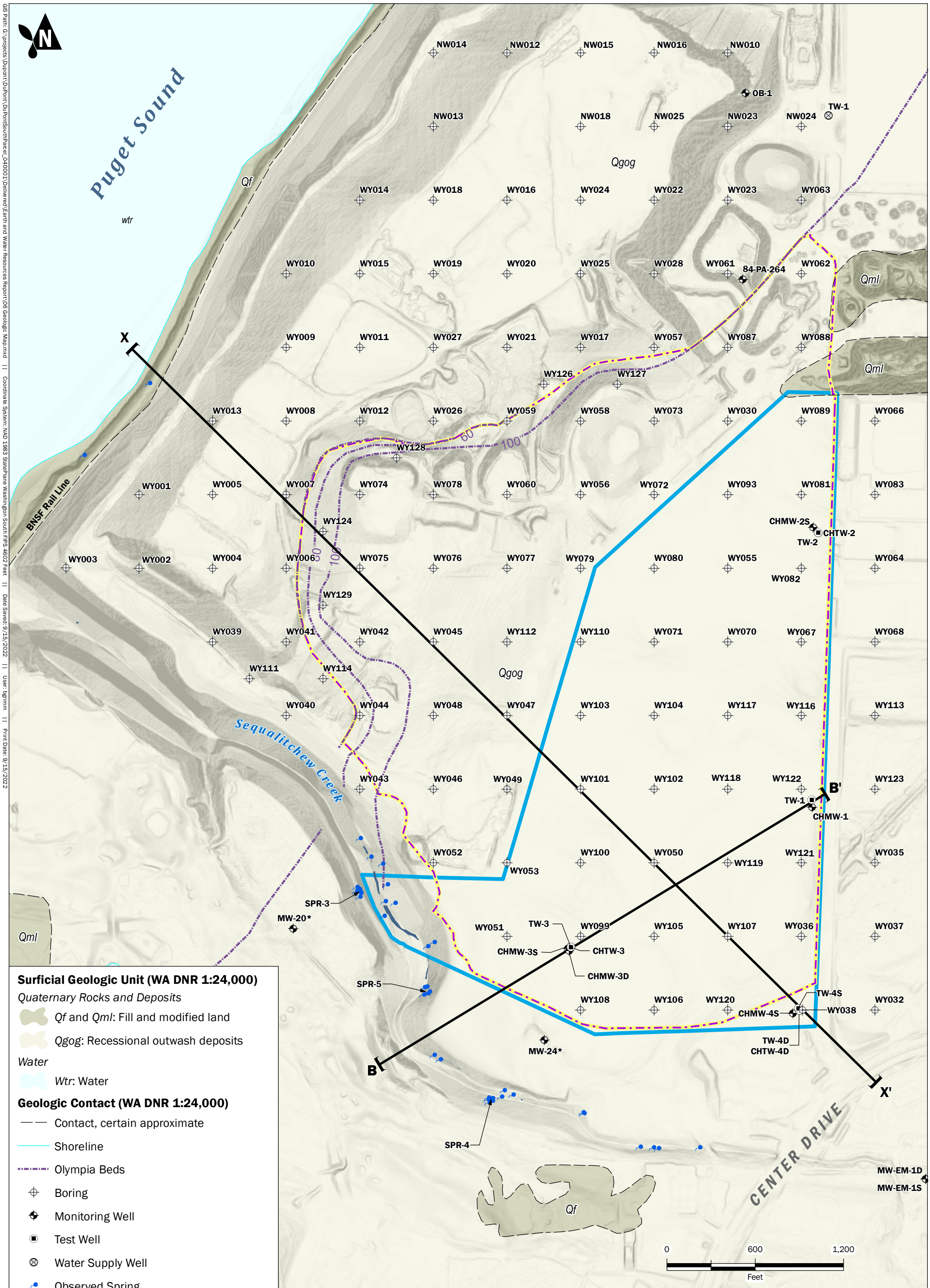
0 2000 4000
Feet

Regional Geologic Map

Earth and Water Resources Report
Pioneer Aggregates South Parcel Project
DuPont, Washington

Aspect Consulting	Oct-2022	BY: DFR/SCC	FIGURE NO. 6
	PROJECT NO. 040001-I-018	REV BY: OGR/SCC	

CAD Path: Q:\CalPortland\040001 DuPont Hydrologic Study\2022-10 Earth and Water Resources Report\040001-05 Geologic Map.dwg 05 Regional Geologic Map 11x17 L || Date Saved: Oct 25, 2022 3:31pm || User: scudd



Surficial Geologic Unit (WA DNR 1:24,000)

Quaternary Rocks and Deposits

- *Qf* and *Qml*: Fill and modified land
- *Qgog*: Recessional outwash deposits

Water

- *Wtr*: Water

Geologic Contact (WA DNR 1:24,000)

- Contact, certain approximate
- Shoreline
- Olympia Beds
- Boring
- Monitoring Well
- Test Well
- Water Supply Well
- Observed Spring
- Observed Seepage Area
- Generalized Geologic Cross-Section
- South Parcel Project Area
- South Parcel

Notes:
- Existing topography based on aerial photogrammetric survey conducted on 10/30/2021 by David C. Smith & Associates, Inc.
* Locations of MW-20 and MW-24 are approximate.

Project Geologic Map

Earth and Water Resources Report
Pioneer Aggregates South Parcel Project
DuPont, Washington

Aspect Consulting	SEP-2022	BY: ETB / WEG	FIGURE NO. 7
	PROJECT NO. 040001-I-018-02	REVISED BY: ETB / SJG / WEG	

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X Northwest — Southeast X'

South Parcel Project

Existing Mine | Re-Mine Area | Mine Expansion Area

Elevation in Feet (NGVD 29)

Puget Sound

BNSF Rail Line

Olympia Beds Truncation

Existing Mine Pit

Center Drive

WY013 WY07 WY0124 WY075 WY045 WY047 WY101 WY050 WY107 WY038 CHMW-4

Qf Qb Qvs Qvi Qgog/Qva Qob Qpog Qpon

Note: Topography from Pierce County LiDAR, 2011.

Legend

Qf	Fill	Qvi	Silty Lenses and/or Ice Contact Till-like Deposits
Qb	Beach and Shallow Marine Deposits	Qob	Olympia Beds
Qvs	Steilacoom Gravel Member of Vashon Recessional Outwash (Qgog)	Qpog	Pre-Olympia glacial Deposits
Qgog/Qva	Vashon Recessional Outwash and/or Advance Outwash	Qpon	Pre-Olympia Non glacial Deposits

Existing Ground Surface
Proposed Mined Surface
Existing Groundwater Level
Explorations

0 600 1,200 Feet

Horizontal Scale (1" = 600')
Vertical Scale (1" = 60')
Vertical Exaggeration x 10

Generalized Geologic Cross Section X-X'

Earth and Water Resources Report
Pioneer Aggregates South Parcel Project
DuPont, Washington

Aspect Consulting	Oct-2022	BY: DHM/PMB/CMV	FIGURE NO. 8
	PROJECT NO. 040001	REV BY: CMV/OGR/SCC	

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Puget Sound

Oversteepened slope from historical mining

Active Railroad Corridor

Active Mining Slope

West Slope

East Slope

Reclaimed Slopes

Sequalitchew Creek

Approximate contact with a permeable sediment over an impermeable sediment

Localized Cut and Fill Slopes for Old Rail Grade

Old Rail Grade/ Sequalitchew Creek Trail

100

200

300

0 500 1,000

Feet

Note: Existing topography of the mined based on aerial photogrammetric survey conducted on 10/30/2021 by David C. Smith & Associates, Inc.

Existing topography in forested areas outside the existing mine (e.g., South Parcel, Sequalitchew Creek Ravine, and Puget Sound bluffs) is based on 2011 LiDAR topography from the Puget Sound LiDAR Consortium.

Aerial photograph dated 10/30/2021.

Vertical Datum = NGVD 29

- Geologically Hazardous Area
- Slope 40% or Greater
- Slope Between 15% and 40%
- Observed Spring
- Observed Seepage Area
- South Parcel
- Clearing Limits for Mine Expansion
- South Parcel Project Area
- 20-ft. Contour
- Watercourse Centerline (WA DNR)
- Pierce County Tax Parcel

Geologic Hazards Map Existing Conditions

Earth and Water Resources Report
Pioneer Aggregates South Parcel Project
DuPont, Washington

Aspect Consulting	FEB-2022	BY: ETB / MAV / WEG	FIGURE NO. 9
	PROJECT NO. 040001-I-018-02	REVISED BY: NLK	

GIS Path: G:\projects\Dupont\DuPont\DuPontSouthParcel_040001\Delivered\Earth and Water Resources Report\09 Geologic Hazards Map - Proposed Conditions.mxd || Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet || Date Saved: 2/24/2022 || User: nkochie || Print Date: 2/24/2022

Puget Sound

Active Railroad Corridor

Reclaimed West Slope

East Slope

Proposed Constructed Mitigation Wetland

Sequalitchew Creek

Proposed Mine Slopes (Graded into Pit) are not GHAs because they are engineered slopes and have been evaluated for stability.

Old Rail Grade/ Sequalitchew Creek Trail

Noise/Visual Screening Berm

Recommended Minimum 50-ft. Setback from Top of Sequalitchew Creek Ravine Slopes

0 500 1,000 Feet

- Geologically Hazardous Area
- Slope 40% or Greater
- Slope Between 15% and 40%
- Watercourse Centerline (WA DNR)
- Recommended Minimum 50-ft Setback
- Proposed Mine 25-ft Contour
- Proposed Mine 5-ft Contour
- South Parcel
- Clearing Limits for Mine Expansion
- South Parcel Project Area
- Pierce County Tax Parcel

Note: Existing topography of the mined based on aerial photogrammetric survey conducted on 10/30/2021 by David C. Smith & Associates, Inc.

Existing topography in forested areas outside the existing mine (e.g., South Parcel, Sequalitchew Creek Ravine, and Puget Sound bluffs) is based on 2011 LiDAR topography from the Puget Sound LiDAR Consortium.

Aerial photograph dated 10/30/2021.

Vertical Datum = NGVD 29

Geologic Hazards Map
Proposed Conditions

Earth and Water Resources Report
Pioneer Aggregates South Parcel Project
DuPont, Washington

Aspect Consulting	FEB-2022	BY: ETB / MAV / WEG	FIGURE NO. 10
	PROJECT NO. 040001-I-018-02	REVISED BY: SCC / EAC / NLK	

GIS Path: G:\projects\Dupont\DuPont\DuPontSouthParcel_040001\Delivered\Earth and Water Resources Report\10 Slope Stability Sections.mxd || Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet || Date Saved: 2/24/2022 || User: nkochie || Print Date: 2/24/2022

Puget Sound

Static FOS = 2.92
Seismic FOS = 1.30

Static FOS = 1.69
Seismic FOS = 1.17

Static FOS = 2.01
Seismic FOS = 1.14

Static FOS = 2.53
Seismic FOS = 1.19

Sequalitchew Creek

0 500 1,000
Feet

Slope Stability Section
Factors of Safety (FOS) from slope stability analysis are indicated alongside each section, see Table 1 in Section 2.2.

Geotechnical Recommended 50-ft Setback from Top of Slope

Olympia Beds

South Parcel Project Area

South Parcel

Proposed Mine 25-ft Contour

20-ft Contour

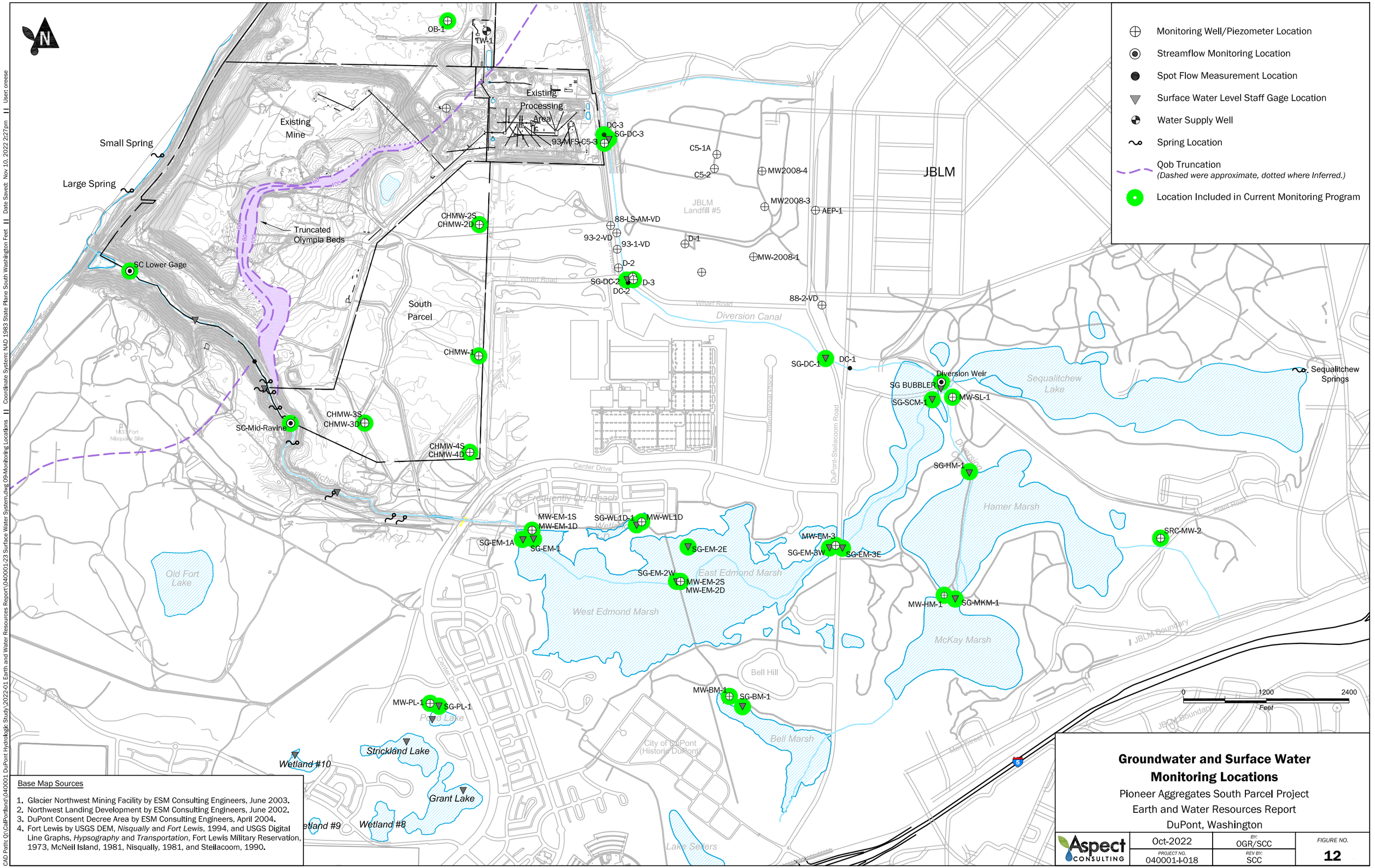
Pierce County Tax Parcel

Note: Existing topography based on aerial photogrammetric survey conducted on 10/30/2021 by David C. Smith & Associates, Inc. Vertical Datum = NGVD29

Slope Stability Sections
Proposed Conditions

Earth and Water Resources Report
Pioneer Aggregates South Parcel Project
DuPont, Washington

Aspect Consulting	FEB-2022	BY: CRS / WEG	FIGURE NO. 11
	PROJECT NO. 040001-I-018-02	REVISED BY: ETB / WEG / NLK	



Base Map Sources

1. Glacier Northwest Mining Facility by ESM Consulting Engineers, June 2003.
2. Northwest Landing Development by ESM Consulting Engineers, June 2002.
3. DuPont Consent Decree Area by ESM Consulting Engineers, April 2004.
4. Fort Lewis by USGS DEM, *Nisqually* and *Fort Lewis*, 1994, and USGS Digital Line Graphs, *Hypsography* and *Transportation*, Fort Lewis Military Reservation, 1973, McNeil Island, 1981, Nisqually, 1981, and Steilacoom, 1990.

Groundwater and Surface Water Monitoring Locations

Pioneer Aggregates South Parcel Project
Earth and Water Resources Report
DuPont, Washington

Aspect Consulting	Oct-2022	BY: OGR/SCC	FIGURE NO. 12
	PROJECT NO. 040001-I-018	REV BY: SCC	

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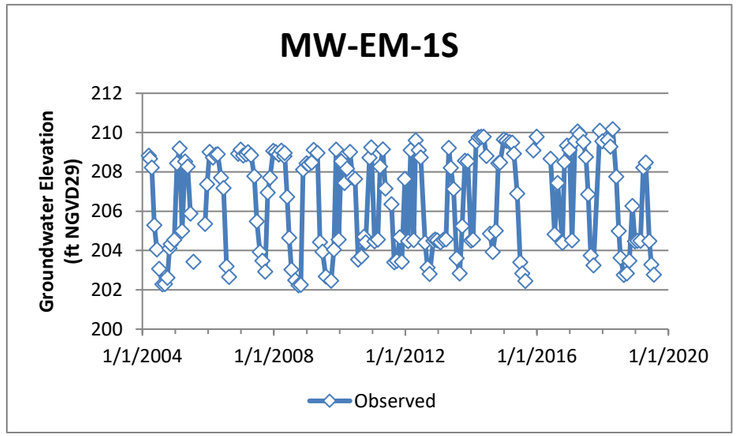
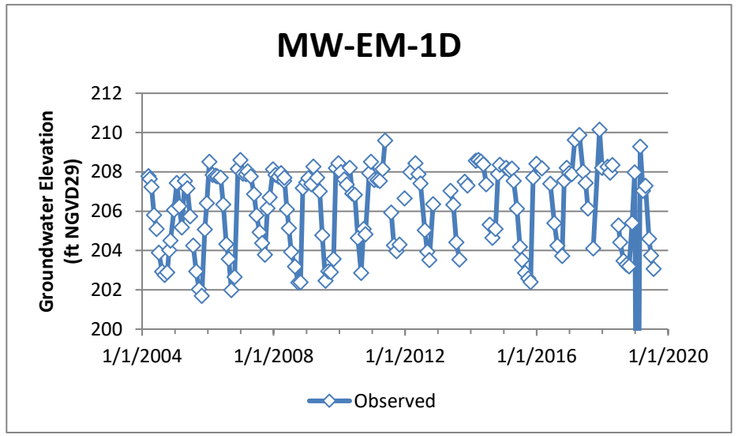
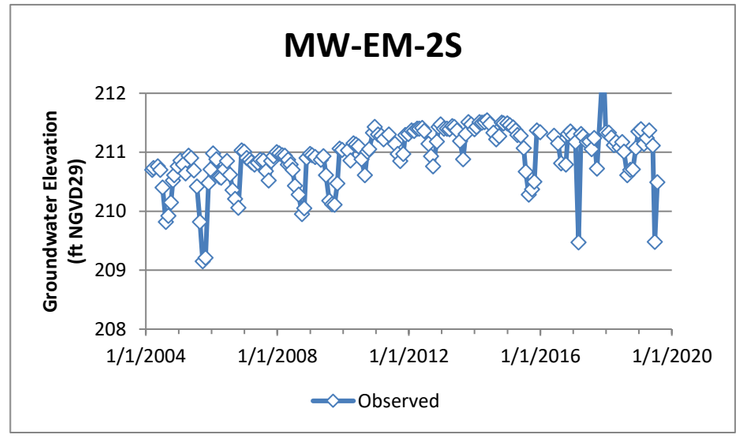
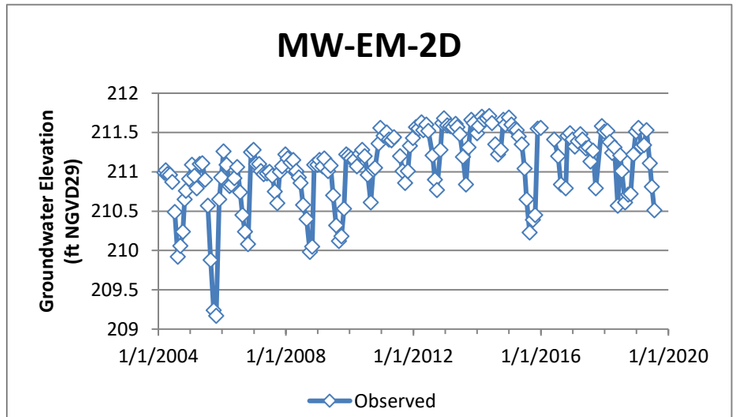
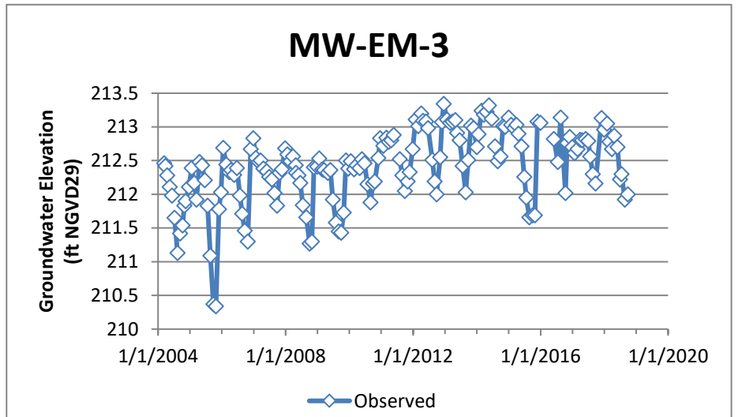
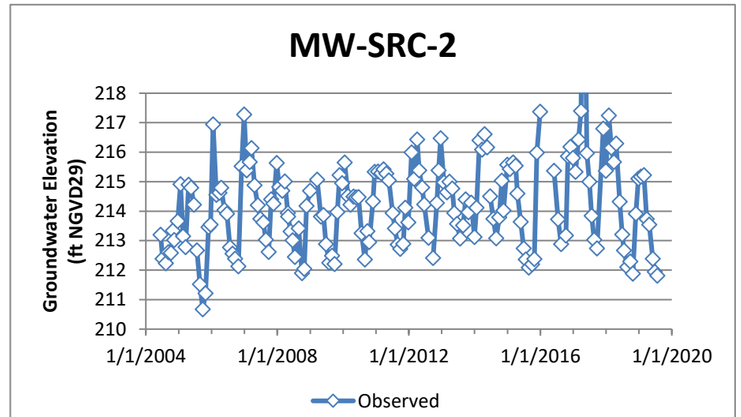


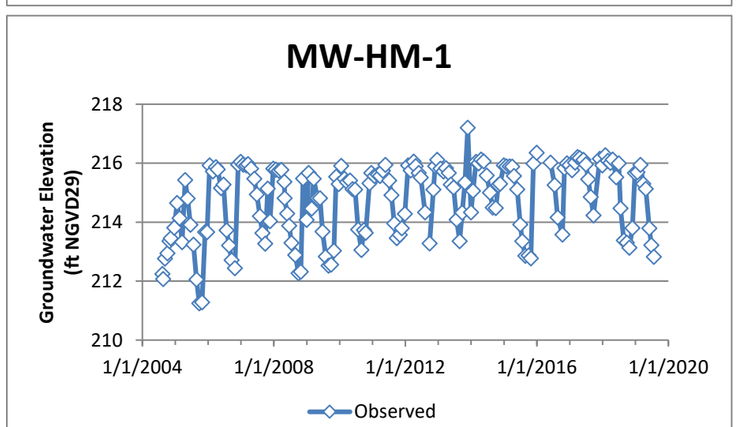


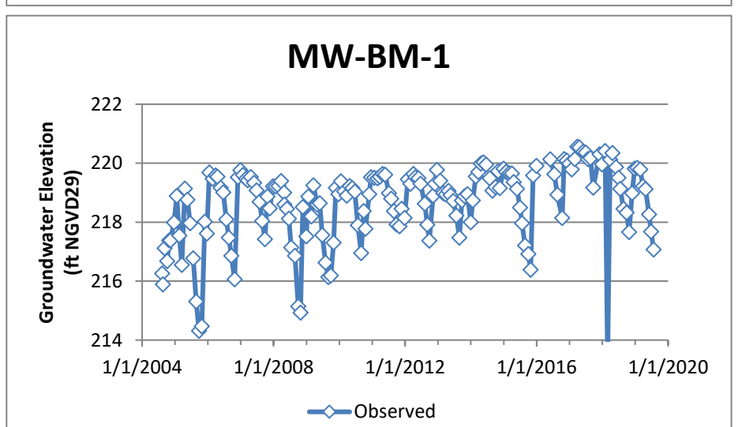


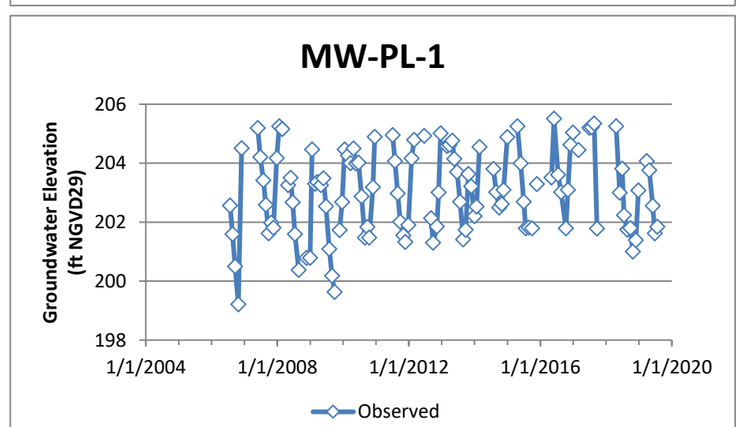






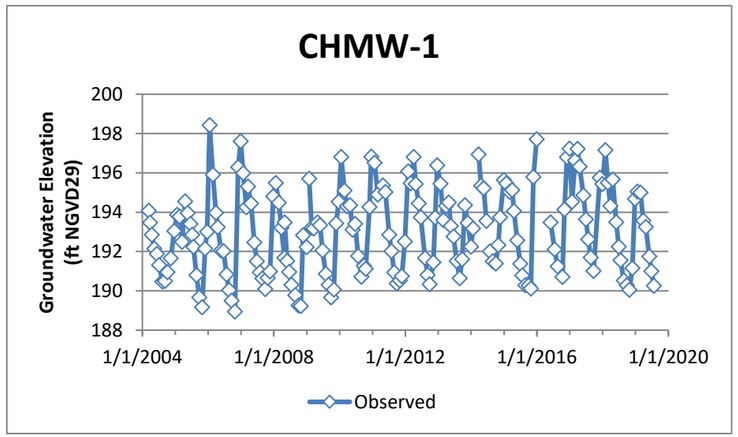


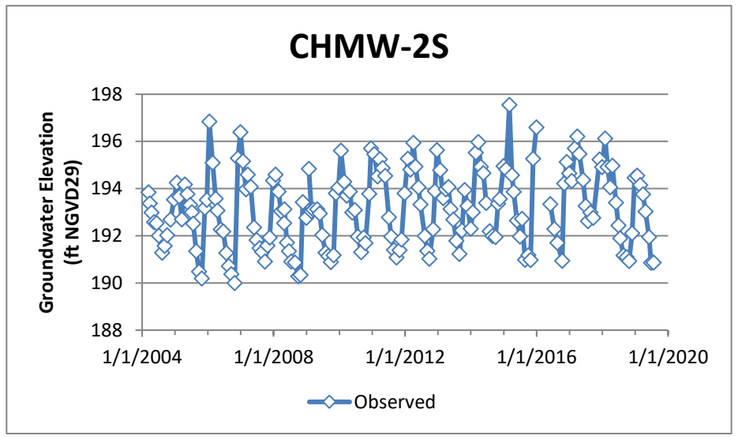


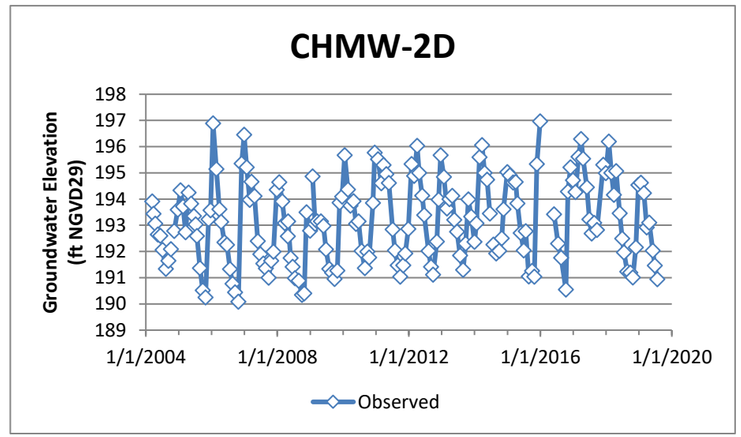


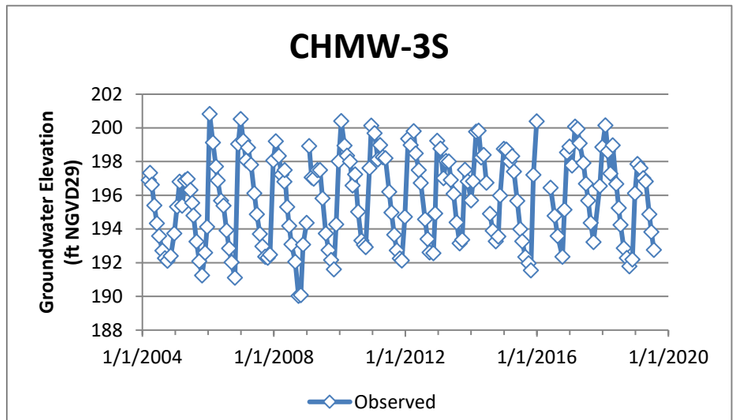
Aspect Consulting, LLC
1/27/2022
S:\CalPortland\DuPont\South Parcel\Groundwater Modeling\DRAFT_20170327\StatusUpdate_20211122.xlsm

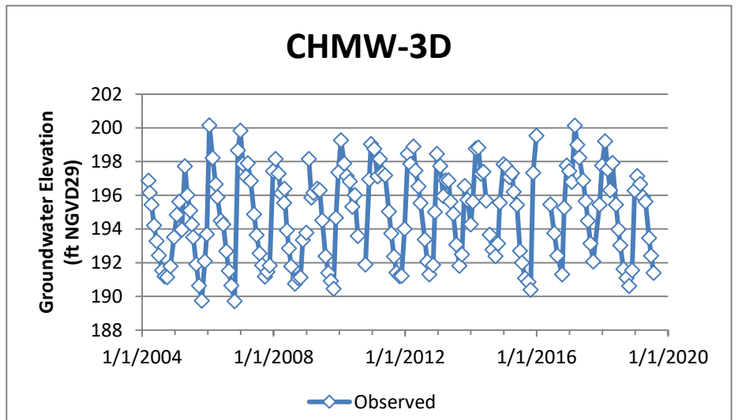
Figure 13
Observed Groundwater Levels
Earth and Water Resources Report

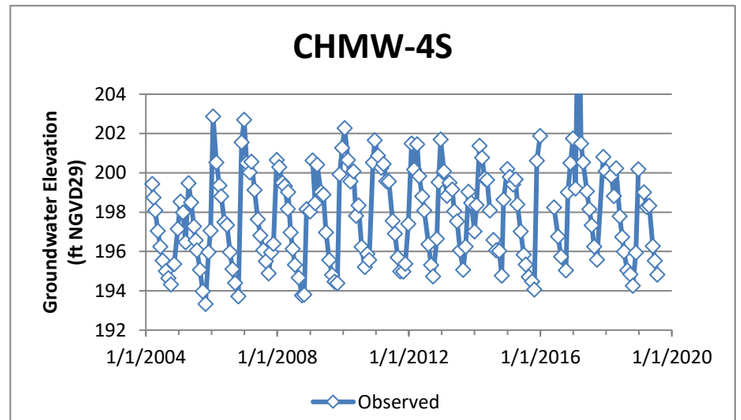

CHMW-1
Groundwater Elevation (ft NGVD29)
200
198
196
194
192
190
188
1/1/2004
1/1/2008
1/1/2012
1/1/2016
1/1/2020
Observed

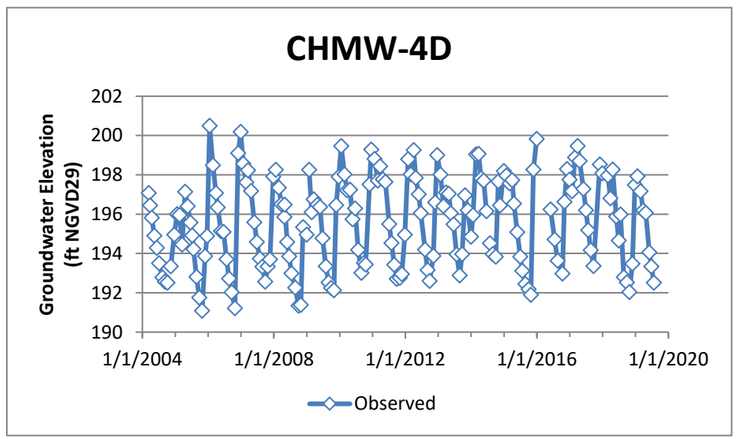

CHMW-2S
Groundwater Elevation (ft NGVD29)
198
196
194
192
190
188
1/1/2004
1/1/2008
1/1/2012
1/1/2016
1/1/2020
Observed

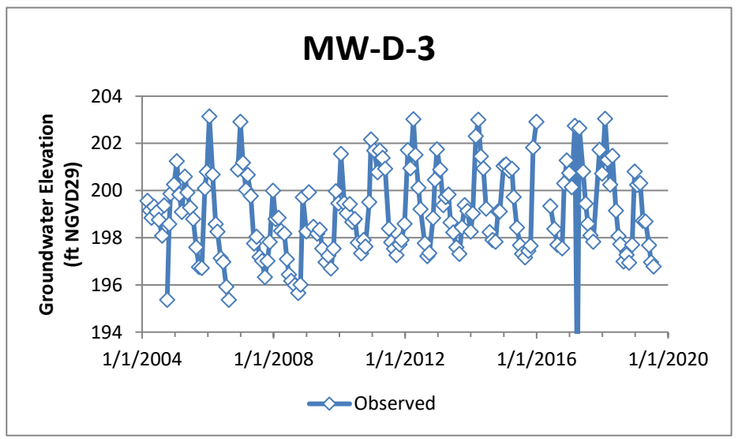

CHMW-2D
Groundwater Elevation (ft NGVD29)
198
197
196
195
194
193
192
191
190
189
1/1/2004
1/1/2008
1/1/2012
1/1/2016
1/1/2020
Observed

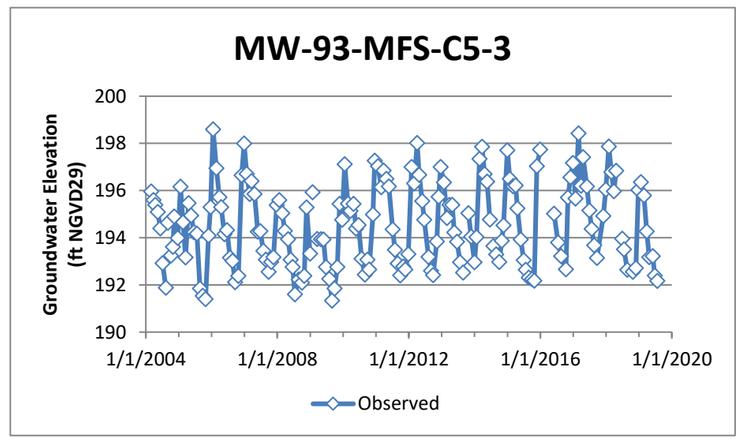

CHMW-3S
Groundwater Elevation (ft NGVD29)
202
200
198
196
194
192
190
188
1/1/2004
1/1/2008
1/1/2012
1/1/2016
1/1/2020
Observed

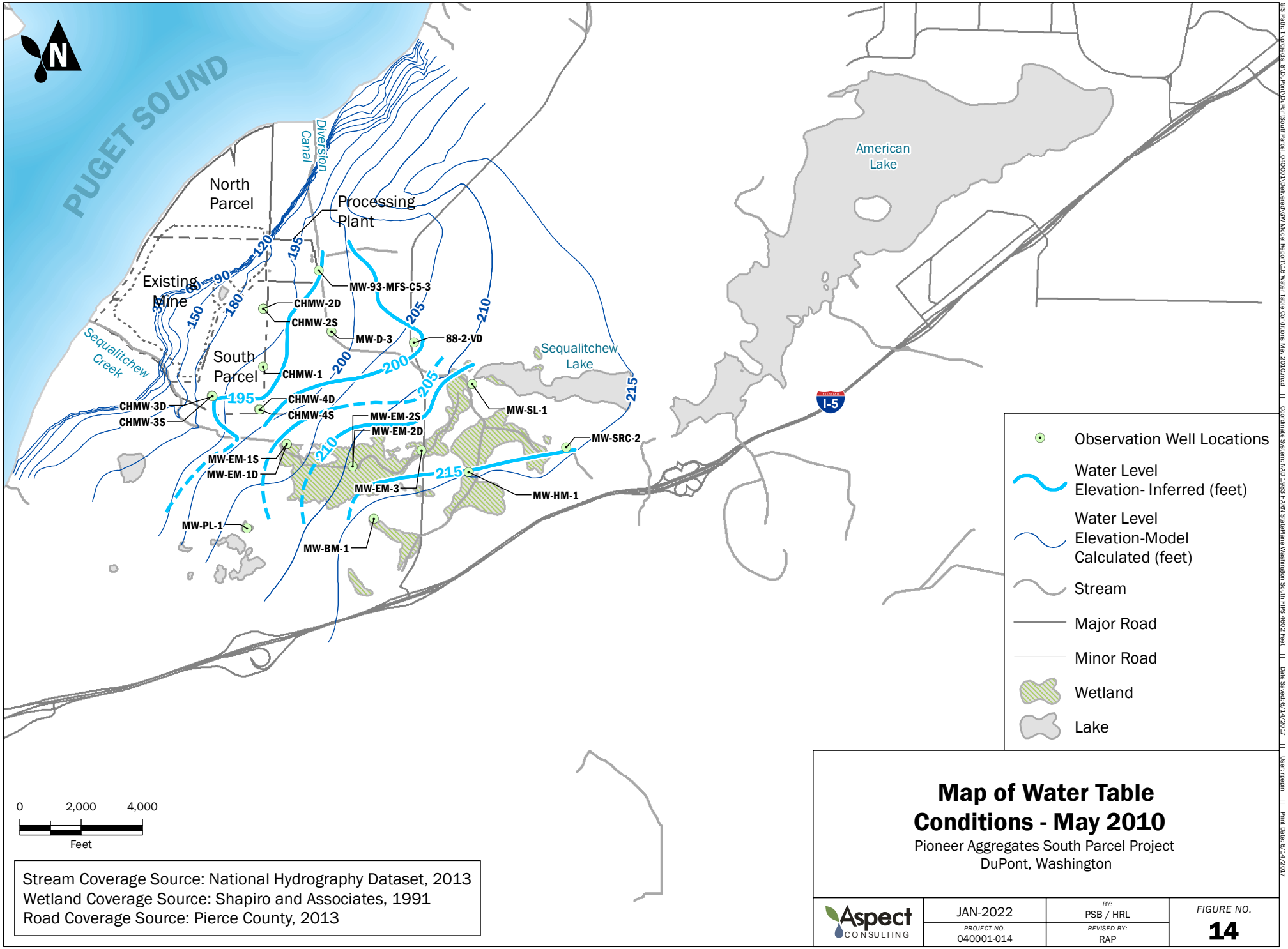

CHMW-3D
Groundwater Elevation (ft NGVD29)
202
200
198
196
194
192
190
188
1/1/2004
1/1/2008
1/1/2012
1/1/2016
1/1/2020
Observed


CHMW-4S
Groundwater Elevation (ft NGVD29)
204
202
200
198
196
194
192
1/1/2004
1/1/2008
1/1/2012
1/1/2016
1/1/2020
Observed


CHMW-4D
Groundwater Elevation (ft NGVD29)
202
200
198
196
194
192
190
1/1/2004
1/1/2008
1/1/2012
1/1/2016
1/1/2020
Observed


MW-D-3
Groundwater Elevation (ft NGVD29)
204
202
200
198
196
194
1/1/2004
1/1/2008
1/1/2012
1/1/2016
1/1/2020
Observed


MW-93-MFS-C5-3
Groundwater Elevation (ft NGVD29)
200
198
196
194
192
190
1/1/2004
1/1/2008
1/1/2012
1/1/2016
1/1/2020
Observed

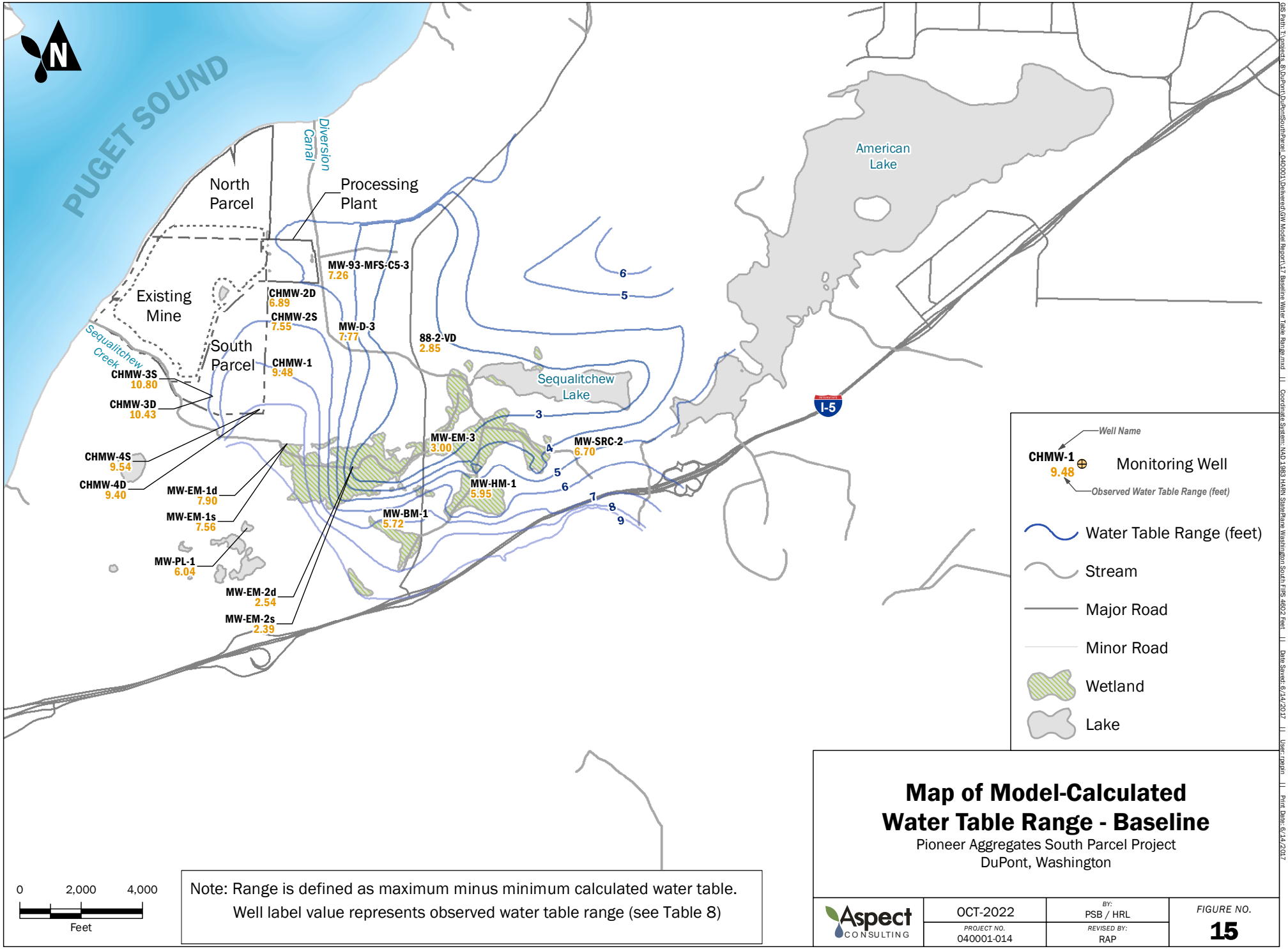


Map of Water Table Conditions - May 2010

Pioneer Aggregates South Parcel Project
DuPont, Washington

Aspect CONSULTING	JAN-2022	BY: PSB / HRL	FIGURE NO. 14
	PROJECT NO. 040001-014	REVISED BY: RAP	

GIS Path: T:\projects_8\DuPont\DuPontSouthParcel_040001\Delivered\GW Model Report\16 Water Table Conditions May 2010.mxd LL Coordinate System: NAD 1983 HARN StatePlane Washington South FIPS 4602 Feet LL Date Saved: 6/14/2017 LL User: rpegin LL Print Date: 6/14/2017



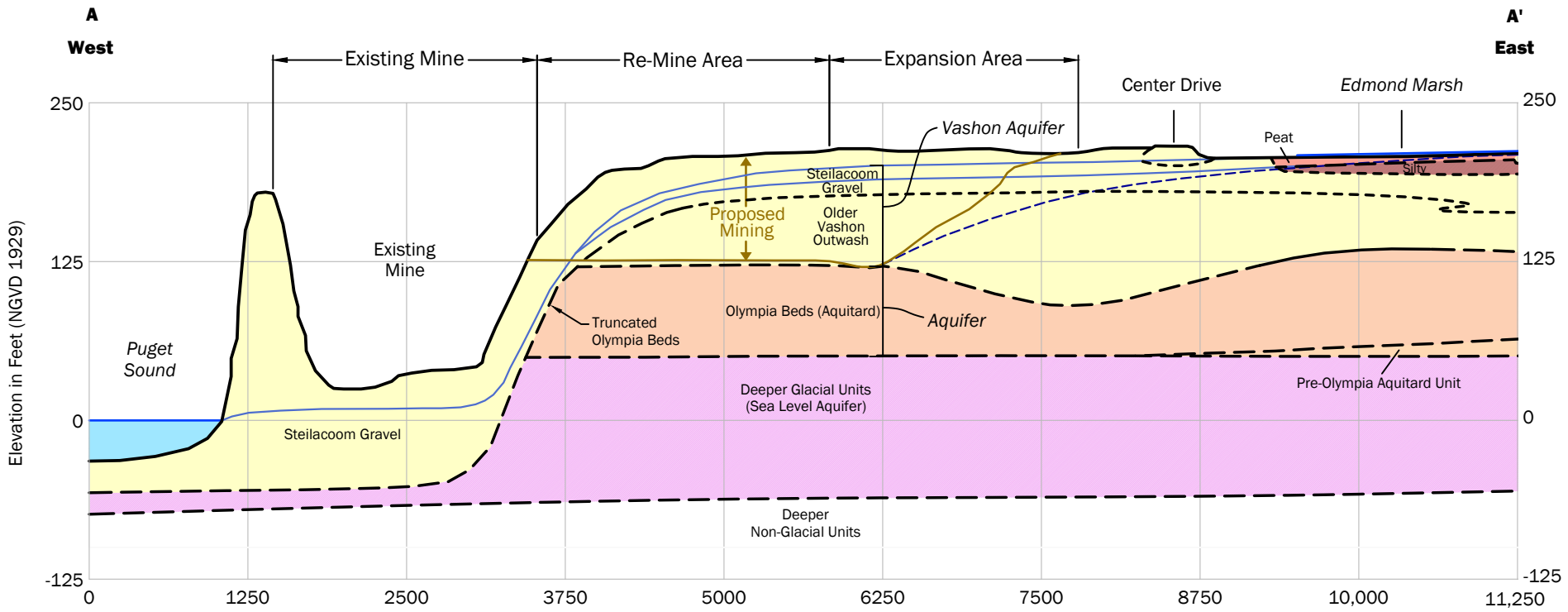
Note: Range is defined as maximum minus minimum calculated water table.
Well label value represents observed water table range (see Table 8)

Map of Model-Calculated Water Table Range - Baseline

Pioneer Aggregates South Parcel Project
DuPont, Washington

Aspect Consulting	OCT-2022	BY: PSB / HRL	FIGURE NO. 15
	PROJECT NO. 040001-014	REVISED BY: RAP	

GIS Path: T:\projects_8\DuPont\DuPontSouthParcel_040001\Delivered\GW Model Report\17 Baseline Water Table Range.mxd || Coordinate System: NAD 1983 HARN StatePlane Washington South FIPS 4602 Feet || Date Saved: 6/14/2017 || User: rpain || Print Date: 6/14/2017



Legend

Existing Groundwater Table (range indicates seasonal variation)

Predicted Groundwater Table with South Parcel Project

Note: 10x Vertical vs. Horizontal Exaggeration for Illustration

Horizontal Scale: 0 — 1250 Feet

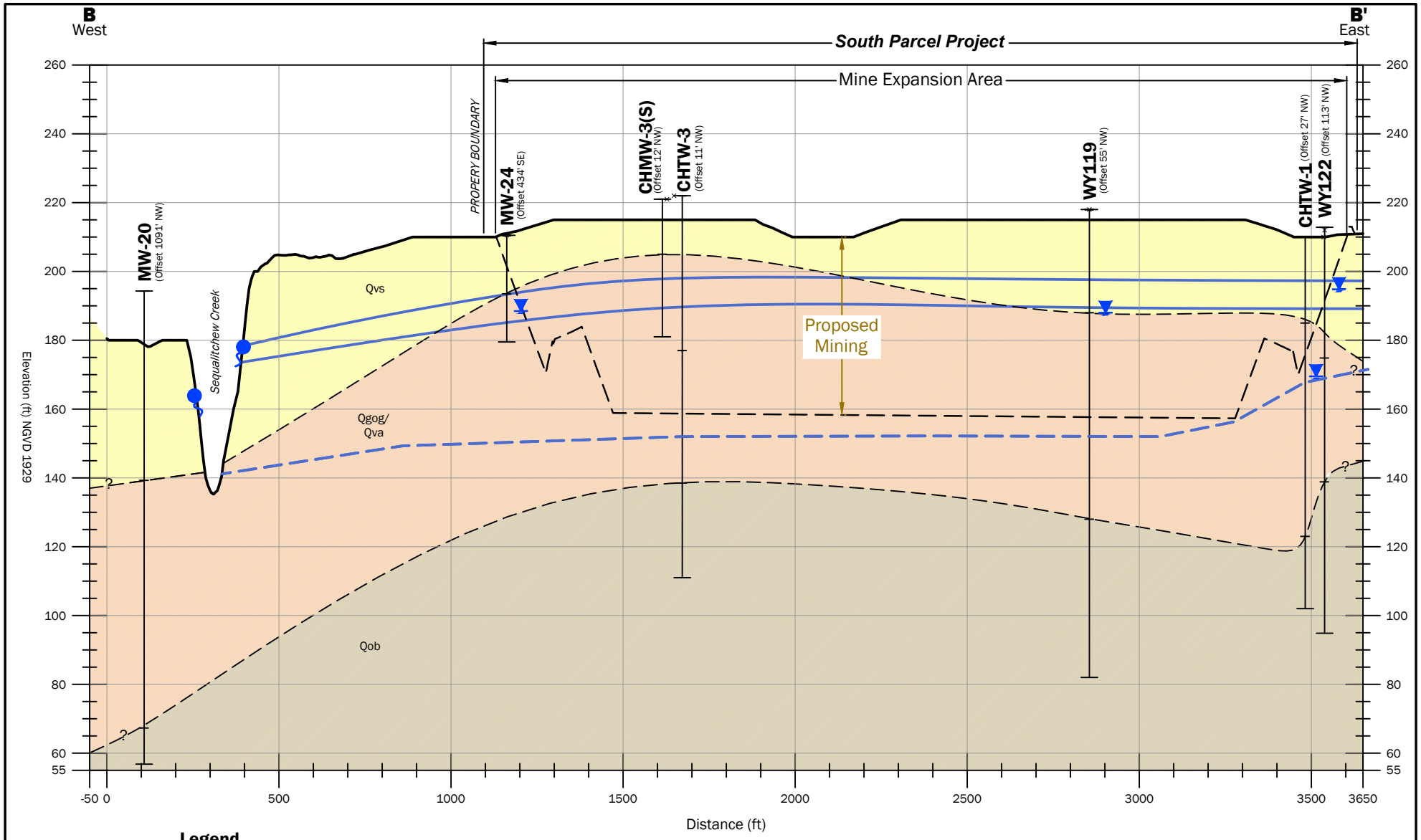
Vertical Scale: 0 — 125 Feet

Hydrogeologic Cross Section - A-A'

Pioneer Aggregates South Parcel Project
Earth and Water Resources Report
DuPont, Washington

Aspect Consulting	Feb-2022	BY: OGR/SCC/CMV	FIGURE NO. 16
	PROJECT NO. 040001-014	REVISED BY: -	

CAD Path: Q:\CalPortland\040001 DuPont Hydrologic Study\2022-01 Earth and Water Resources Report\040001-14 Hydrogeologic x-sec.dwg || Date Saved: 2/24/2022 12:48:27 PM || User: cvanslyke



Legend

- Geologic Contact
- ***Qvs*** — Steilacoom Gravel Member of Vashon Recessional Outwash
- ***Qgog/Qva*** — Vashon Recessional Outwash and/or Advance Outwash
- ***Qob*** — Olympia Beds
- Existing Water Level at Time of Drilling (ATD)
- Seep
- Existing Groundwater Table (range indicates seasonal variation)
- Predicted Groundwater Table with South Parcel Project

Horizontal Scale: 0 — 400 Feet

Vertical Scale: 0 — 40 Feet

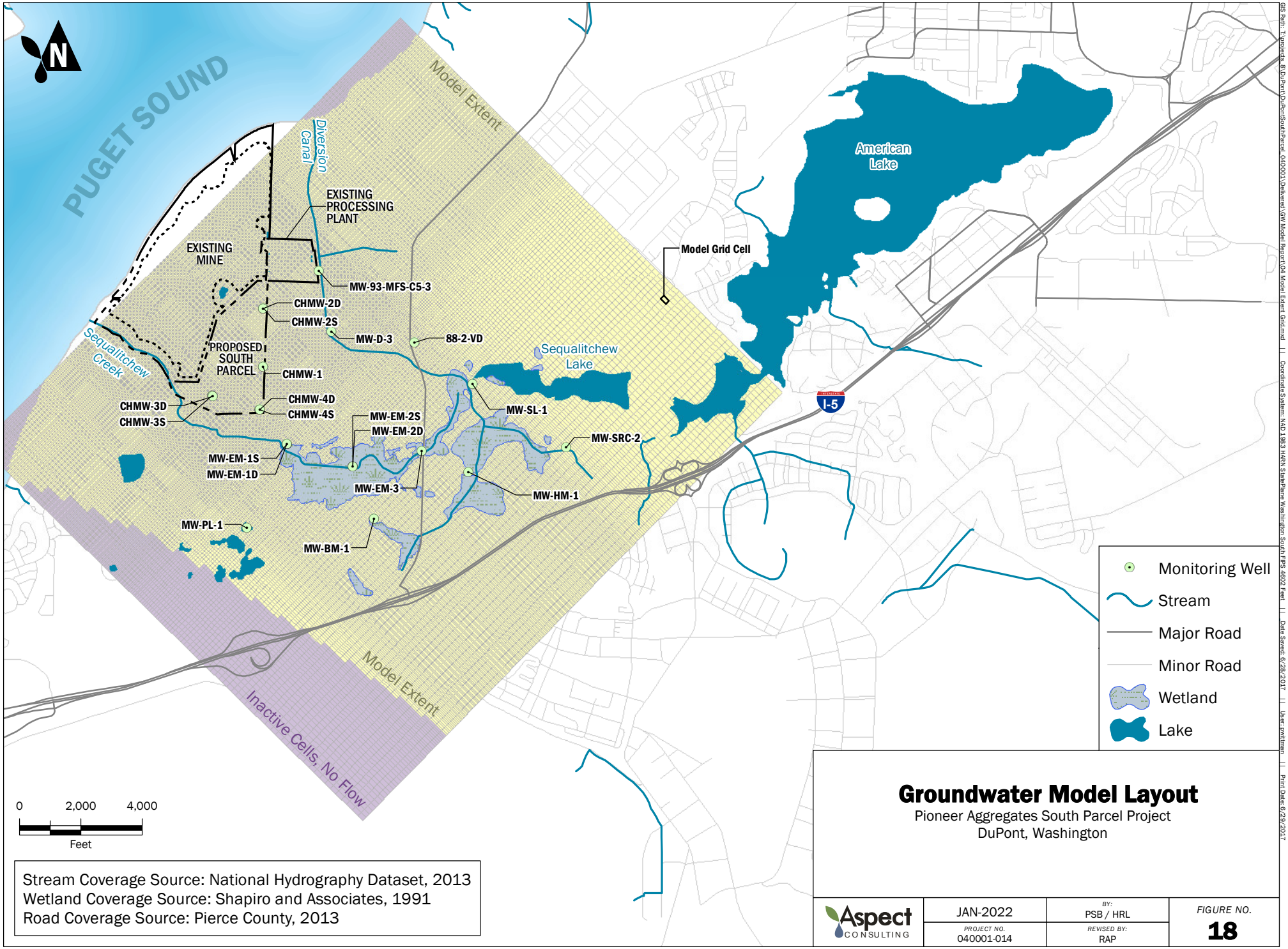
Note: 10x Vertical vs. Horizontal Exaggeration for Illustration

Source: Topography from Pierce County LiDAR, 2011.

Hydrogeologic Cross Section

Pioneer Aggregates South Parcel Project
Earth and Water Resources Report
DuPont, Washington

Aspect Consulting	Oct-2022	BY: ETB/CMV	FIGURE NO. 17
	PROJECT NO. 040001	REVISED BY: -	



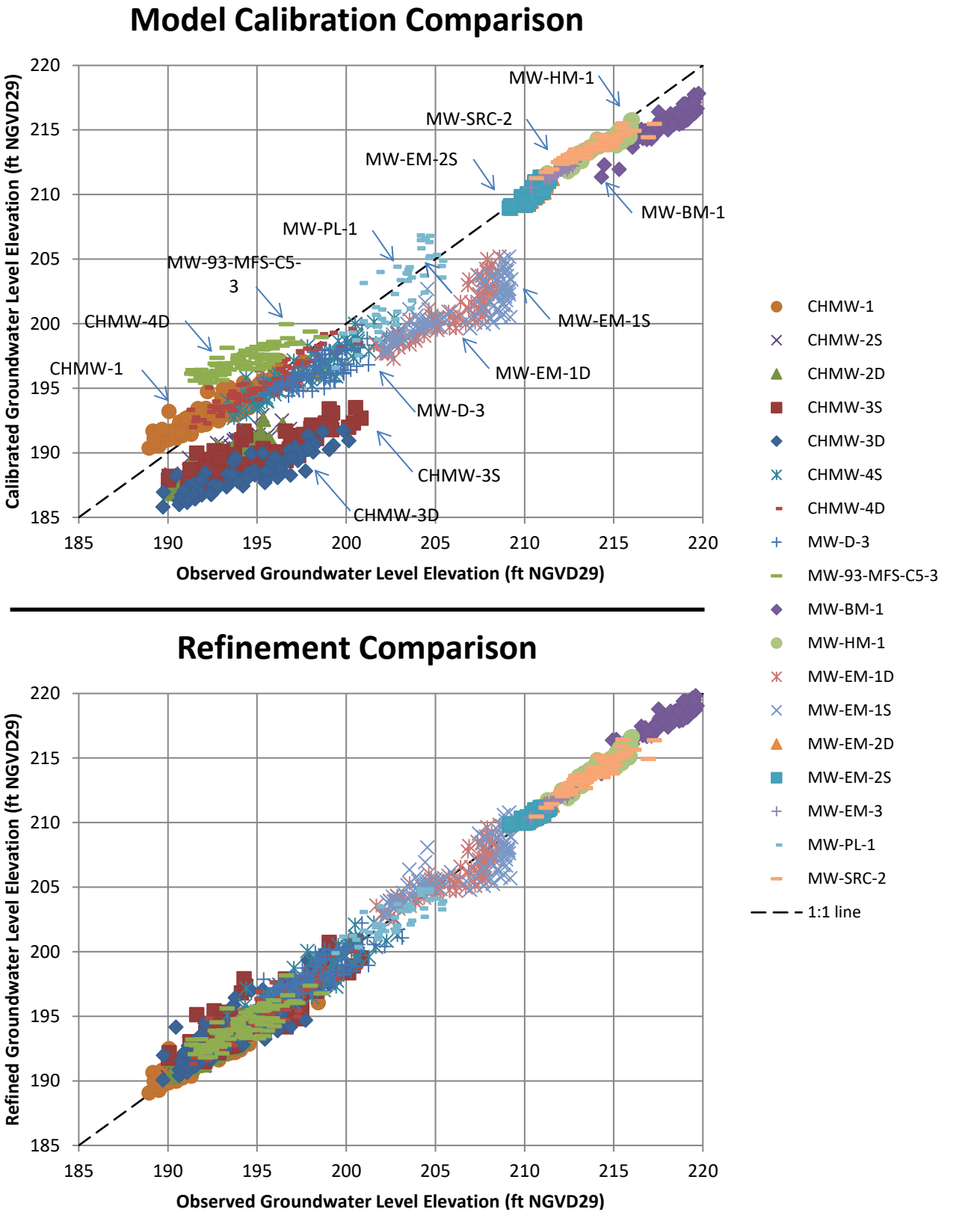
Stream Coverage Source: National Hydrography Dataset, 2013
Wetland Coverage Source: Shapiro and Associates, 1991
Road Coverage Source: Pierce County, 2013

Groundwater Model Layout

Pioneer Aggregates South Parcel Project
DuPont, Washington

Aspect CONSULTING	JAN-2022	BY: PSB / HRL	FIGURE NO. 18
	PROJECT NO. 040001-014	REVISED BY: RAP	

GIS Path: T:\projects_8\DuPont\DuPontSouthParcel_040001\Deliverest\GW Model Report\04 Model Extent Grid.mxd LL Coordinate System: NAD 1983 HARN StatePlane Washington South FIPS 4602 Feet LL Date Saved: 6/28/2017 LL User: pwitman LL Print Date: 6/29/2017



Aspect Consulting, LLC

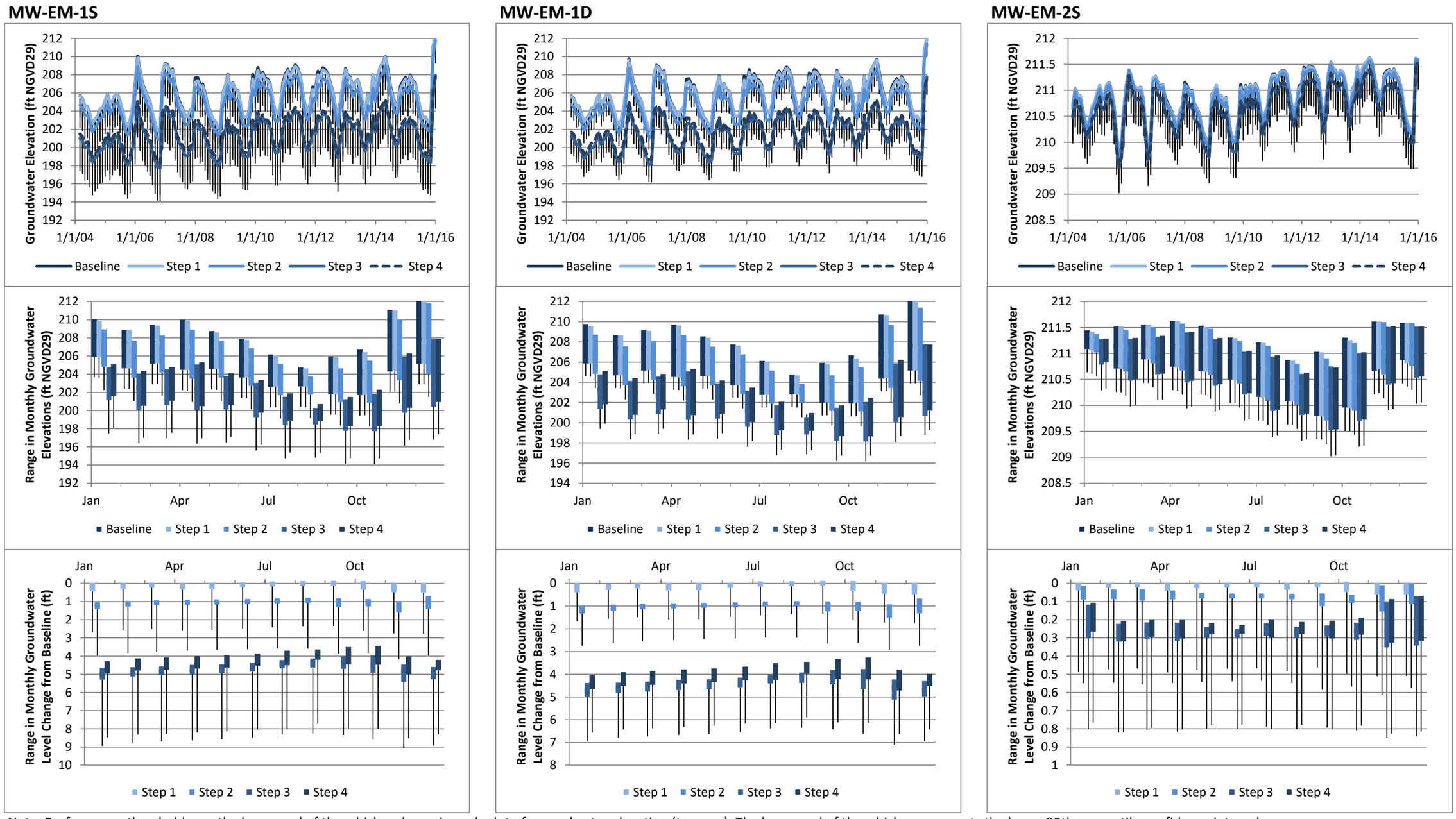
1/27/2022

S:\CalPortland\DuPont\South Parcel\Groundwater Modeling\DRAFT_20170327\StatusUpdate_20211122.xlsm

Figure 19

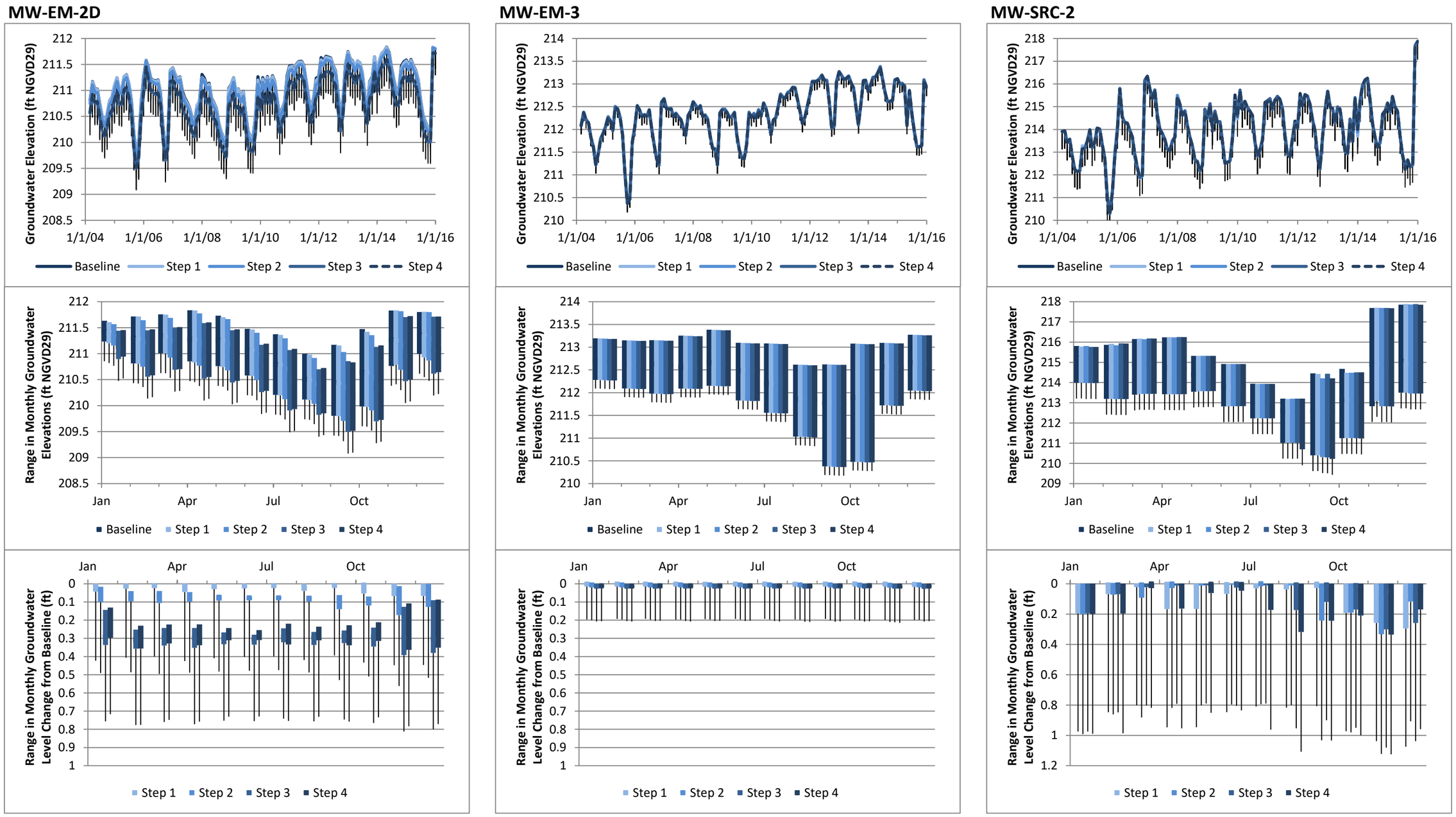
Comparison of Observed and Calculated Groundwater Levels

Earth and Water Resources Report



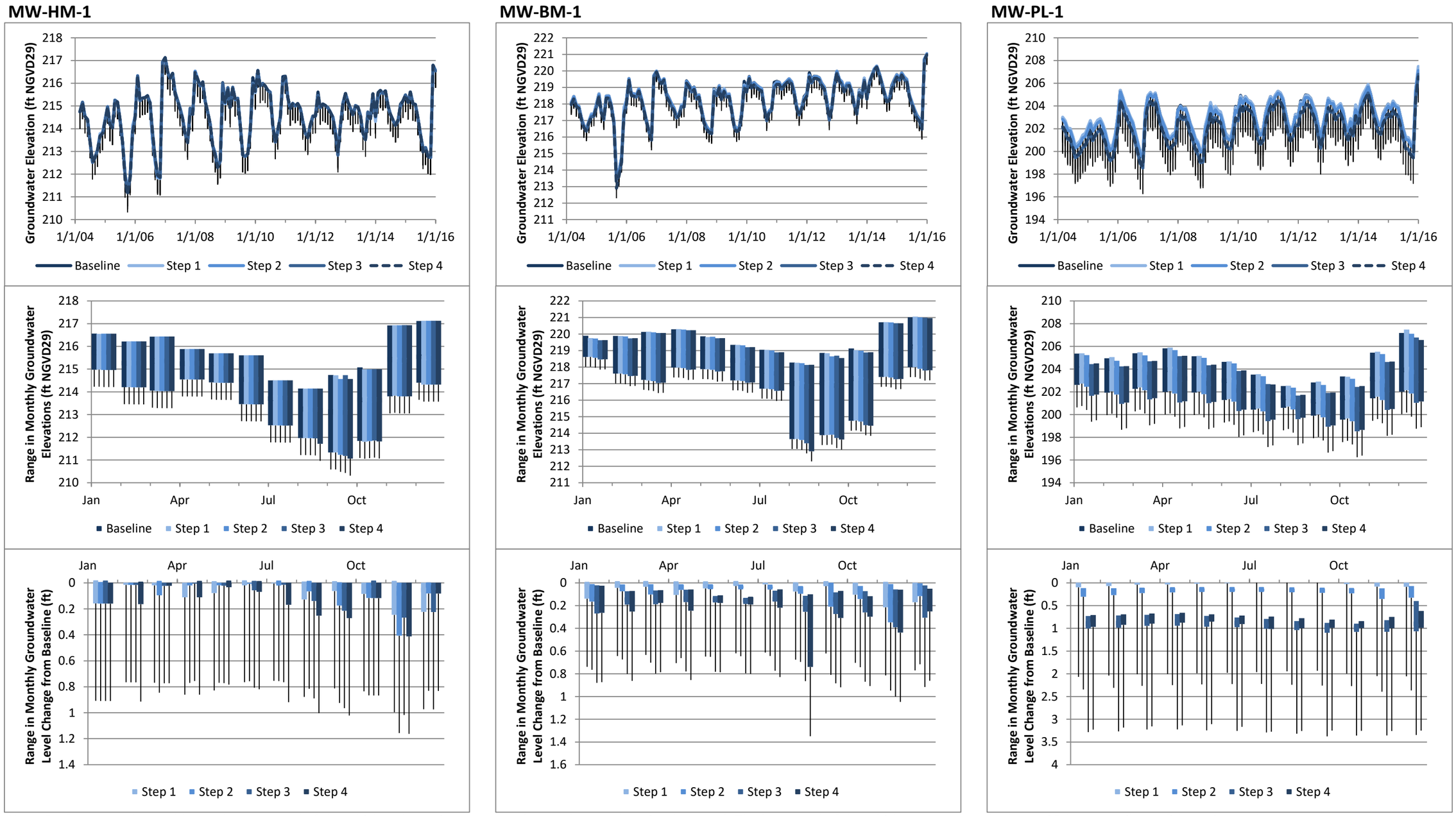
Note: Performance thresholds are the lower end of the whisker shown in each plot of groundwater elevation (top row). The lower end of the whisker represents the lower 95th-percentile confidence interval.

Figure 20
Predicted Changes and Ranges in Groundwater Levels
Earth and Water Resources Report



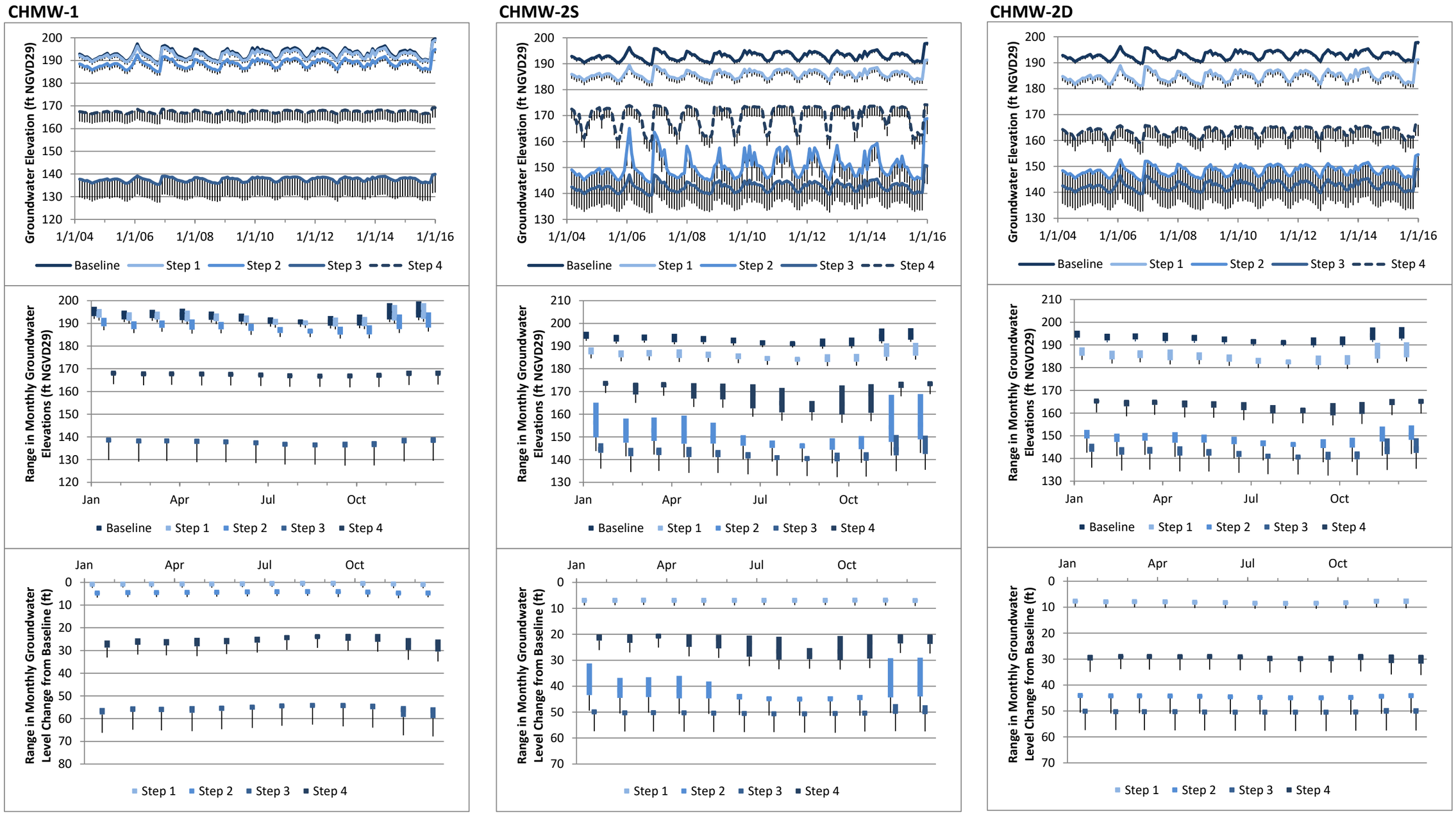
Note: Performance thresholds are the lower end of the whisker shown in each plot of groundwater elevation (top row). The lower end of the whisker represents the lower 95th-percentile confidence interval.

Figure 20
Predicted Changes and Ranges in Groundwater Levels
Earth and Water Resources Report



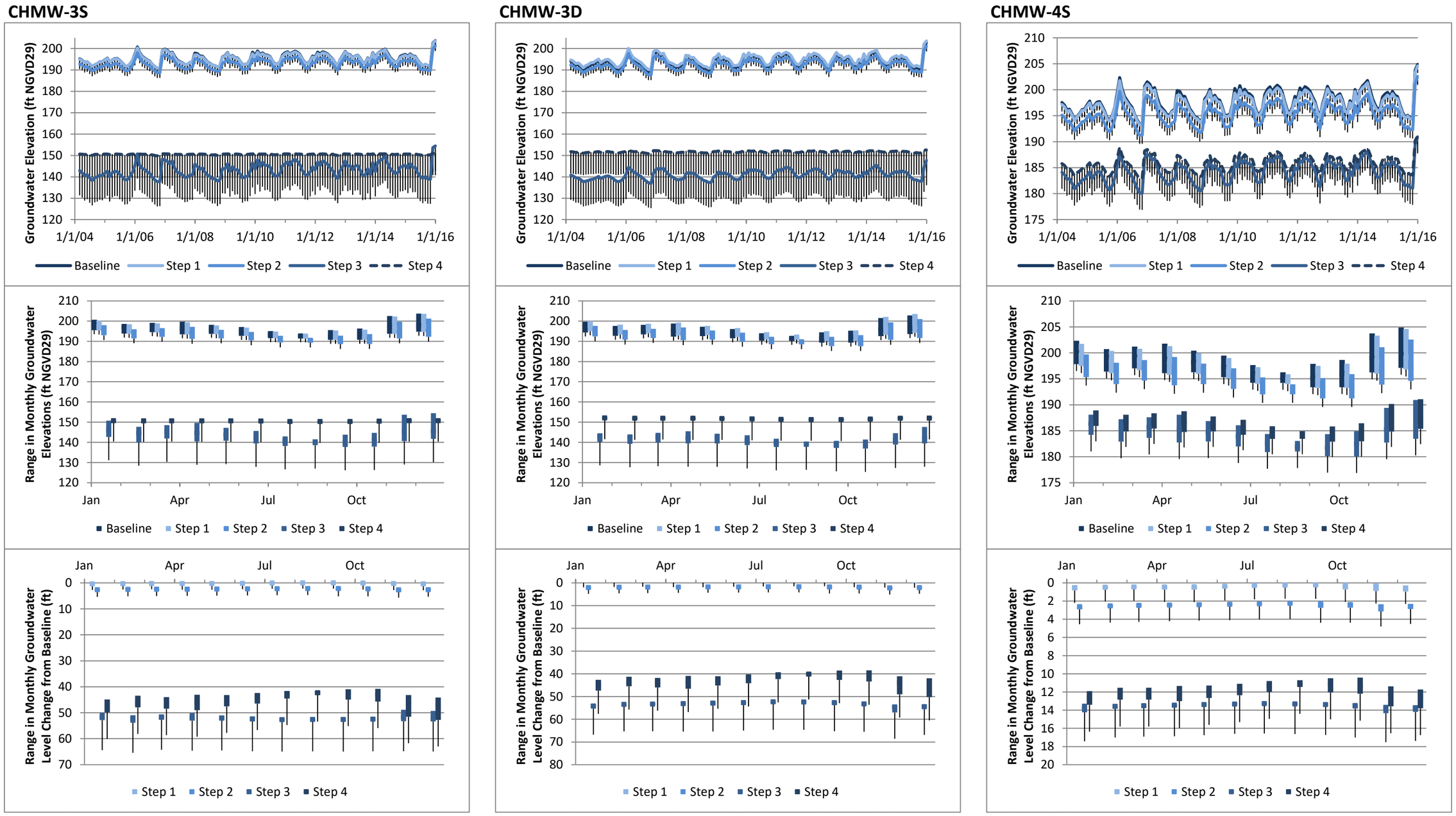
Note: Performance thresholds are the lower end of the whisker shown in each plot of groundwater elevation (top row). The lower end of the whisker represents the lower 95th-percentile confidence interval.

Figure 20
Predicted Changes and Ranges in Groundwater Levels
Earth and Water Resources Report



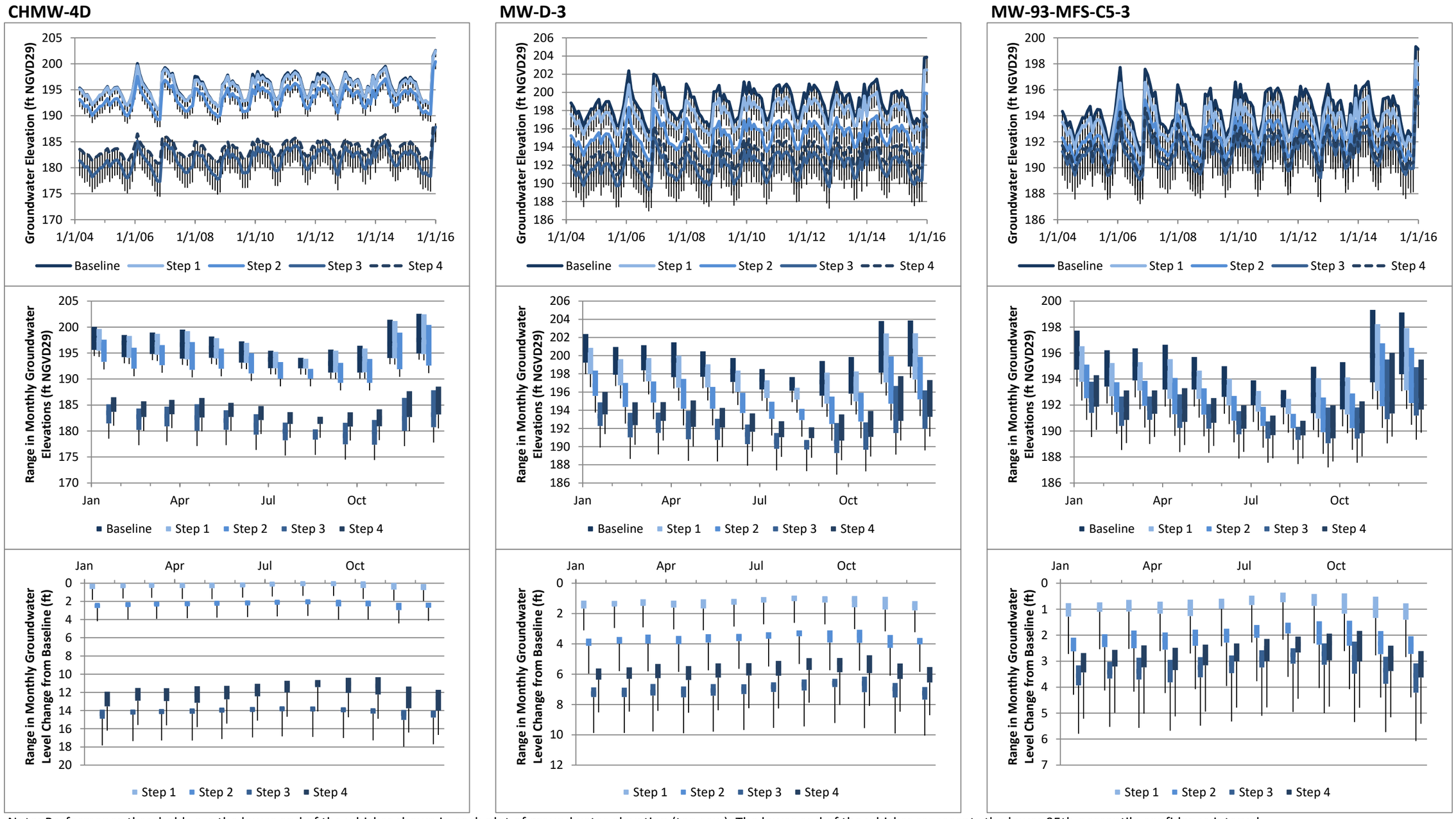
Note: Performance thresholds are the lower end of the whisker shown in each plot of groundwater elevation (top row). The lower end of the whisker represents the lower 95th-percentile confidence interval.

Figure 20
Predicted Changes and Ranges in Groundwater Levels
Earth and Water Resources Report



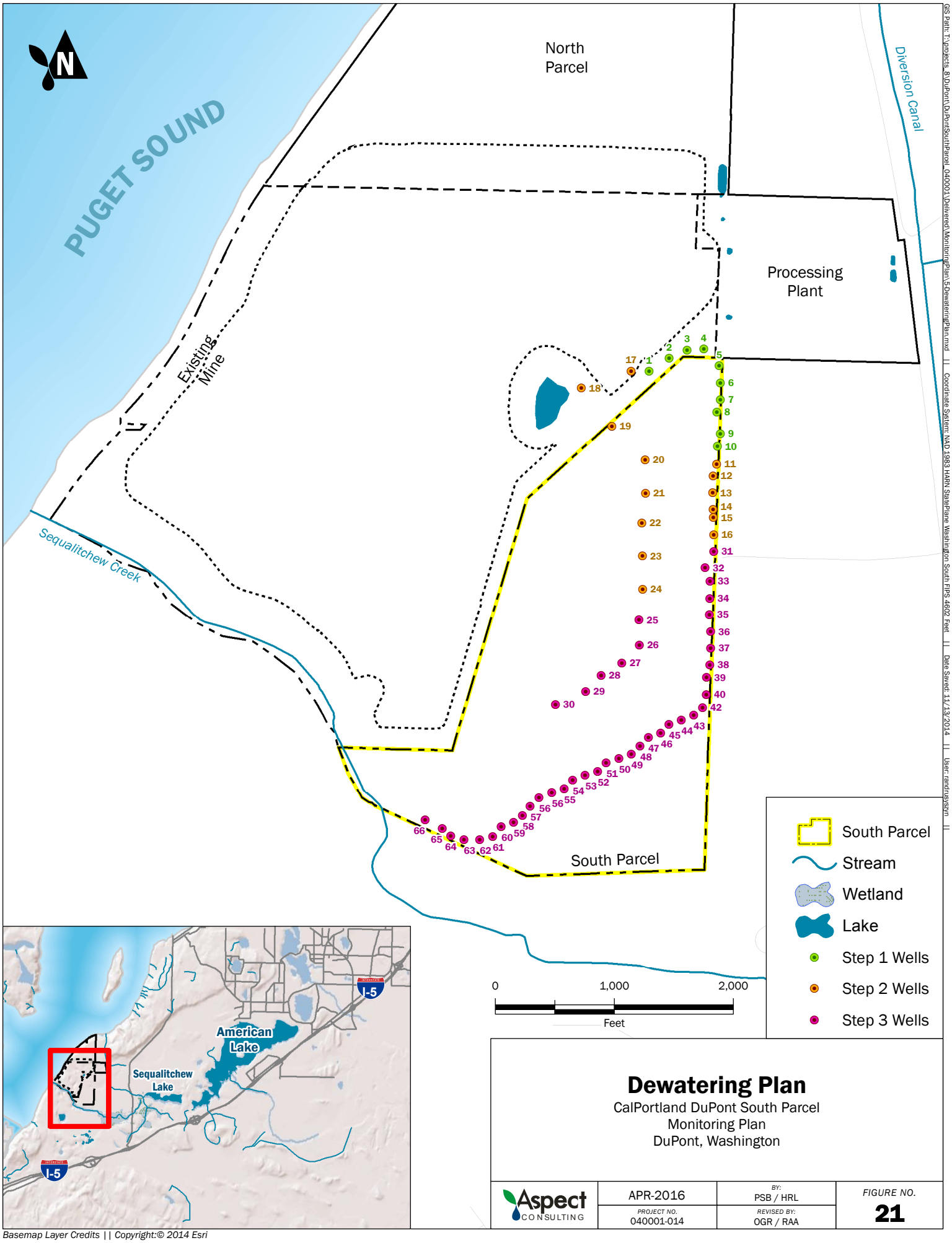
Note: Performance thresholds are the lower end of the whisker shown in each plot of groundwater elevation (top row). The lower end of the whisker represents the lower 95th-percentile confidence interval.

Figure 20
Predicted Changes and Ranges in Groundwater Levels
Earth and Water Resources Report



Note: Performance thresholds are the lower end of the whisker shown in each plot of groundwater elevation (top row). The lower end of the whisker represents the lower 95th-percentile confidence interval.

Figure 20
Predicted Changes and Ranges in Groundwater Levels
Earth and Water Resources Report



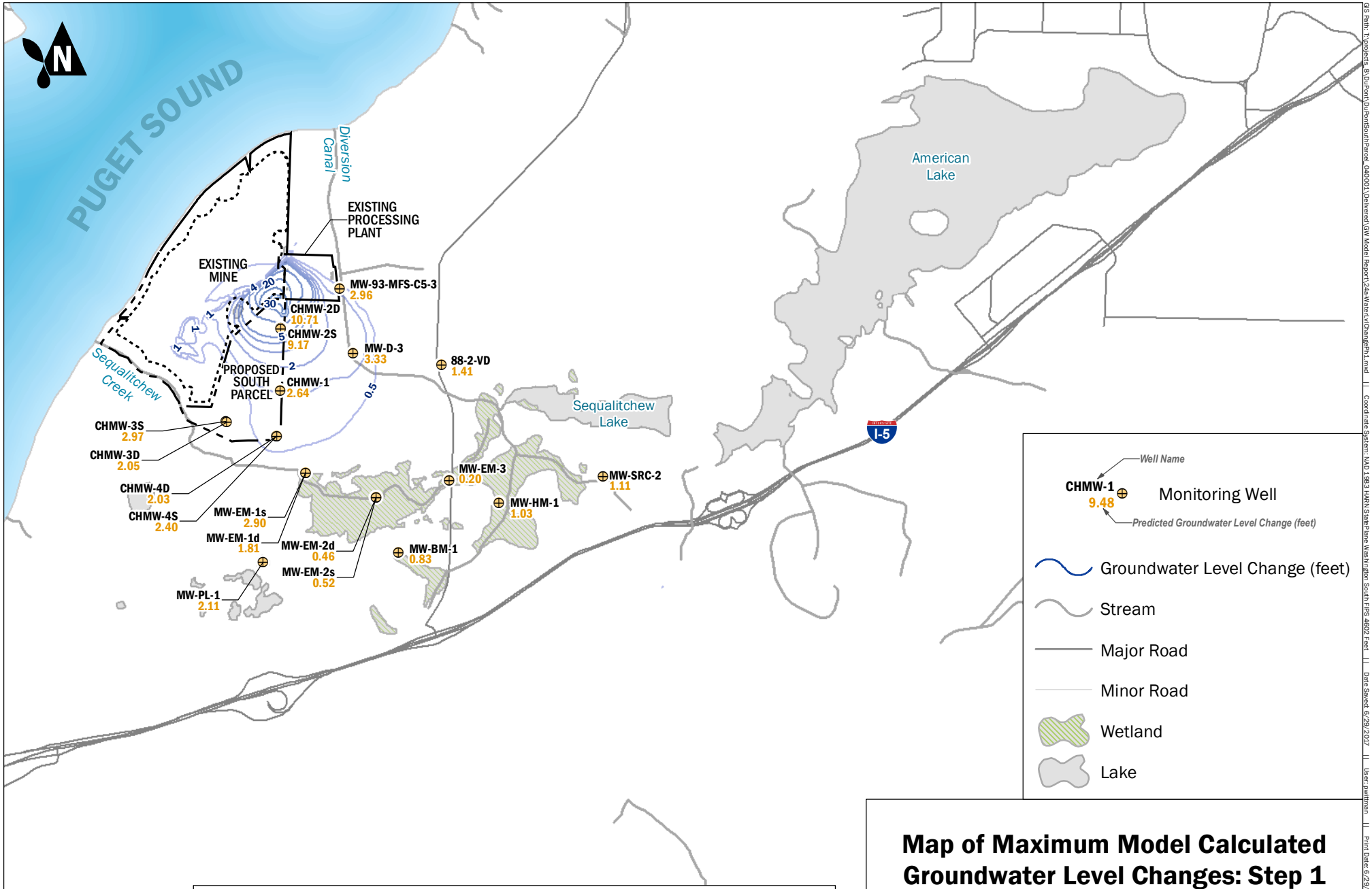
Dewatering Plan

CalPortland DuPont South Parcel
Monitoring Plan
DuPont, Washington

Aspect CONSULTING	APR-2016	BY: PSB / HRL	FIGURE NO. 21
	PROJECT NO. 040001-014	REVISED BY: OGR / RAA	

Basemap Layer Credits || Copyright:© 2014 Esri

GIS Path: T:\projects_8\DuPont\DuPontSouthParcel_040001\Delivered\MonitoringPlan\5DewateringPlan.mxd || Coordinate System: NAD 1983 HARN StatePlane Washington South FIPS 4602 Feet || Date Saved: 11/13/2014 || User: randrusyszyn ||



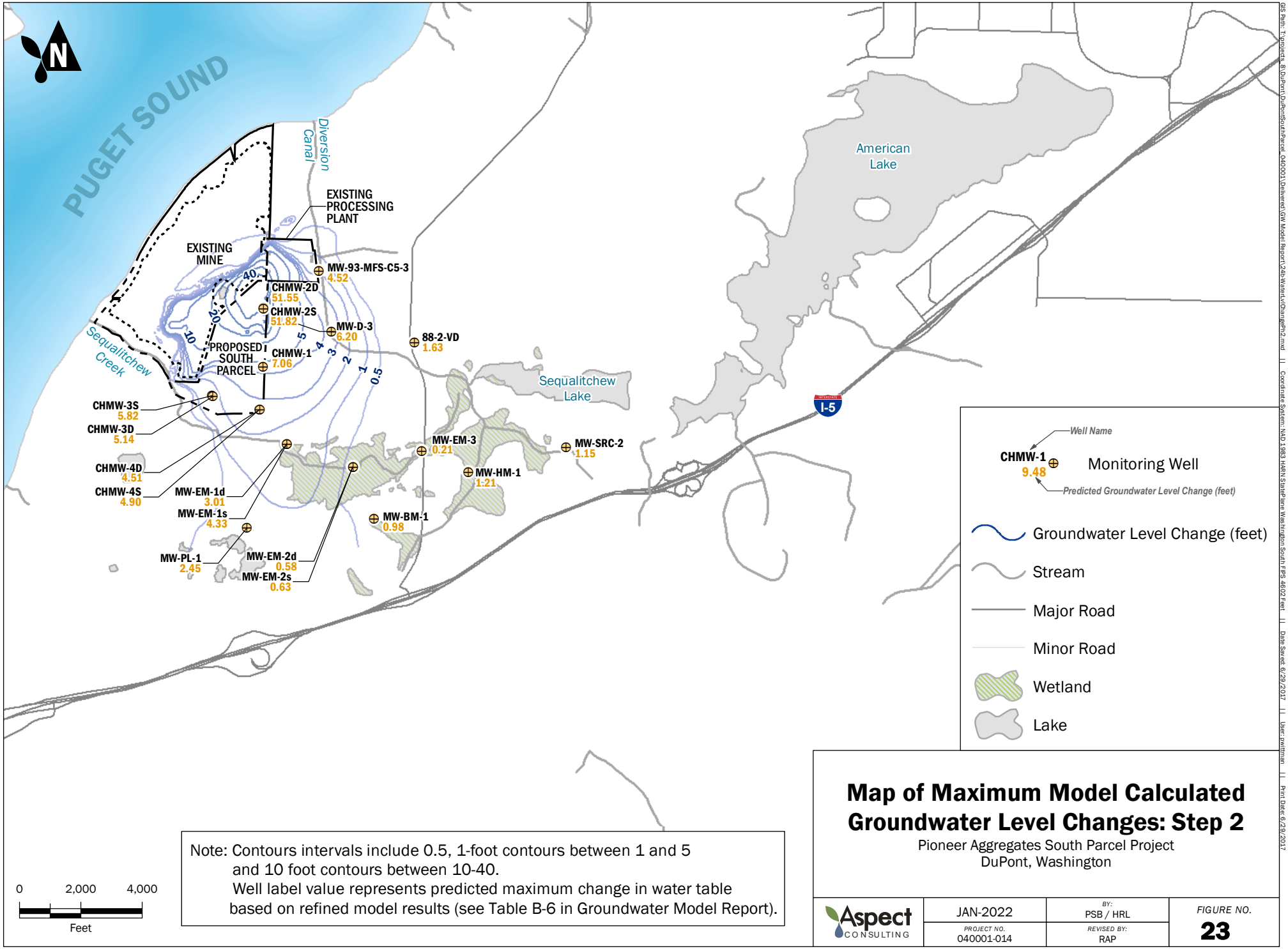
Note: Contours intervals include 0.5, 1-foot contours between 1 and 5 and 10 foot contours between 10-40.
Well label value represents predicted maximum change in water table based on refined model results (see Table B-6 in Groundwater Model Report).

Map of Maximum Model Calculated Groundwater Level Changes: Step 1

Pioneer Aggregates South Parcel Project
DuPont, Washington

Aspect CONSULTING	JAN-2022	BY: PSB / HRL	FIGURE NO. 22
	PROJECT NO. 040001-014	REVISED BY: RAP	

GIS Path: T:\projects_8\DuPont\DuPontSouthParcel_040001\Deliverable\GW Model Report\24a-WaterLvlChangePh1.mxd || Coordinate System: NAD 1983 HARN State Plane Washington South FIPS 4602 Feet || Date Saved: 6/29/2017 || User: pwittman || Print Date: 6/29/2017



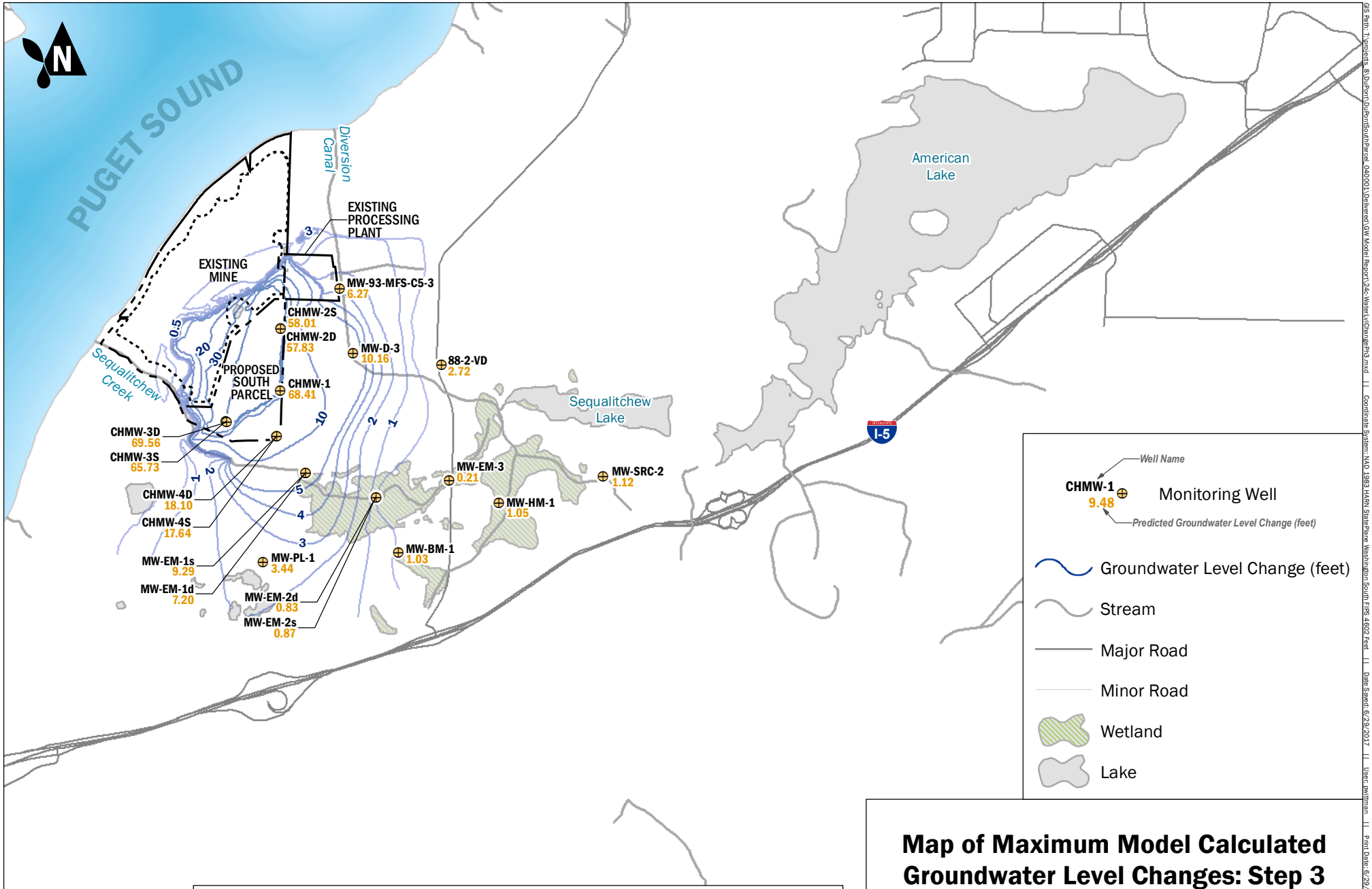
Note: Contours intervals include 0.5, 1-foot contours between 1 and 5 and 10 foot contours between 10-40.
Well label value represents predicted maximum change in water table based on refined model results (see Table B-6 in Groundwater Model Report).

Map of Maximum Model Calculated Groundwater Level Changes: Step 2

Pioneer Aggregates South Parcel Project
DuPont, Washington

Aspect CONSULTING	JAN-2022	BY: PSB / HRL	FIGURE NO. 23
	PROJECT NO. 040001-014	REVISED BY: RAP	

GIS Path: T:\projects_8\DuPont\DuPontSouthParcel_040001\Deliverable\GW Model Report\24b Waterlvl\ChangePh2.mxd || Coordinate System: NAD 1983 HARN StatePlane Washington South FIPS 4602 Feet || Date Saved: 6/29/2017 || User: jwitman || Print Date: 6/29/2017



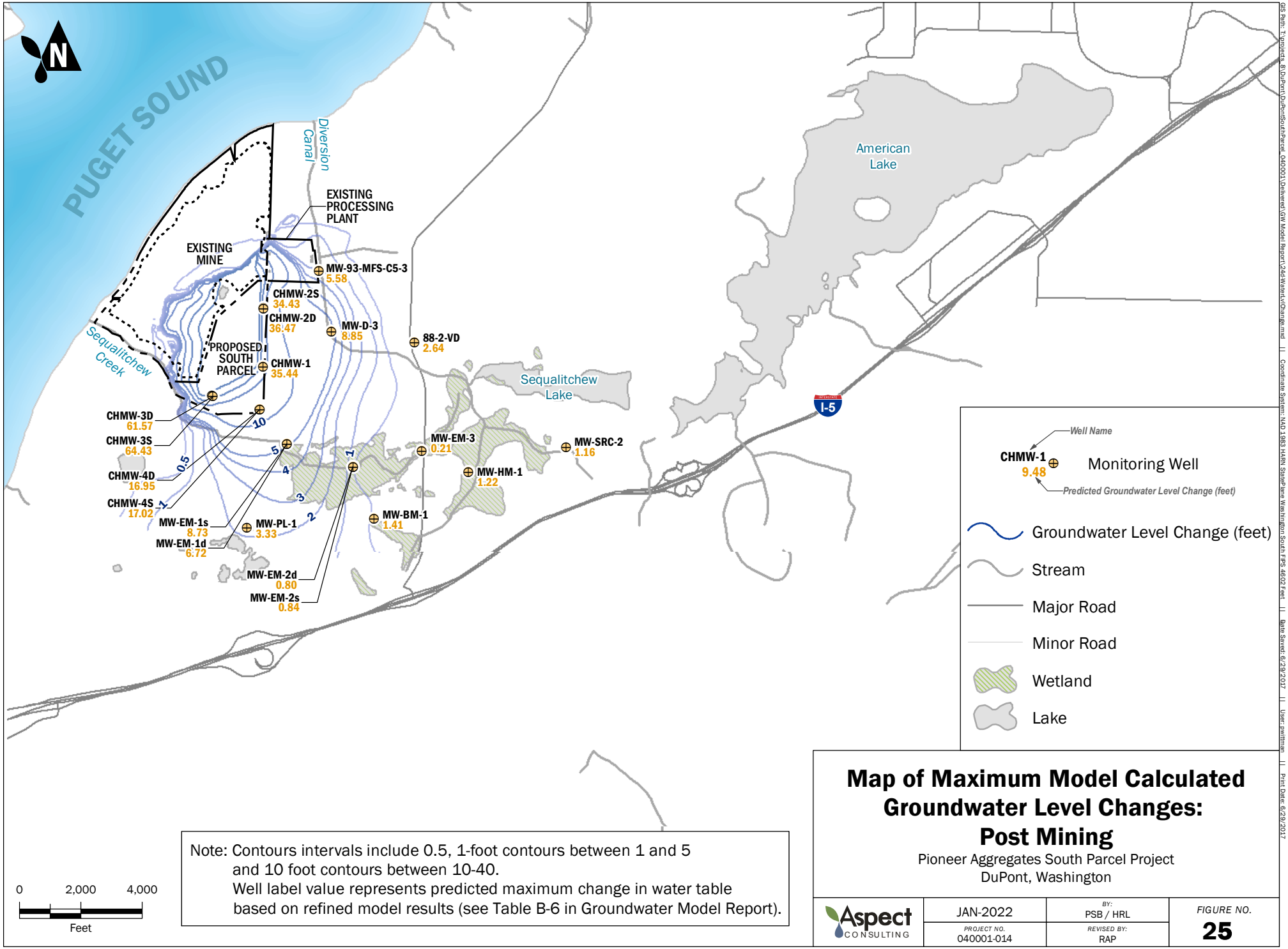
Note: Contours intervals include 0.5, 1-foot contours between 1 and 5 and 10 foot contours between 10-40.
Well label value represents predicted maximum change in water table based on refined model results (see Table B-6 in Groundwater Model Report).

Map of Maximum Model Calculated Groundwater Level Changes: Step 3

Pioneer Aggregates South Parcel Project
DuPont, Washington

Aspect CONSULTING	JAN-2022	BY: PSB / HRL	FIGURE NO. 24
	PROJECT NO. 040001-014	REVISED BY: RAP	

GIS Path: T:\projects_8\DuPont\DuPontSouthParcel_040001\Deliverest\GW Model Report\24c-WaterLvlChangeStp3.mxd LL Coordinate System: NAD 1983 HARN StatePlane Washington South FIPS 4602 Feet LL Date Saved: 6/29/2017 LL User: pwittman LL Print Date: 6/29/2017



Note: Contours intervals include 0.5, 1-foot contours between 1 and 5 and 10 foot contours between 10-40.
Well label value represents predicted maximum change in water table based on refined model results (see Table B-6 in Groundwater Model Report).

Map of Maximum Model Calculated Groundwater Level Changes: Post Mining

Pioneer Aggregates South Parcel Project
DuPont, Washington

Aspect CONSULTING	JAN-2022	BY: PSB / HRL	FIGURE NO. 25
	PROJECT NO. 040001-014	REVISED BY: RAP	

GIS Path: T:\projects_8\DuPont\DuPontSouthParcel_040001\Deliverable\GW Model Report\24d\WaterLvlChange.mxd || Coordinate System: NAD 1983 HARN StatePlane Washington South FIPS 4602 Feet || Date Saved: 6/29/2017 || User: pwittman || Print Date: 6/29/2017

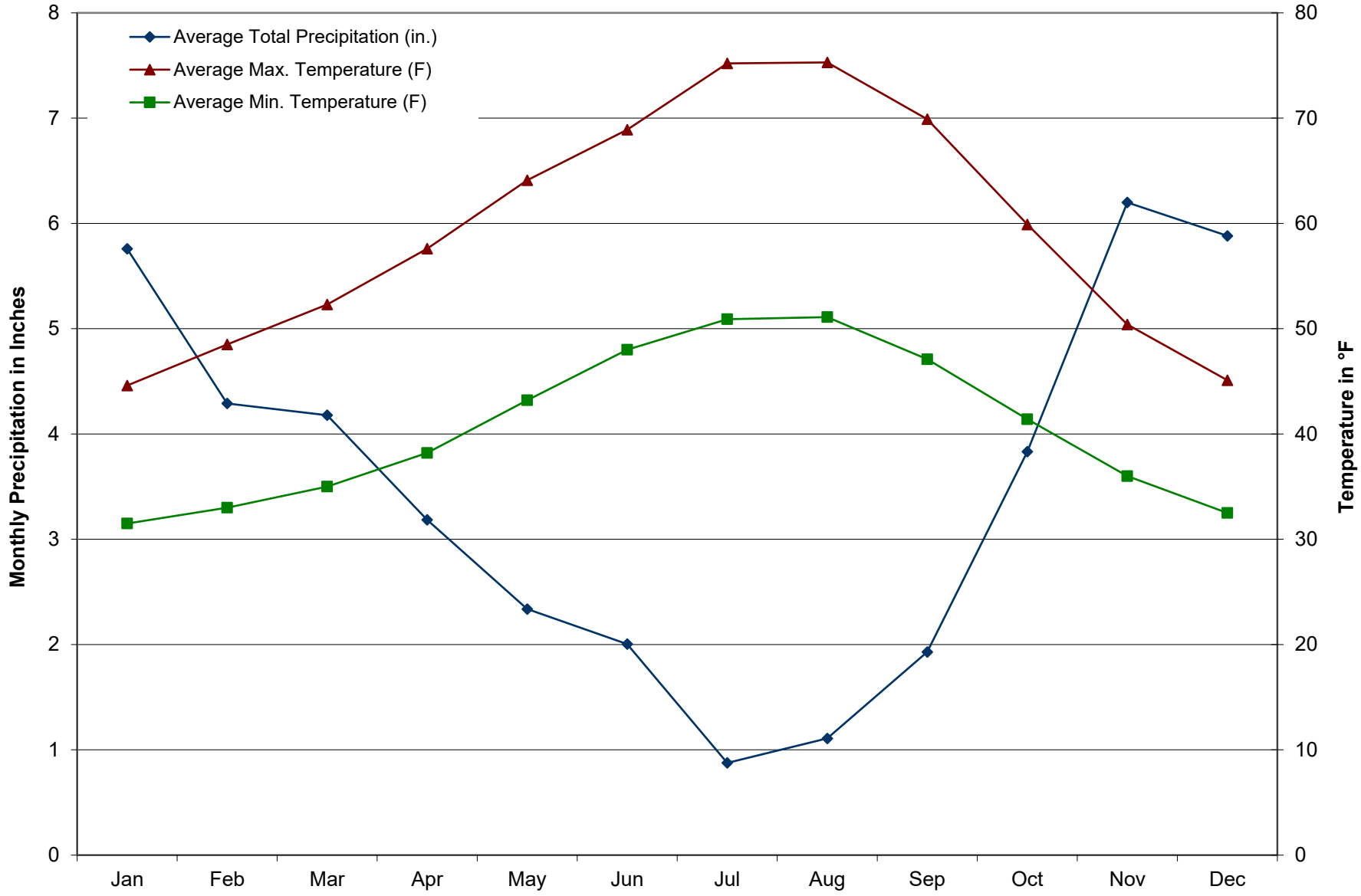


Figure 26

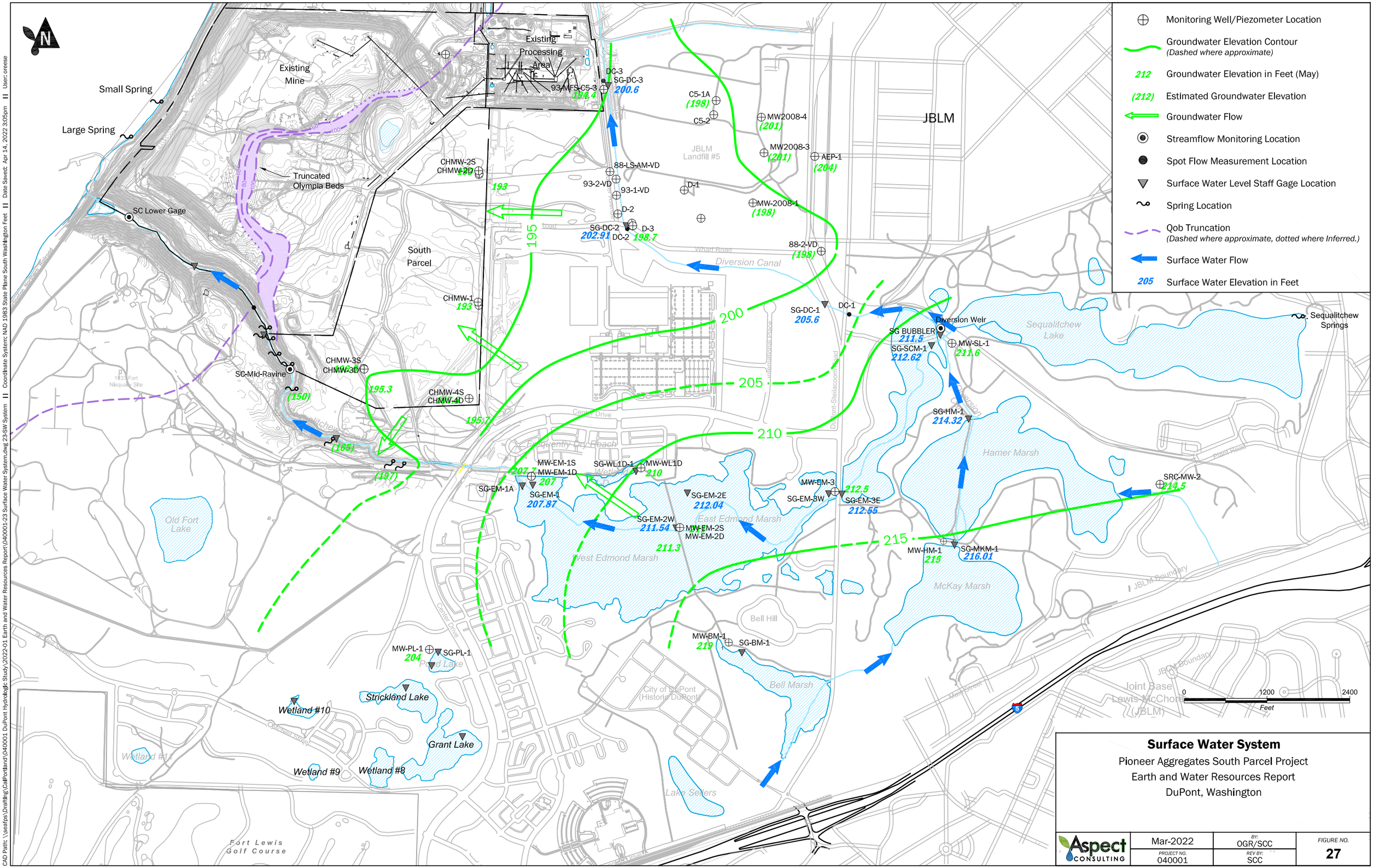
Average Precipitation and Temperature by Month

Pioneer Aggregates South Parcel Project

Aspect Consulting

02/23/22

S:\CalPortland\DuPont\South Parcel\Report Drafts\Earth and Water Resources Report 2021\Analysis\Water Balance\Figure 22.xlsm

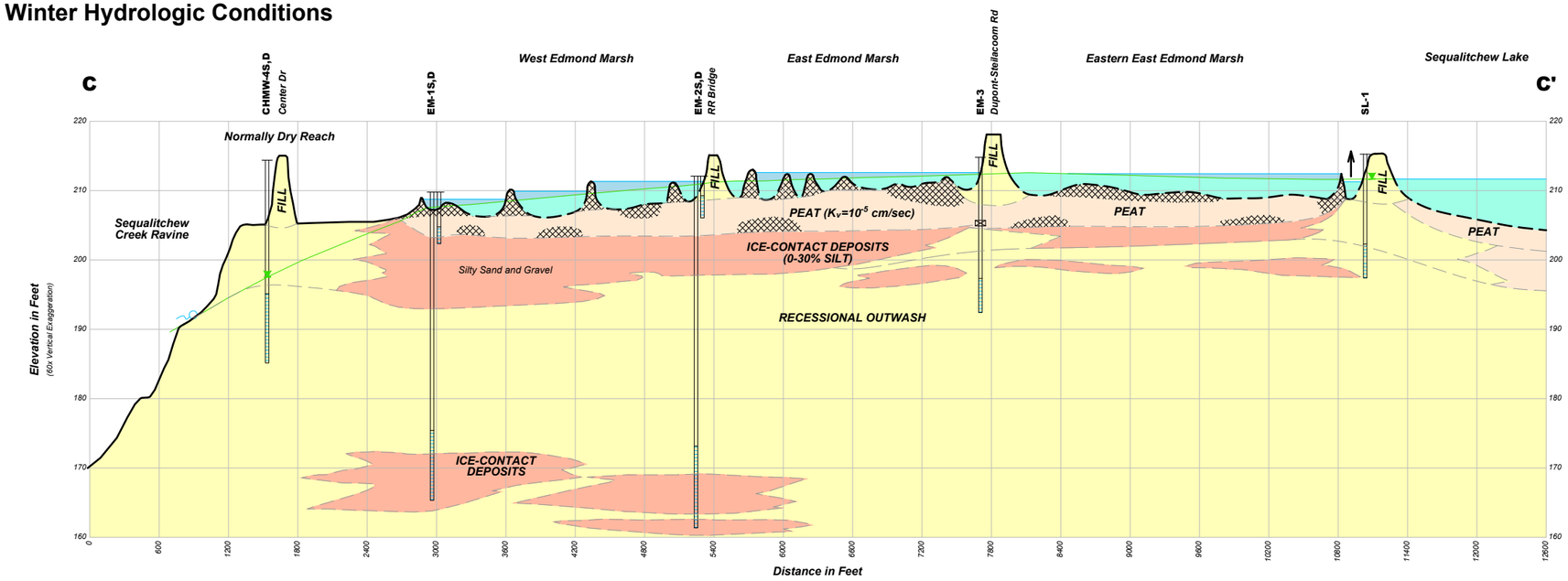


Surface Water System

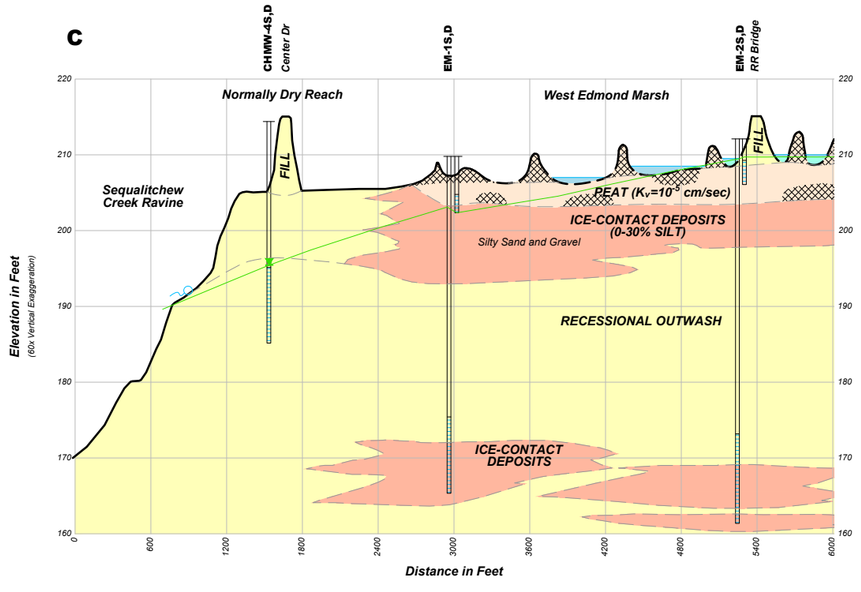
Pioneer Aggregates South Parcel Project
Earth and Water Resources Report
DuPont, Washington

Aspect Consulting	Mar-2022	BY: OGR/SCC	FIGURE NO. 27
	PROJECT NO. 040001	REV BY: SCC	

Winter Hydrologic Conditions



Summer Hydrologic Conditions
West Edmonds



Legend

- Groundwater Elevation
- Surface Water Elevation
- Beaver Dam

0 1200 2400
Horizontal Feet

0 20 40
Vertical Feet

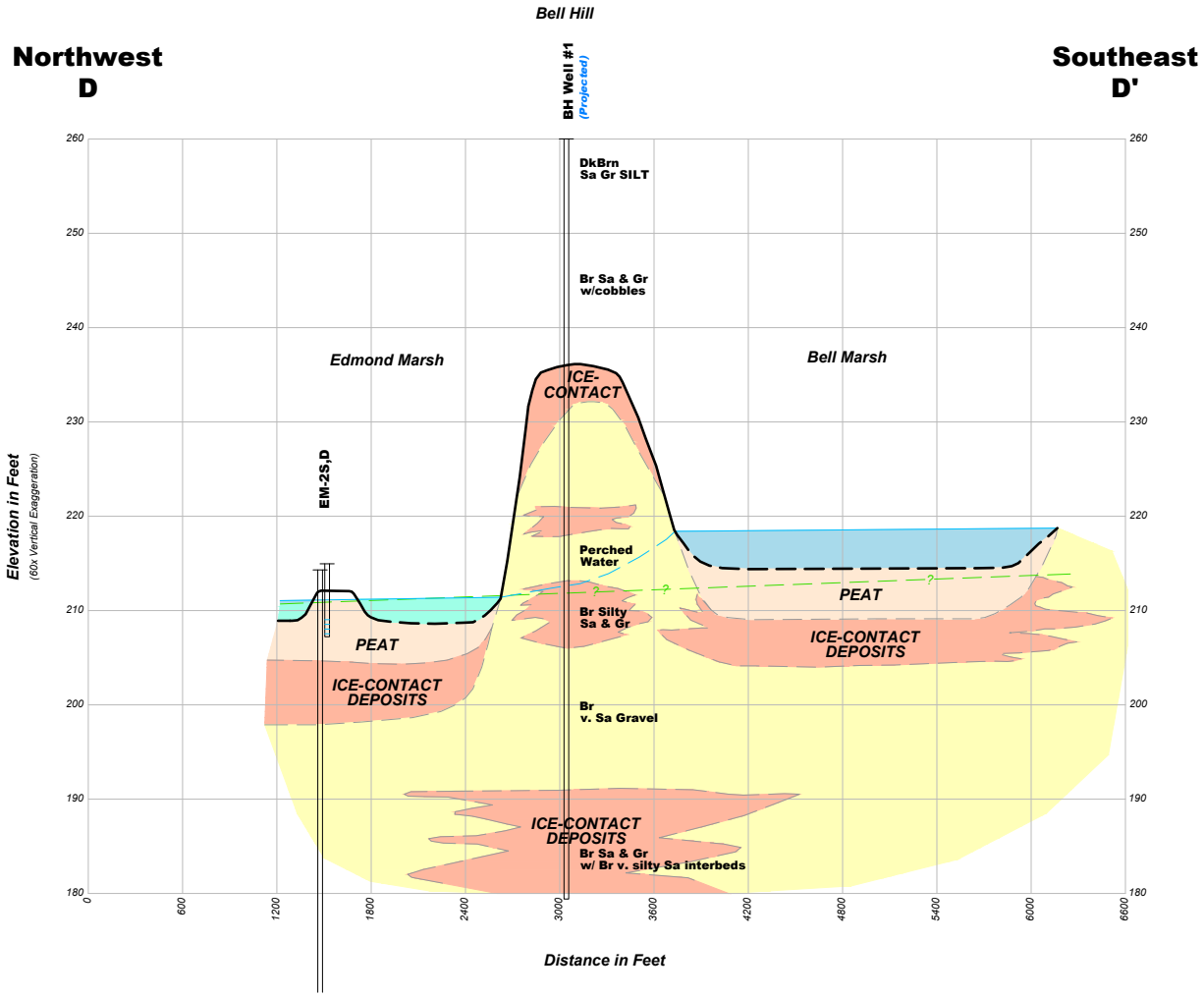
Edmond Marsh Cross Section - C-C'

Earth and Water Resources Report
Pioneer Aggregates South Parcel Project
DuPont, Washington

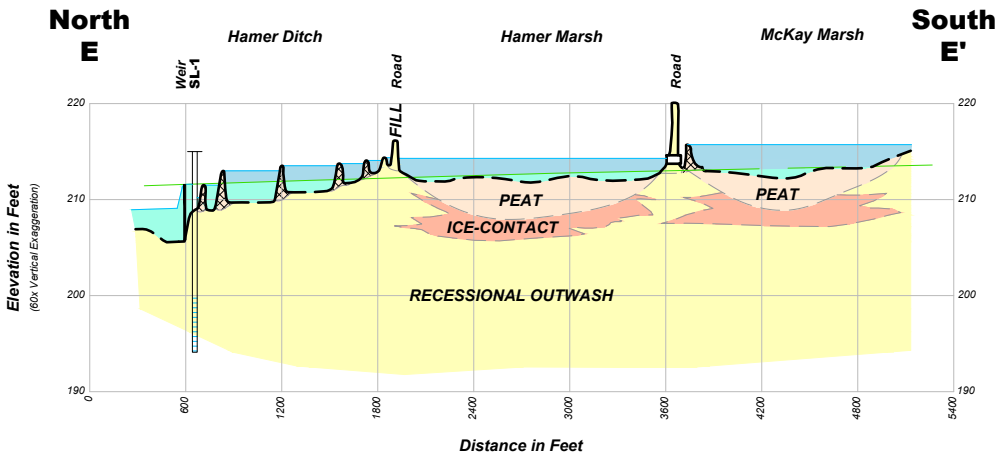
Aspect CONSULTING	Oct-2022	BY: OGR/SCC	FIGURE NO. 28
	PROJECT NO. 040001-I-018	REVISED BY: -	

CAD Path: Q:\CalPortland\040001 DuPont Hydrologic Study\2022-10 Earth and Water Resources Report\040001-08.dwg 27 Edmond Marsh Cross Section - C-C' || Date Saved: Oct 24, 2022 4:25pm || User: scudd

Winter Hydrologic Conditions - Bell/Edmond Marsh



Winter Hydrologic Conditions - Hamer/McKay Marsh



Legend

- Groundwater Elevation
- Surface Water Elevation
- Beaver Dam

0 1200 2400
Horizontal Feet

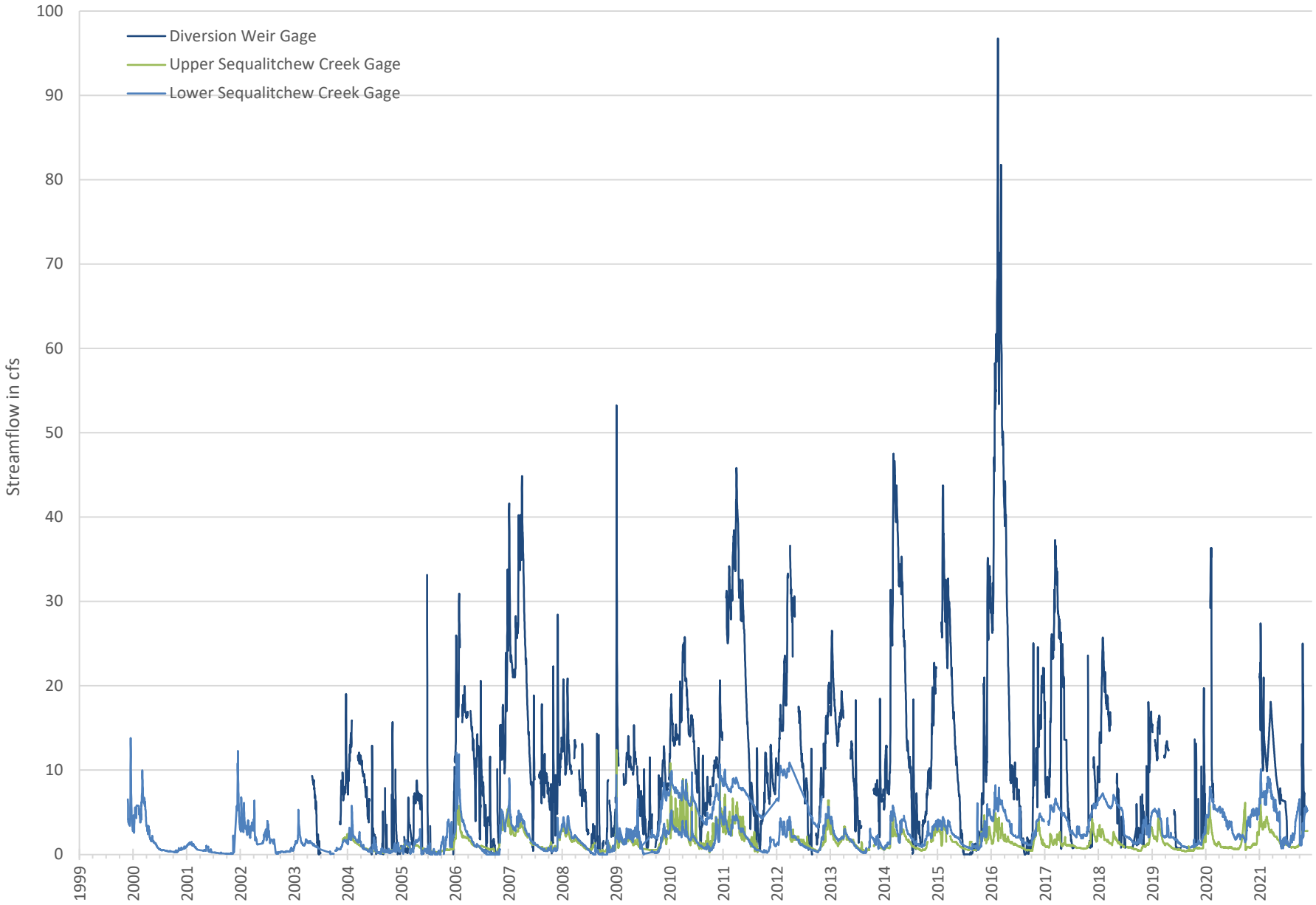
0 20 40
Vertical Feet

Bell, McKay and Hamer Marsh Cross Sections - D-D' and E-E'

Earth and Water Resources Report
Pioneer Aggregates South Parcel Project
DuPont, Washington

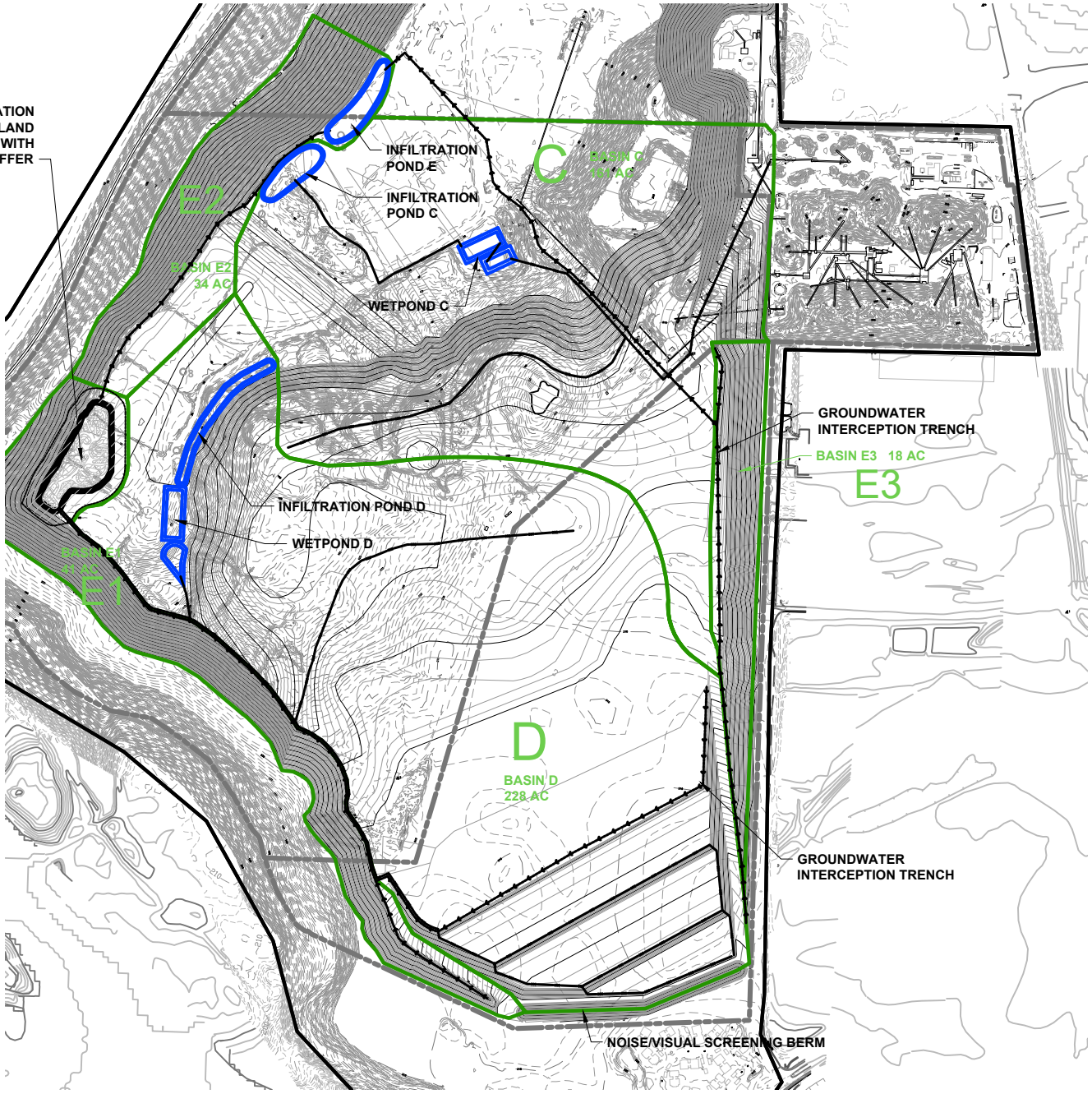
Aspect Consulting	Oct-2022	BY: OGR/SCC	FIGURE NO. 29
	PROJECT NO. 040001-I-018	REVISED BY: -	

CAD Path: Q:\CalPortland\040001 DuPont Hydrologic Study\2022-10 Earth and Water Resources Report\040001-08.dwg 28 Bell-McKay-Hamer Marsh Cross Sections - D-D' and E-E' || Date Saved: Oct 26, 2022 11:58am || User: scudd



Aspect Consulting
02/27/2022
S:\CalPortland\DuPont\South Parcel\Data\Flows\Flow Data Summary 3_v1.2.xlsm

Figure 30
Streamflow Hydrograph for Diversion Weir and Sequalitchew Creek
South Parcel Project



Legend

- Stormwater Management Facility
- Groundwater Interception Trench
- Drainage Ditch
- 8 — Location and Identifier of Soil Borings Used in Assessing Infiltration Rates
- A — Drainage Basin Label
- Drainage Basin Boundary

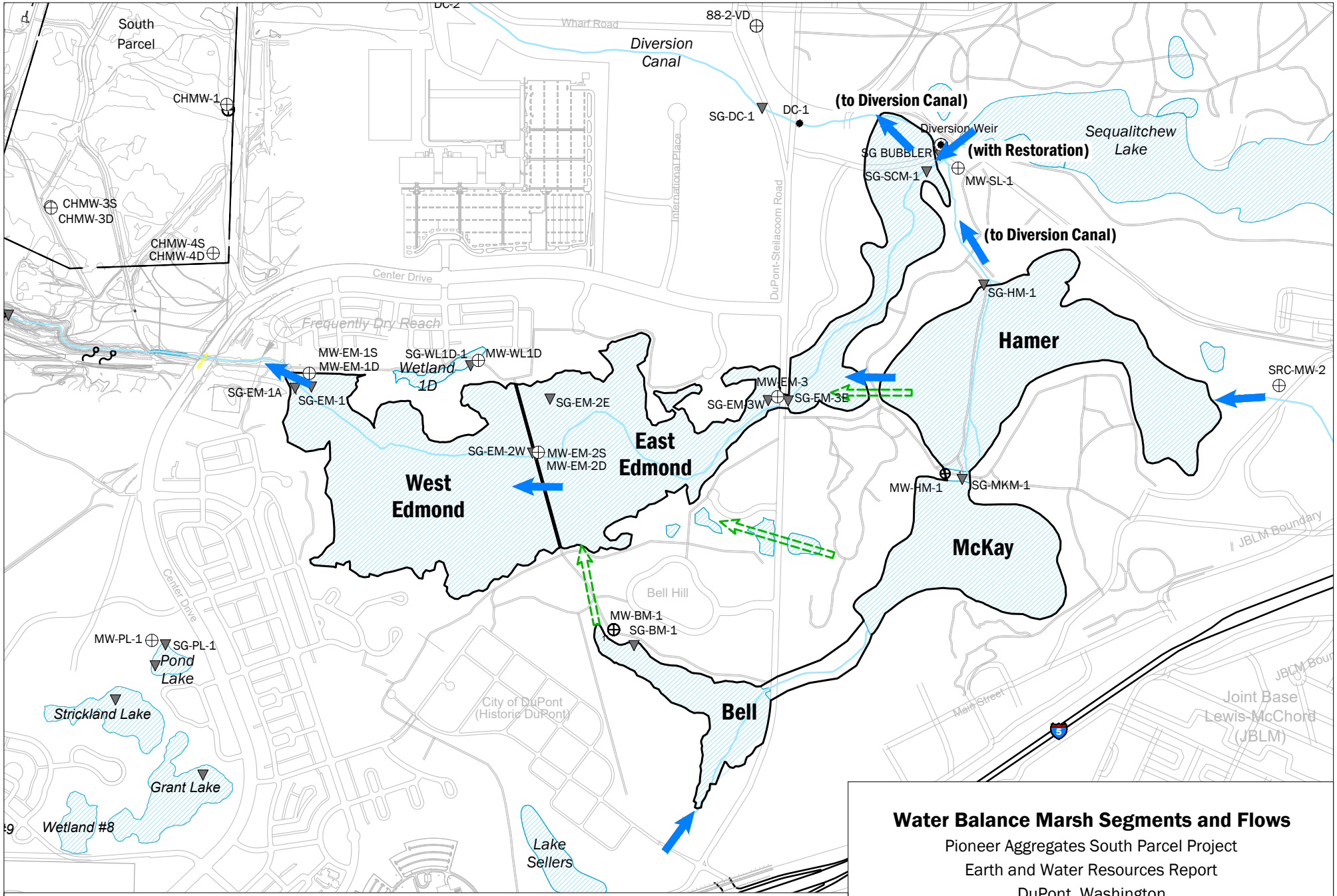
0 1000 2000 Feet

Proposed Drainage Basins and Stormwater Management Facilities

Pioneer Aggregates South Parcel Project
CalPortland
Dupont, Washington

Aspect CONSULTING	Feb-2022	BY: BMG/CMV	FIGURE NO. 31
	PROJECT NO. 040001	REVISED BY: -	

CAD Path: Q:\CalPortland\040001 DuPont Hydrologic Study\2022-01 Earth and Water Resources Report\040001-03 Prop Drainage&SW_Mgmt.dwg || Date Saved: 2/15/2022 4:46:30 PM || User: cvanslyke



Water Balance Marsh Segments and Flows

Pioneer Aggregates South Parcel Project
Earth and Water Resources Report
DuPont, Washington

Aspect Consulting	Oct-2022	BY: OGR/SCC	FIGURE NO. 32
	PROJECT NO. 040001-I-018	REV BY: -	

CAD Path: Q:\CalPortland\040001 DuPont Hydrologic Study\2022-10 Earth and Water Resources Report\040001-03 Water Balance Marsh Segments and Flows.dwg 31 Water Balance Marsh Segments and Flows || Date Saved: Oct 26, 2022 12:18pm || User: scudd

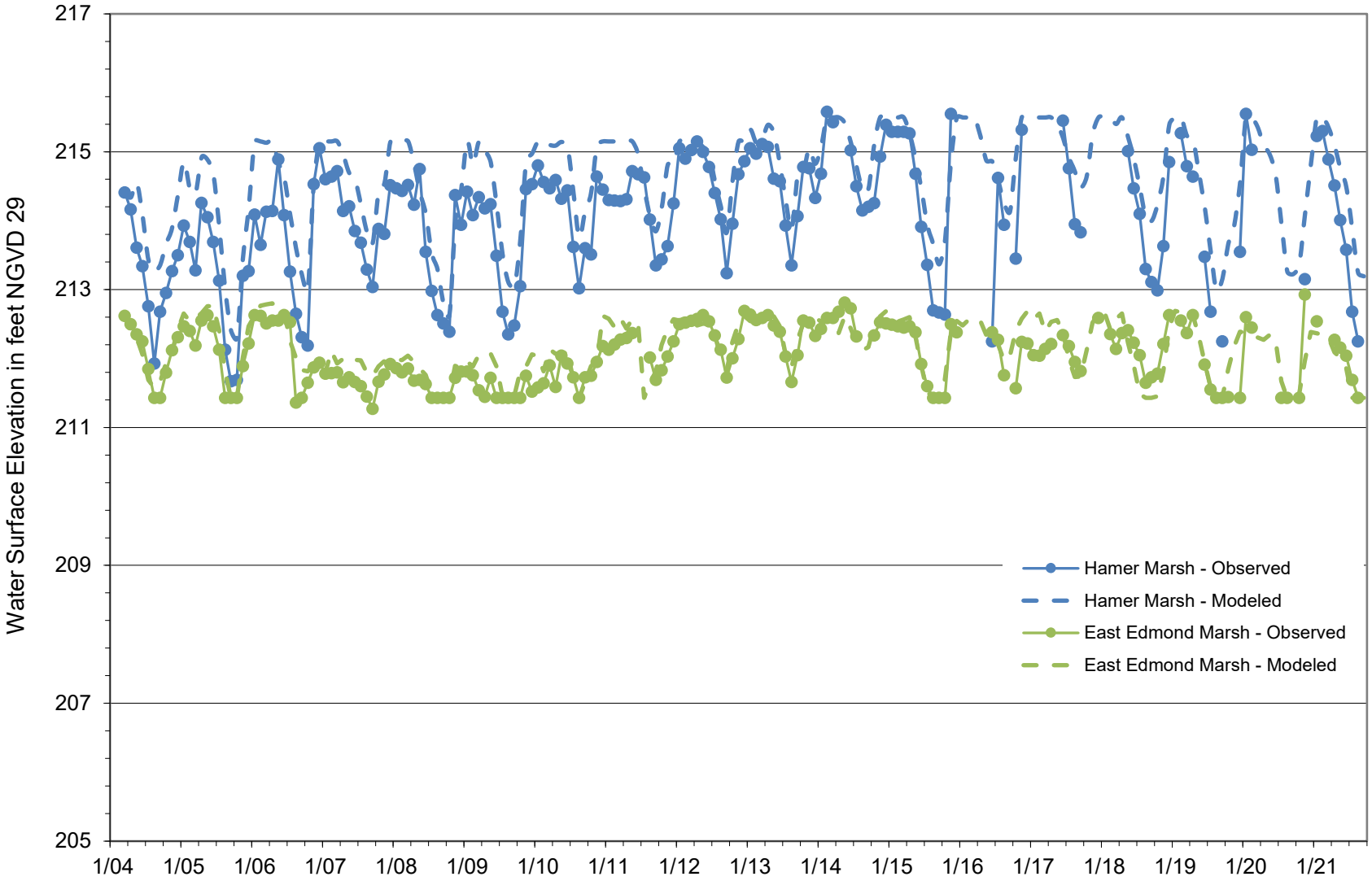


Figure 33

Water Balance Calibration for Hamer and East Edmond Marshes

Pioneer Aggregates South Parcel Project

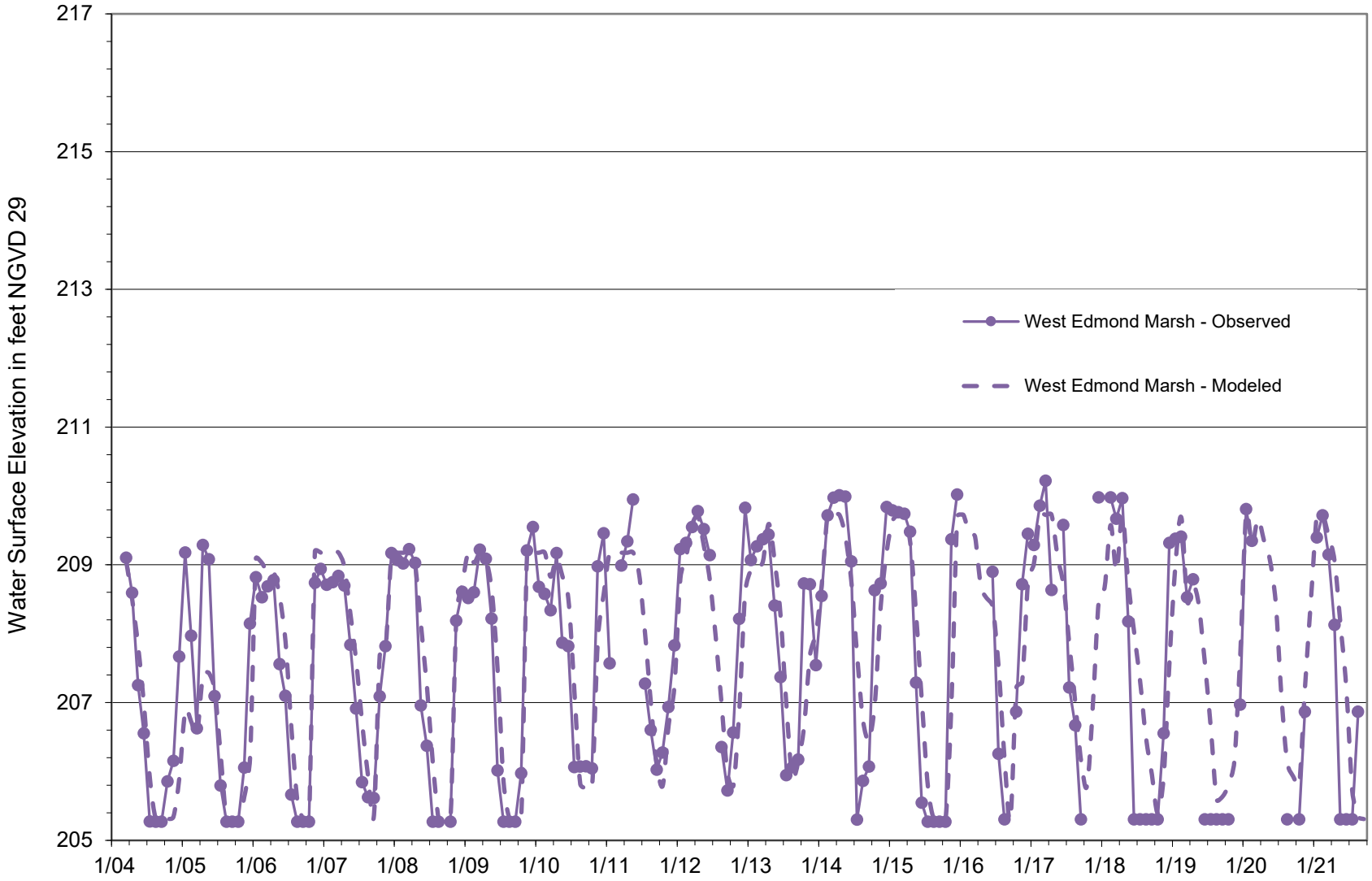
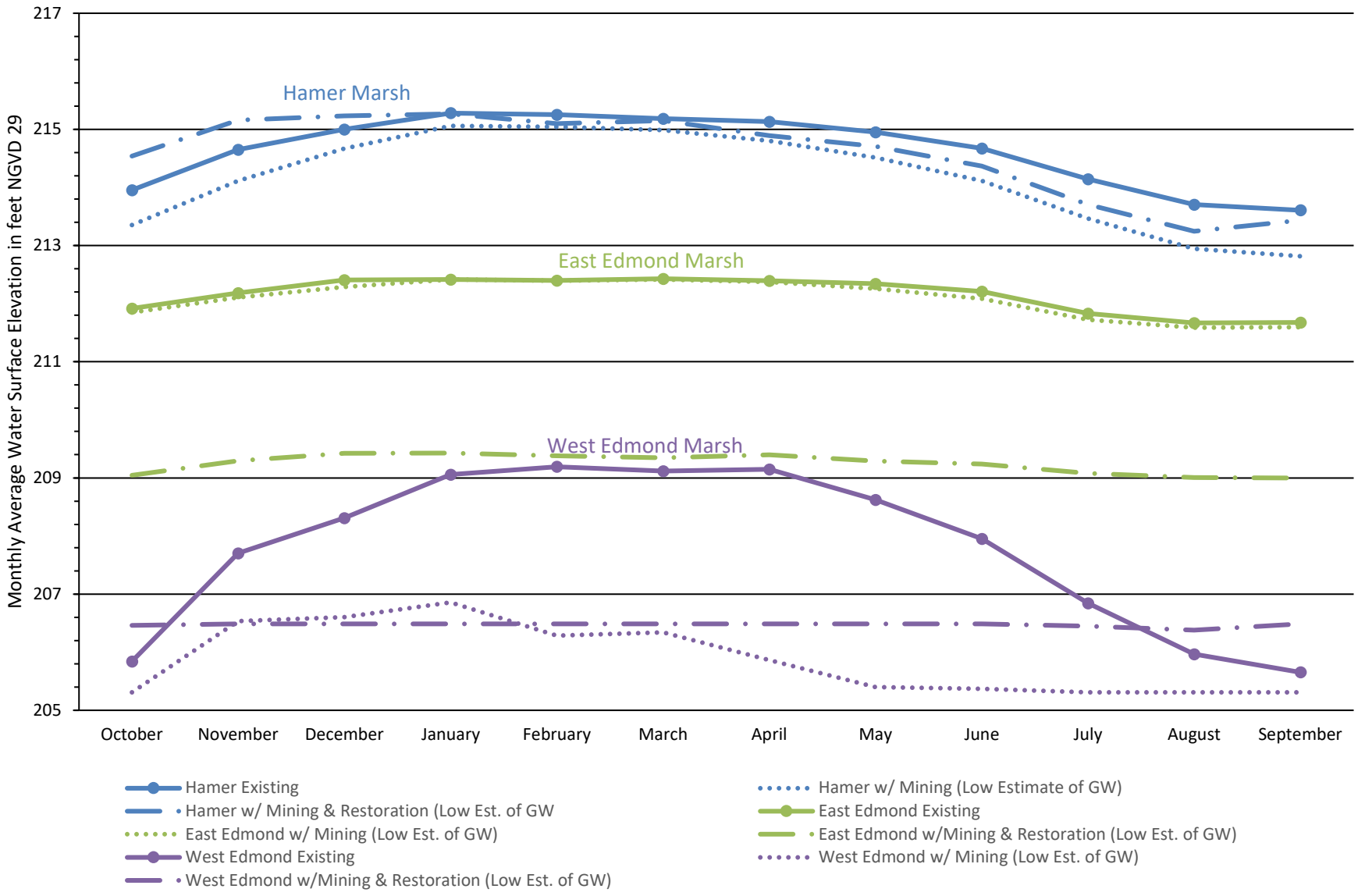


Figure 34

Water Balance Calibration for West Edmond Marsh Under Existing Conditions



Aspect Consulting
11/1/2022
S:\CalPortland\DuPont\South Parcel\Water Balance Analyses\Water Balance -2022 - Mining&Restoration.xlsm

Figure 35
Predicted Marsh Hydrographs with Mining and Restoration
Pioneer Aggregates South Parcel Project

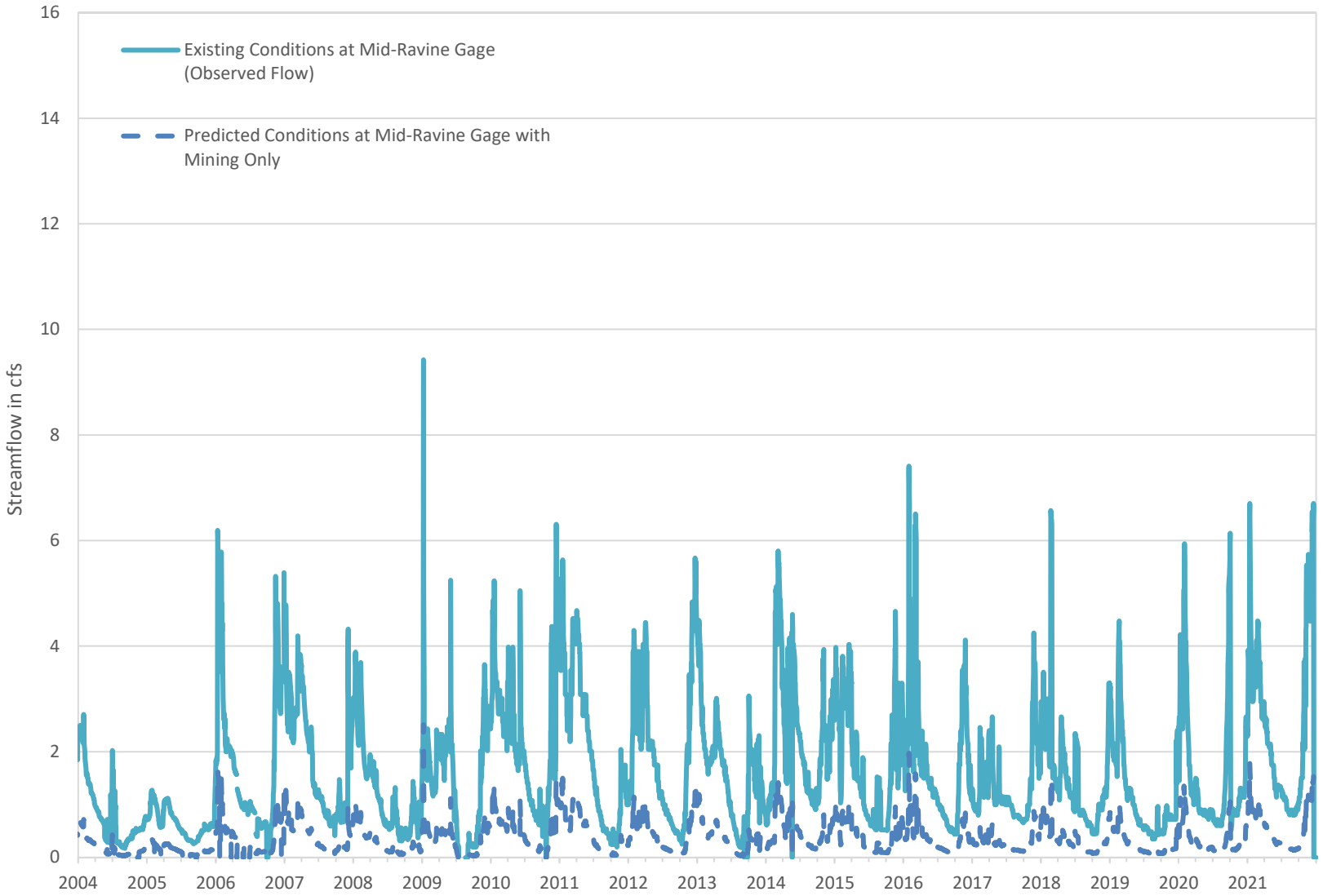


Figure 36

Predicted Streamflow Hydrograph for Sequalitchew Creek with Mining Only

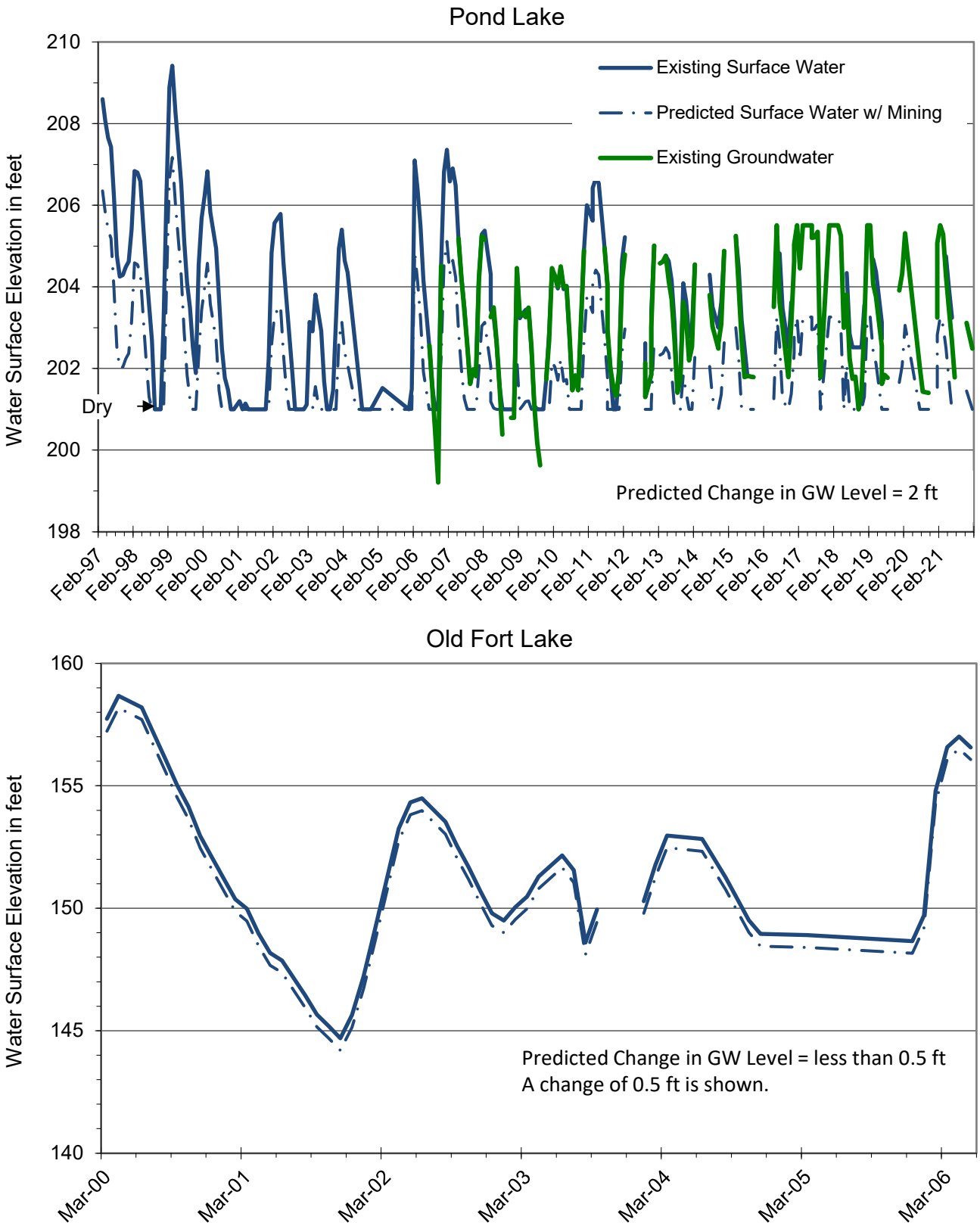


Figure 37

Predicted Hydrographs for Pond and Old Fort Lakes

Aspect Consulting
03/23/2022
S:\CalPortland\DuPont\South Parcel\Report Drafts\Earth and Water Resources Report 2021\Analysis\WetlandWLs.xlsx

Nisqually Reach

Joint Base Lewis-McChord

J: Ravine Habitat

H: City Hall Culvert
Replace the culvert near City Hall with one designed for fish passage

I: Center Drive Culvert
Evaluate and improve channel in culvert under Center Drive

G: Losing Reach
Monitor flow loss in losing reach Seal stream bed, if needed Restore channel structure and riparian vegetation

K: Lake Outlet Area - Part 2
Improve wetland habitat

C: Sequalitchew Lake Water Levels
Seasonally manage lake levels

Sequalitchew Lake

D: Lake Outlet Area - Part 1
Remove crossover culverts and reduce barriers to flow

Sequalitchew Creek

Homer Marsh

E: Hamer Marsh
Install weir in Hamer Marsh

B: Beavers
Install flexible levelers and beaver exclusion devices at multiple locations in Edmond Marsh

Old Fort Lake

West Edmond Marsh

East Edmond Marsh

E: Hamer Marsh
Replace the 12-inch culvert btwn Hamer and Edmond Marsh if water quality meets standards

B: Beavers
Install flexible levelers and beaver exclusion devices at multiple locations in Edmond Marsh

F: Railroad Trail Bridge
Replace portion of trail with pedestrian bridge

Bell Marsh

Definite Elements – core initial elements, well-defined and known

Contingent Elements -- specific additional information is necessary to design

Adaptive Management Elements– actions optional depending on conditions observed during restoration

Restored Flow Direction

Water Body

Joint Base Lewis - McChord Boundary

Notes:
1. Element numbering per Sequalitchew Creek Watershed Restoration Plan (2017).
2. Implementation of elements on JBLM will be permitted and led by JBLM.

N

0 1,300 2,600

Feet

Restoration Plan Elements

Earth and Water Resources Report
Pioneer Aggregates South Parcel Project
DuPont, Washington

Aspect CONSULTING	FEB-2022	BY: OR / SBM	FIGURE NO. 38
	PROJECT NO. 040001-I-018-02	REVISED BY: NLK	

Basemap Layer Credits || Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

GIS Path: G:\projects\Dupont\DuPont\DuPont\SouthParcel_040001\Delivered\Earth and Water Resources Report\28 Restoration Plan Elements.mxd || Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet || Date Saved: 2/17/2022 || User: nkochie || Print Date: 2/17/2022

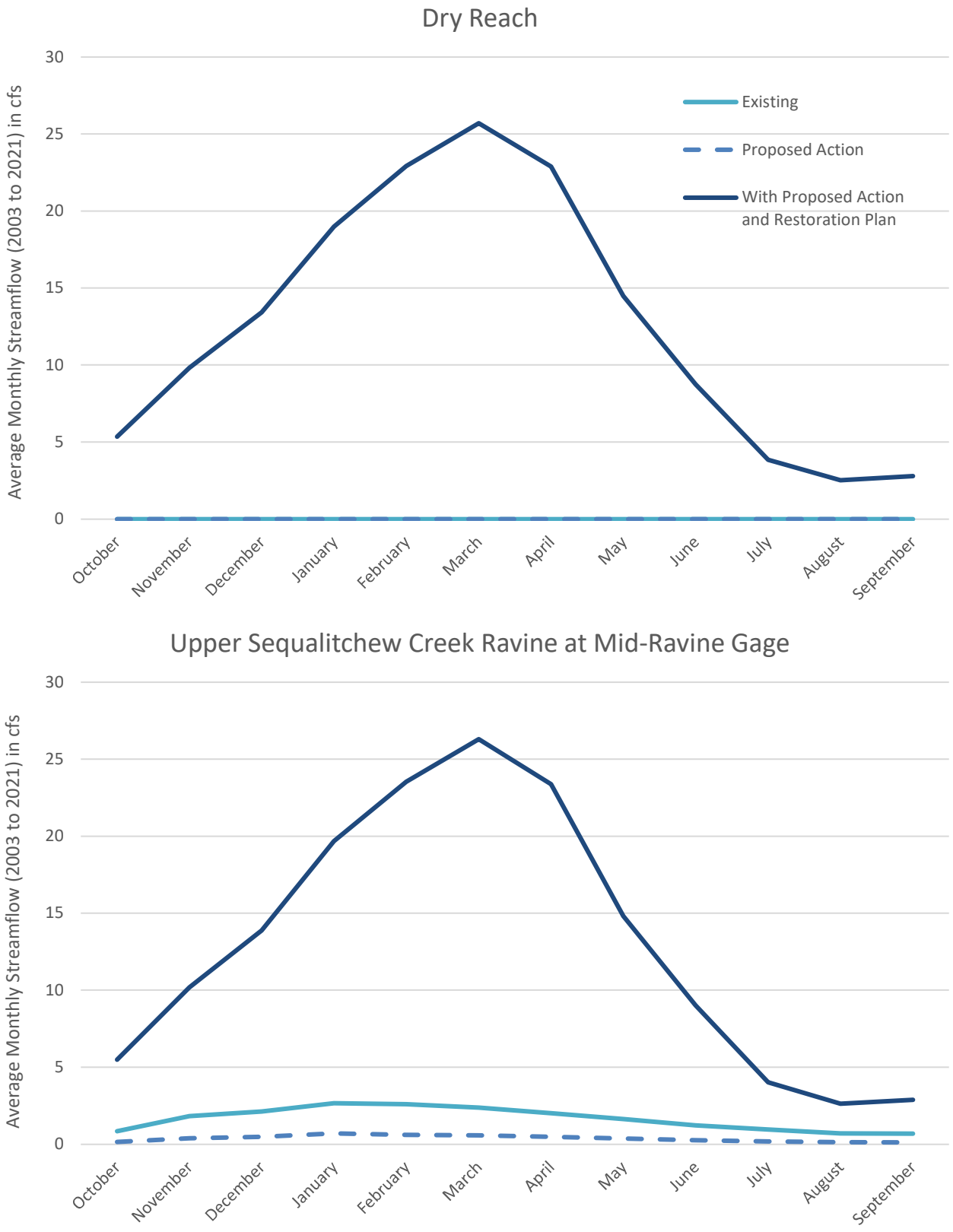


Figure 39
Predicted Streamflow Hydrograph for Sequalitchew Creek with Mining and Restoration

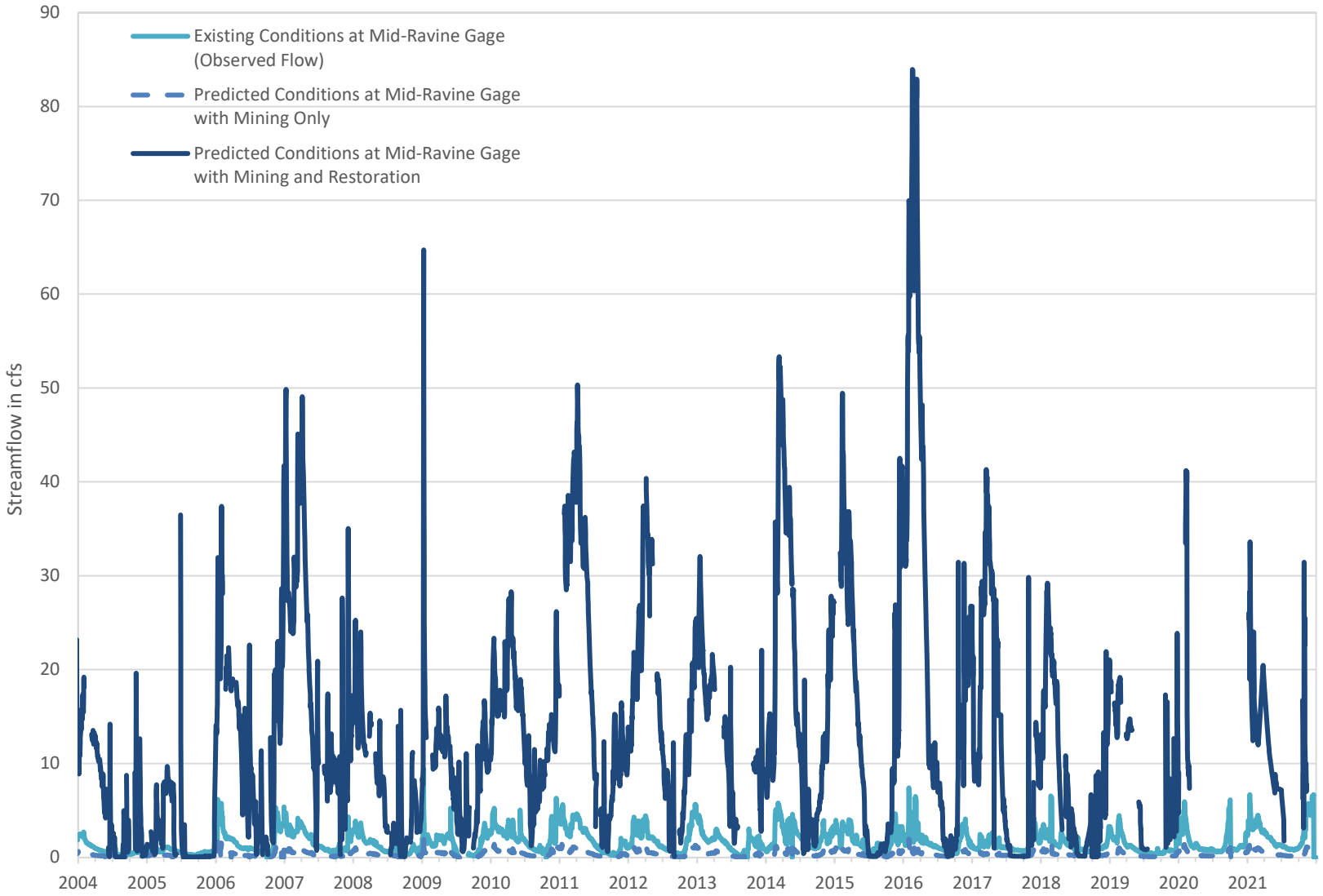
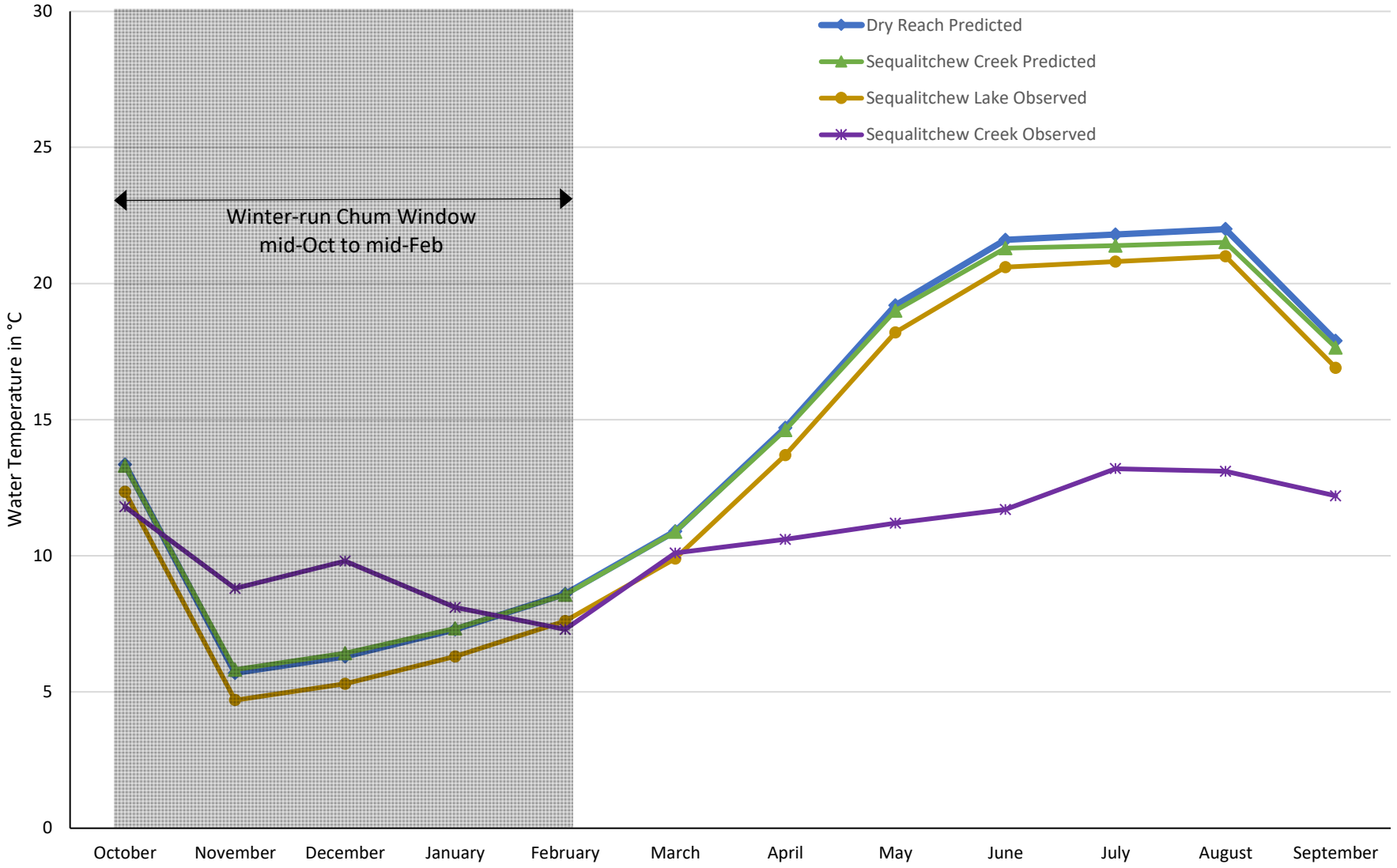


Figure 40

Predicted Streamflow Hydrograph for Sequalitchew Creek with Mining and Restoration

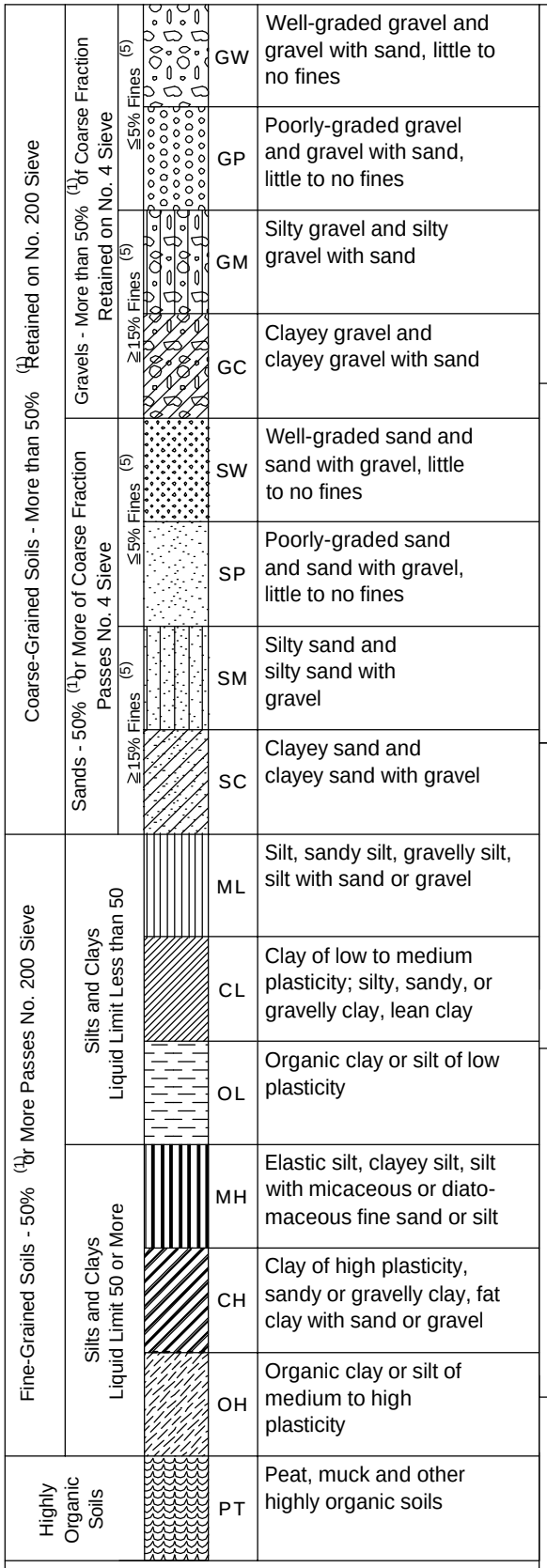


Aspect Consulting
10/28/2022
S:\CalPortland\DuPont\South Parcel\Report Drafts\Earth and Water Resources Report 2021\Analysis\WQCalcs-r2.xlsx

Figure 41
Predicted Effects on Stream Temperature in Sequalitchew Creek
Pioneer Aggregates South Parcel Project

APPENDIX A

Select Boring Logs



Terms Describing Relative Density and Consistency

	Density	SPT (2) blows/foot
Coarse-Grained Soils	Very Loose	0 to 4
	Loose	4 to 10
	Medium Dense	10 to 30
	Dense	30 to 50
	Very Dense	>50

	Consistency	SPT (2) blows/foot
Fine-Grained Soils	Very Soft	0 to 2
	Soft	2 to 4
	Medium Stiff	4 to 8
	Stiff	8 to 15
	Very Stiff	15 to 30
	Hard	>30

Test Symbols

FC = Fines Content
G = Grain Size
M = Moisture Content
A = Atterberg Limits
C = Consolidation
DD = Dry Density
K = Permeability
Str = Shear Strength
Env = Environmental
PiD = Photoionization Detector

Component Definitions

Descriptive Term	Size Range and Sieve Number
Boulders	Larger than 12"
Cobbles	3" to 12"
Gravel	3" to No. 4 (4.75 mm)
Coarse Gravel	3" to 3/4"
Fine Gravel	3/4" to No. 4 (4.75 mm)
Sand	No. 4 (4.75 mm) to No. 200 (0.075 mm)
Coarse Sand	No. 4 (4.75 mm) to No. 10 (2.00 mm)
Medium Sand	No. 10 (2.00 mm) to No. 40 (0.425 mm)
Fine Sand	No. 40 (0.425 mm) to No. 200 (0.075 mm)
Silt and Clay	Smaller than No. 200 (0.075 mm)

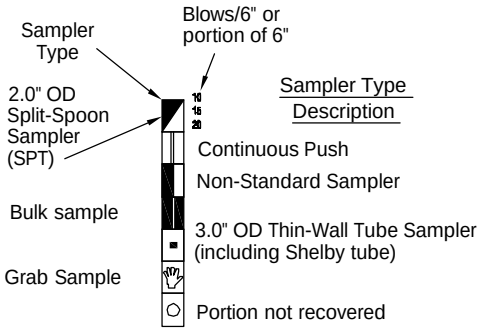
(3) Estimated Percentage

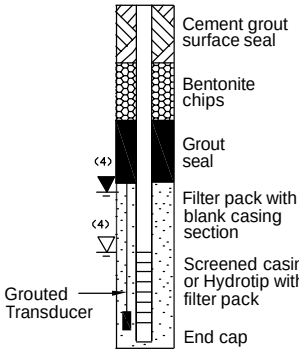
Percentage by Weight	Modifier
<5	Trace
5 to 15	Slightly (sandy, silty, clayey, gravelly)
15 to 30	Sandy, silty, clayey, gravelly)
30 to 49	Very (sandy, silty, clayey, gravelly)

Moisture Content

Dry - Absence of moisture, dusty, dry to the touch
Slightly Moist - Perceptible moisture
Moist - Damp but no visible water
Very Moist - Water visible but not free draining
Wet - Visible free water, usually from below water table

Symbols





(1) Percentage by dry weight
(2) (SPT) Standard Penetration Test (ASTM D-1586)
(3) In General Accordance with Standard Practice for Description and Identification of Soils (ASTM D-2488)
(4) Depth of groundwater — ATD = At time of drilling; Static water level (date); BGS = below ground surface
(5) Combined USCS symbols used for fines between 5% and 15% as estimated in General Accordance with Standard Practice for Description and Identification of Soils (ASTM D-2488)

Classifications of soils in this report are based on visual field and/or laboratory observations, which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field or laboratory testing unless presented herein. Visual-manual and/or laboratory classification methods of ASTM D-2487 and D-2488 were used as an identification guide for the Unified Soil Classification System.

Aspect CONSULTING

Exploration Log Key

DATE:
DESIGNED BY:
DRAWN BY:
REVISED BY:

PROJECT NO.

FIGURE NO.
A-1

Q:_ACAD Standards\Standard Details\Exploration Log Key B1.dwg

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
040001	BM-MW-1	1 of 1

Project Name: North Sequalitchew Creek
Location: DuPont, Washington
Drilling Method: Hollow Stem Auger - 4" ID ; Holt Drilling
Sampling Method: 3" Diameter D&M

Top of Casing Elev. (ft mllw): 232.32
Ground Surfave Elev. (ft): 229.37
Depth to Water (ft bgs): 12.5
Start Date: August 3, 2004
Finish Date: August 3, 2004

Depth feet	Well Construction	Tests\Remarks	Blows/ 6"	Sample ID	Mtl. Graphic	Description
1	5" diameter steel monument, cement seal 0'-1.5'					Brown, dry, GRAVEL, trace silt; gravel fine to coarse, predominantly coarse; abundant cobbles, subrounded to rounded (GW)
2						
3						(Road fill)
4	Natural Fill 1.5'-5'					
5		18"/4"	11	5-6.5		Brown to tan, moist sandy GRAVEL, trace silt; gravel fine to coarse, subrounded to rounded; sand predominantly medium to coarse.
6			12			
7			10			
8		18"/12"	4	7.5-9		Brown to reddish brown, moist, slightly gravelly SAND, trace silt; sand fine to coarse, predominantly medium; gravel fine, subangular to rounded (SP)
9	Bentonite Chips 5'-12'		10			
10			16			
11		18"/5"	9	10-11.5		Occasional coarse gravel and grades medium to coarse sand.
12		8/3/04	15			
13		18"/6"	19			
			8	12.5-14		Brown to red-brown, wet, gravelly SAND, trace silt; sand predominantly coarse; gravel fine to coarse, predominantly fine.
	10/20 silica sand filter pack 12'-26.5'		14			
15		18"/10"	15			
16			9	15-16.5		
17			10			
18		18"/8"	16			Yellowish-green to brown, highly oxidized, wet, slightly to trace silt; sandy GRAVEL; gravel fine to coarse; sand predominantly coarse (GW-GM)
19			5	17.5-19		Yellow brown, highly oxidized, wet, slightly gravelly SAND, trace silt; sand medium to coarse, predominantly coarse; gravel predominantly fine (SP)
20	20-slot screen 15'-25'; slip cap with SS screw 25'-25.3'	18"/12"	8			Grades to slightly silty and gravelly in shoe (SP-SM)
21			8			
22			9	20-21.5		Gray olive, wet, SAND; trace gravel; trace to no silt; sand predominantly medium to coarse (SP)
23		18"/14"	11			Gray green, wet, slightly silty to trace silt, sandy GRAVEL; gravel fine to coarse, subrounded to rounded; sand medium to coarse. (GP-GM)
24			13	22.5-24		Gray green, wet, SAND; sand medium (SP)
25		18"/3"	25			
26			24			Gray olive, wet, sandy GRAVEL, trace silt; gravel fine to coarse, sand predominantly medium to coarse (GP)
27			28	25-26.5		Gray olive, wet, slightly silty sandy GRAVEL; gravel fine to coarse; sand medium to coarse (GP-GM)
28			19			
29			17			Total depth = 25' drilled; 26.5' driven.

Sampler Type (ST):
- 3.25" OD D & M Split-Spoon Ring Sampler
- No Recovery
- 2" OD Split-Spoon Sampler

PID - Photoionization Detector
Water Level (ATD)
Static Water Level

Logged by: ILE
Approved by: LJH
Figure No. A- 1

APPENDIX B

MW_GEOL S CRK_SEQ CRK.GPJ November 23, 2004

CH2MHILL

Well Number: CHMW-1

Sheet: 1 of 1

Client: Glacier NW
Project: N Sequalitchew Creek Aquifer Tests
Location: DuPont, Washington
Project Number: 151973.A2.AT

Driller: Hokkaido Drilling (Bill & Steve)
Drilling Method: Speedstar 15 Truck-Mounted Air Rotary
Sampling Method: Sand pump (water added)
Logged by: driller
Start/Finish Date: 9/23/99 - 9/24/99

Depth (ft)	Sample Info: Sample #	Sample Info: STP (6"-6"-6")	Soil Log	Soil Description	Depth / Elev	Well Drawing	Well Construction Notes
-5					5		
					217		Monument (not shown)-- Lockable 6" steel protective casing in concrete.
0				Ground Surface			
				Topsoil	2		
5				Sand and gravel with silt, dry, brown	210		
10							Casing - 2" sch 40 PVC pipe
15							
20					22		
				Brown silty gravel	190		
25					26		
				Brown gravel, like till	186		
30					33		
				Brown silt	179		
35				Light brown gravel, productive water-bearing zone			
40							
45							
50							
55					57		
				Dark brown gravel and sand. Note no "soupy sand" like in CHTW-1.	155		
60							Casing Seal - Hydrated medium bent
65							
70							
75					76		Filter pack - 10-20 CSSI sand
				Dark brown sand and gravel	136		Screen - 2" sch 40 PVC, 0.020-in slot
80					82		
				Gray-blue silty sand, sand and gravel.	130		
85					85		6" end cap
					127		

CH2MHILL

PROJECT NUMBER : 151973.A1.AT

WELL NUMBER : CHMW-1

WELL CONSTRUCTION/BORING LOG

PROJECT : **LONE STAR, DUPONT** LOCATION : **50' S. OF CHTW-1**

WATER LEVELS : **21'6 3/4" ATD**

DRILLING METHOD/EQUIPMENT : **SPEEDSTAR 15 TRUCK-MOUNTED AIR ROTARY**

START : **9/23/99** END : **9/24/99** LOGGER: **HOKKAIDO(BILL&STEVE)**

DEPTH BELOW SURFACE (FT)	CORE DESCRIPTION/COMMENTS
0	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.
	0-2FT Topsoil
	2-22FT Sand/gravel w/silt (dry,brown)
5	
10	
15	
20	
	22-26FT Brown silty gravel
25	
	26-33FT Brown gravel (like till)
30	

CH2MHILL

PROJECT NUMBER : 151973.A1.AT	WELL NUMBER : CHMW-1 SHEET 2 OF 3

WELL CONSTRUCTION/BORING LOG

PROJECT : **LONE STAR, DUPONT** LOCATION : **50' S. OF CHTW-1**

WATER LEVELS : **21'6 3/4" ATD**

DRILLING METHOD/EQUIPMENT : **SPEEDSTAR 15 TRUCK-MOUNTED AIR ROTARY**

START : **9/23/99** END : **9/24/99** LOGGER: **HOKKAIDO(BILL&STEVE)**

DEPTH BELOW SURFACE (FT)	CORE DESCRIPTION/COMMENTS
	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.
	33-35FT Brown silt
35	35-57FT Lt.brown gravel, productive water-bearing zone
40	
45	
50	
55	
	57-59FT Dk.brown gravel & sand NOTE: No "soupy sand" at 50' like in CHTW
60	

CH2MHILL

PROJECT NUMBER : 151973.A1.AT	WELL NUMBER : CHMW-1 SHEET 3 OF 3

WELL CONSTRUCTION/BORING LOG

PROJECT : **LONE STAR, DUPONT** LOCATION : **50' S. OF CHTW-1**

WATER LEVELS : **21'6 3/4" ATD**

DRILLING METHOD/EQUIPMENT : **SPEEDSTAR 15 TRUCK-MOUNTED AIR ROTARY**

START : **9/23/99** END : **9/24/99** LOGGER: **HOKKAIDO(BILL&STEVE)**

DEPTH BELOW SURFACE (FT)	CORE DESCRIPTION/COMMENTS
	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.
65	
70	
75	
	76-82FT Dk.brown sand & gravel
80	
	82-83FT Gray silty sand & gravel
	83-85FT Blue sand & gravel
85	
	WELL: STICKUP=2' (2"sch 40 pvc) SCREEN=75'-84.5' (2"sch 40 pvc, 20-slot) 6" endcap 84.5 -85 fbgs ANNULUS=15 bags 10-20 cost sand (50lb. ea) 52 bags med. bentonite chips (50lbs ea) MONUMENT=6" steel protective casing in concrete
0	

CH2MHILL

Well Number: CHMW-2(D)

Sheet: 1 of 1

Client: Glacier NW
Project: N Sequalitchew Creek Aquifer Tests
Location: DuPont, Washington
Project Number: 151973.A2.AT

Driller: Hokkaido Drilling (Steve & Tom)
Drilling Method: Speedstar 15 & Star 71 Cable Tool
Sampling Method: Sand pump (water added)
Logged by: Driller
Start/Finish Date: 11/12/99 - 11/18/99

Depth (ft)	Sample Info: Sample #	Sample Info: STP (6"-6"-6")	Soil Log	Soil Description	Depth / Elev	Well Drawing	Well Construction Notes
-5					5 212		Monument (not shown): Lockable 6' steel protection casing in concrete
0				Ground Surface			
				Topsoil	4		
5				Brown silty gravel	203 9		
10				Brown gravel	198		Casing--2" sch 40 PVC pipe
15				Brown silty gravel, moist	15 192		
20					24		
25				Hard till, brown	[illegible]		
				Loose sand and gravel, water	181		
30							Casing Seal--Hydrated medium bentc
35				Brown till	35 172		
40							
45					48		
50				Loose sand and gravel, water	159		
55					58		
60				Brown silt bound sand and gravel, tight	149		
65					66		Screen - 2" sch 40 PVC, 0.020-in slot with centralizer
				no record	141		
70					73		6" end cap
75				End of Log	134		

CH2MHILL

PROJECT NUMBER : 151973.A1.AT	WELL NUMBER : CHMW-2(D) SHEET 1 OF 3

WELL CONSTRUCTION/BORING LOG

TOC elev = 209 Stickup = 1.8 grd = 207.2

PROJECT : **LONE STAR, DUPONT** LOCATION : **50' N. OF TW-2**

WATER LEVELS :

DRILLING METHOD/EQUIPMENT: **SPEEDSTAR 15, 8" STEEL CASING(TO58") &STAR 71 CABLE TOOL, 8" CASING**

START : **11/12/99** END : **11/18/99** LOGGER: **HOKKAIDO(STEVE & TOM)**

DEPTH BELOW SURFACE (FT)	CORE DESCRIPTION/COMMENTS
0	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.
	0-4FT Dark brown topsoil
	4-9FT Brown silty gravel
5	
	9-15FT Brown gravel
10	
	15-24FT Brown, silty gravel, moist
15	
20	
25	24-26FT Hard till, brown
	26-35FT Loose sand & gravel H20
30	

CH2MHILL

PROJECT NUMBER : 151973.A1.AT	WELL NUMBER : CHMW-2(D)
	SHEET 2 OF 3

WELL CONSTRUCTION/BORING LOG

PROJECT : **LONE STAR, DUPONT** LOCATION : **50' N. OF TW-2**

WATER LEVELS :

DRILLING METHOD/EQUIPMENT: **SPEEDSTAR 15, 8" STEEL CASING(TO58") &STAR 71 CABLE TOOL, 8" CASING**

START : **11/12/99** END : **11/18/99** LOGGER: **HOKKAIDO(STEVE & TOM)**

DEPTH BELOW SURFACE (FT)	CORE DESCRIPTION/COMMENTS
	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.
35	35-48FT Brown till
40	
45	
50	48-58FT Loose sand & gravel H20
55	
60	58-66FT Brown light Silt Bound sand & gravel

CH2MHILL

PROJECT NUMBER : 151973.A1.AT	WELL NUMBER : CHMW-2(D) SHEET 3 OF 3

WELL CONSTRUCTION/BORING LOG

PROJECT : **LONE STAR, DUPONT** LOCATION : **50' N. OF TW-2**

WATER LEVELS :

DRILLING METHOD/EQUIPMENT: **SPEEDSTAR 15, 8" STEEL CASING(TO58") &STAR 71 CABLE TOOL, 8" CASING**

START : **11/12/99** END : **11/18/99** LOGGER: **HOKKAIDO(STEVE & TOM)**

DEPTH BELOW SURFACE (FT)	CORE DESCRIPTION/COMMENTS
	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.
65	66-73FT NO RECORD
	Total Casing=72'-41/4"
	Well:
70	Stickup=2' (2"sch 40 pvc) w/j plug Screen= 63'-721/2' bgs (2" sch 40 pvc, 20-slot) w/centralizer 6"end cap 721/2-73 fbgs Annulus=13 50-lb bags 10-20 cssi sand 34 50-lb bags medium bentonite chips Monument= 6" steel protectivecasing in concrete
75	
80	
85	
90	

CH2MHILL

Well Number: CHMW-2(S)

Sheet: 1 of 1

Client: Glacier NW
Project: N Sequalitchew Creek Aquifer Tests
Location: DuPont, Washington
Project Number: 151973.A2.AT

Driller: Hokkaido Drilling (Daryl & Tom)
Drilling Method: Star 71 cable tool, 8" steel casing
Sampling Method: Sand pump (water added)
Logged by: driller
Start/Finish Date: 11/17/99 - 11/19/99

Depth (ft)	Sample Info: Sample #	Sample Info: STP (6"-6"-6")	Soil Log	Soil Description	Depth / Elev	Well Drawing	Well Construction Notes
-5					5 212		Monument (not shown)-- Lockable 6" steel protection casing in concrete.
0				Ground Surface Topsoil and gravel	3		
5				Brown silty sand and gravel	204		
10							Casing - 2" sch. 40 PVC pipe
15							Casing seal - Hydrated medium bentc
20					21		
25				Larger gravel and sand, slightly silty, very hard	186 26		
30				Brown silty sand, gravel Sandier with gravel	181		Sandy filterpack - 10-20 CSSI sand
35					36		
40				Clean sand and gravel, water	171		Screen - 2 centralizers, 2" sch 40 PV(0.020-inch slot width
45					43		6" end cap
50				End of Log	164		

CH2MHILL

PROJECT NUMBER : 151973.A1.AT	WELL NUMBER : CHMW-2(S)
	SHEET 1 OF 2

WELL CONSTRUCTION/BORING LOG

TOC elev = 209.39 Stickup = 1.45
grd = 207.94

PROJECT : **LONE STAR, DUPONT** LOCATION : **50' N. OF TW-2(~15FT E.OF MW-2(D)**

WATER LEVELS :

DRILLING METHOD/EQUIPMENT: **STAR 71 CABLE TOOL, 8" STEEL CASING**

START : **11/17/99** END : **11/19/99** LOGGER: **HOKKAIDO(DARYL & TOM)**

DEPTH BELOW SURFACE (FT)	CORE DESCRIPTION/COMMENTS
0	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.
	0-3FT Topsoil & gravels
	3-21FT Brown silty sand and gravels
5	
10	
15	
20	
	21-26FT Larger gravels & sand slightly silty, very hard
25	
	26-27FT Brown silty sand & gravel
	27-28FT Sandier w/gravel (gravel smaller)
30	

CH2MHILL

PROJECT NUMBER : 151973.A1.AT	WELL NUMBER : CHMW-2(S) SHEET 2 OF 2

WELL CONSTRUCTION/BORING LOG

PROJECT : **LONE STAR, DUPONT** LOCATION : **50' N. OF TW-2(~15FT E.OF MW-2(D)**

WATER LEVELS :

DRILLING METHOD/EQUIPMENT: **STAR 71 CABLE TOOL, 8" STEEL CASING**

START : **11/17/99** END : **11/19/99** LOGGER: **HOKKAIDO(DARYL & TOM)**

DEPTH BELOW SURFACE (FT)	CORE DESCRIPTION/COMMENTS
	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.
35	36-43FT Clean sand & gravel w/H20 Total casing=46'-81/2" Well: Stickup=2' (2" sch 40 pvc) w/j-plug Screen=33'-421/2' bgs w/2 centralizers & 6' end (2"sch 40 pvc, 20-slot) Annulus=13 50-lb bags 10-20 cgsi sand 18 50-lb bags medium bentonite chips Monument= 6"steel protecting casing in concrete (7 bags)
40	
45	
50	
55	
60	

CH2MHILL

Well Number: CHMW-3(D)

Sheet: 1 of 1

Client: Glacier NW
Project: N Sequalitchew Creek Aquifer Tests
Location: DuPont, Washington
Project Number: 151973.A2.AT

Driller: Hokkaido Drilling (Steve)
Drilling Method: Speedstar 15 Air Rotary Drill Rig
Sampling Method: Sand pump (water added)
Logged by: driller
Start/Finish Date: 11/4/99 - 11/5/99

Depth (ft)	Sample Info: Sample #	Sample Info: STP (6"-6"-6")	Soil Log	Soil Description	Depth / Elev	Well Drawing	Well Construction Notes
-5					5		Monument (not shown): Lockable 6" steel protective casing in concrete
					221		
0				Ground Surface			
				Brown topsoil	2		
5				Loose brown gravel	214		
10							Casing - 2" sch 40 PVC pipe
15					16		
				Brown silty sand and gravel	200		
20							
25					26		
				Brown silty sand and gravel (moist)	190		Casing seal - hydrated medium bento
30					31		
				Brown sand and gravel, dirty, water	185		
35							
40					41		
				Brown till	175		
45							
					48		
50				Sand and gravel, water	168		
					54		
55				Brown till	162		
				Silt, sand and gravel, brown, wet			
60							
					64		
65				Clean sand and gravel	152		
70							
							Filter pack - 10-20 CSSI sand
75							Screen - 2" sch 40 PVC, 0.020-in slot
80							
					85		6" end cap
85				End of Log	131		
90							

CH2MHILL

Well Number: CHMW-3(S)

Sheet: 1 of 1

Client: Glacier NW
Project: N Sequalitchew Creek Aquifer Tests
Location: DuPont, Washington
Project Number: 151973.A2.AT

Driller: Hokkaido Drilling (Steve)
Drilling Method: Speedstar 15 Air Rotary Drill Rig
Sampling Method: Sand pump (water added)
Logged by: driller
Start/Finish Date: 11/5/99

Depth (ft)	Sample Info: Sample #	Sample Info: STP (6"-6"-6")	Soil Log	Soil Description	Depth / Elev	Well Drawing	Well Construction Notes
-5					5 / 221		Monument (not shown): Lockable 6" steel protection casing in concrete
0				Ground Surface			
				Brown topsoil	2		
				Loose gravel	214		
5							Casing - 2" sch 40 PVC pipe
10							
15					16		Casing seal - Hydrated medium bentc
				Silty brown sand and gravel	200		
20							
25					26		
				Moist silty brown sand and gravel	190		Filter pack - 10-30 CSSI sand
30					31		Screen - 2" sch 40 PVC, 0.020-in slot
				Clean sand and gravel, water	185		
35							
40					40		6" end cap
				End of Log	176		
45							

CH2MHILL

Well Number: CHMW-4(D)

Sheet: 1 of 1

Client: Glacier NW
Project: N Sequalitchew Creek Aquifer Tests
Location: DuPont, Washington
Project Number: 151973.A2.AT

Driller: Hokkaido Drilling (Steve)
Drilling Method: air rotary
Sampling Method: Sand pump (water added)
Logged by: diller
Start/Finish Date: 11/11/99

Depth (ft)	Sample info: Sample #	Sample info: STP (6"-6"-6")	Soil Log	Soil Description	Depth / Elev	Well Drawing	Well Construction Notes
-5					5 / 219		
0				Ground Surface			
				Topsoil	2		
5				Brown gravel	212		Monument: Lockable 6" steel protective casing in concrete
10							
15					15		
				Brown till	199		
20							
25							Casing - 2" sch 40 PVC pipe
30							
					34		
35				Sand, gravel, making water	180		Casing seal - hydrated medium bento
40							
45							
					48		
50				Brown till	166		
					53		
55				Sand, gravel, making water	161		
60							
65					66		
				Brownish orange silty gravel	148		
70				Sand, gravel, water			
75							Filter pack - 10-20 CSSI sand
							Screen - 2" sch 40 PVC, 0.020-in slot
80							
					85		6" end cap
85					129		

CH2MHILL

Well Number: CHMW-4(S)

Sheet: 1 of 1

Client: Glacier NW
Project: N Sequalitchew Creek Aquifer Tests
Location: DuPont, Washington
Project Number: 151973.A2.AT

Driller: Hokkaido Drilling (Steve)
Drilling Method: air rotary
Sampling Method: Sand pump (water added)
Logged by: driller
Start/Finish Date: 11/23/99

Depth (ft)	Sample Info: Sample #	Sample Info: STP (6"-6"-6")	Soil Log	Soil Description	Depth / Elev	Well Drawing	Well Construction Notes
-5					5 219		Monument (not shown): Lockable 6" steel protective casing
0				Ground Surface Topsoil with large gravel	3		
5				Brown silty sand and gravel	211		
10					11		Casing - 2" sch 40 pvc pipe w/ j-plug
				Brown silty sand and large boulders	203		
15					15		Casing seal - hydrated medium bento
				Sand and gravel with water	199 17		
				Brown silt with gravel	197		
20							
25							Filterpack - 10-20 CSSI sand
							Screen - 2" sch 40 pvc, 0.020-in slot v
30							
35							
					37		6" end cap
				End of Log	177		
40							

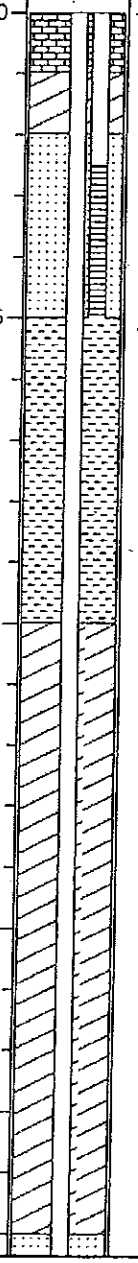
CH2MHILL

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-1
Sheet: 1 of 2

SOIL BORING LOG

GS elev = 207.3

PROJECT: N. Sequalitchew Creek Wetland **LOCATION:** ~100' S. of Edmond Marsh Trail
ELEVATION: **DRILLING CONTRACTOR:** Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log **START:** 12/11/02 1544 **FINISH:** 12/11/02 1620 **LOGGER:** S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0					Ground Surface	Drilled down to 24 feet bgs before first sample. Two piezometers installed in one monument. EM-1(S) is the shallow piezometer, and EM-1(D) is the deep piezometer 4': Driller states in gravel and a little water 12': Sounded gravelley to 14' while drilling, rig stopped in gravel 14': Loaded hole with water 14-16': Gravelly, smoother drilling below 16' 17': Driller states cobbles about 4" in diameter, then smaller sized gravels below 17' 17-24': Smooth drilling, loaded hole with water
5						
10						
15						
20						

CH2MHILL

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-1
Sheet: 2 of 2

SOIL BORING LOG

PROJECT: N. Sequalitchew Creek Wetland **LOCATION:** ~100' S. of Edmond Marsh Trail
ELEVATION: **DRILLING CONTRACTOR:** Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log **START:** 12/11/02 1544 **FINISH:** 12/11/02 1620 **LOGGER:** S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
25		DM	12	16-20-25 (45)	POORLY GRADED SAND WITH GRAVEL (SP) Gray, wet, medium dense, fine to medium grained sand, fine to coarse round to subround gravel, est. 15-20% gravel	
		DM	0	39-50/4" (50/4")	POORLY GRADED SAND WITH GRAVEL (SP) -similar to above but fine to medium gravel	Bottom of boring at 33.5' at 1620 on 12/11/02.
30		DM	12	34-35-35 (70)	No recovery -Slough	Measured groundwater at 6.10' (EM-1(S)) and 7.47' (EM-1 (D)) below top of steel on 12/11/02
		DM	6	50/6" (50/6")	POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM) Gray, wet, very dense, fine to medium grained sand, fine to coarse gravel, gets siltier toward bottom of sample, grades to SILTY SAND WITH GRAVEL (SM) at 32' Gray, wet, very dense, fine to medium grained sand, fine to medium round to subround gravel, est. 10-20% silt, 20-25% gravel	Piezometer Construction (EM-1(S) and EM-1(D)) +3.65-0' Steel riser, locking monument 3.xx-2.5' Blank PVC (EM-1(S)) 3.xx-22' Blank PVC (EM-1(D)) 0-1' Concrete 1-2' Bentonite chips 2-5' Lapis Lustre 2/12 silica sand 2.5-5' 0.020 machine slot screen and cap (EM-1(S)) 5-10' Cuttings 10-20' Bentonite chips 20-33.5' Lapis Lustre 2/12 silica sand 22-32' 0.020 machine slot screen and cap (EM-1(D)) Note: Both piezometers are in one steel, riser monument
35					BOTTOM OF BORING	
40						

CH2MHILL

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-1A
Sheet: 1 of 5

SOIL BORING LOG

PROJECT: N. Sequalitchew Creek Wetland **LOCATION:** ~100' S. of Edmond Marsh Trail
ELEVATION: **DRILLING CONTRACTOR:** Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log **START:** 12/11/02 **FINISH:** 12/11/02 **LOGGER:** S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0					Ground Surface	
		DM	18	1/12"-1/6" (2)	ORGANICS Dark brown, moist, very soft	
		DM	18	5-7-12 (19)	PEAT (PT) Dark brown, moist, very soft, fiberous	
		DM	8	43-40-40 (80)	SANDY SILTY GRAVEL (SM) Light brown, wet, loose, fine to coarse grained sand, coarse round to subround gravel	3': Driller states in gravel and a little water
5		DM	8	35-37-39 (76)	PEAT (PT) Dark brown, moist, very soft, fiberous, trace gravel mixed in	4.5': Sampler very wet, large gravel/small cobble jammed in shoe
					SANDY SILTY GRAVEL (GM) -Similar to above, light brown, wet, dense, fine to coarse grained sand, coarse round to subround gravel	6': Drilled in gravel from 4.5-6'.
					SILTY SAND WITH GRAVEL (SM) Gray, wet, dense, fine to coarse grained sand, fine to coarse round to subround gravel, trace round cobbles (TILL-LIKE)	
10		DM	10	28-35-39 (74)	SILTY GRAVEL WITH SAND (SM) Gray, wet, dense, fine to coarse gravel, fine to coarse grained sand, est. 30% silt, 20% sand (TILL-LIKE) In shoe: SANDY SILT (ML) Gray, moist, hard, fine to medium grained sand, est. 20-30% sand	
15		DM	12	42-35-38 (73) ?	SANDY WELL GRADED GRAVEL WITH SILT (GW-GM) Gray, wet, medium dense, fine to coarse round to subround gravel, fine to coarse sand, est. 30% sand, 10-15% fines	14': Sampler wet 17': Driller states not as much rock, large gravel 19': Water poured out of sampler 19.5': Measured groundwater through augers at 1406 on 12/11/02. Augers may be acting as a barrier.
20		DM	4	21-25-27 (52)		

PT
Qvl
Qvr
dense
med. dense

CH2MHILL

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-1A
Sheet: 2 of 5

SOIL BORING LOG

PROJECT: N. Sequalitchew Creek Wetland **LOCATION:** ~100' S. of Edmond Marsh Trail
ELEVATION: **DRILLING CONTRACTOR:** Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log **START:** 12/11/02 **FINISH:** 12/11/02 **LOGGER:** S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
					GRAVELLY SAND (SW) Gray, wet, medium dense, fine to coarse grained sand, fine to coarse round to subround gravel, est. 30-40% gravel	
25		DM	10	42-33-30 (63)	POORLY GRADED SAND WITH GRAVEL (SP Gray, wet, medium dense, fine to medium grained sand, fine to coarse round to subround gravel, trace fine cobbles, est. 15-20% gravel	
30		DM	12	24-35-38 (73)	WELL GRADED SAND WITH GRAVEL (SW) Gray, wet, medium dense, fine to coarse grained sand, fine to medium round to subround gravel, trace fines, increased fines toward bottom of sampler, est. 20-30% gravel	
35		DM	6	50/6" (50/6")	POORLY GRADED SAND WITH SILT AND GRAVEL TO SILTY SAND WITH GRAVEL (SP-SM/SM) Gray, wet, very dense, fine to medium grained sand, fine to medium round to subround gravel, est. 10-20% fines, 20-25% gravel (TILL??)	34': Driller states back into a few cobbles
40		DM	4	50/4" (50/4")		

Bottom of Boring

CH2MHILL

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-1A
Sheet: 3 of 5

SOIL BORING LOG

PROJECT: N. Sequalitchew Creek Wetland **LOCATION:** ~100' S. of Edmond Marsh Trail
ELEVATION: **DRILLING CONTRACTOR:** Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log **START:** 12/11/02 **FINISH:** 12/11/02 **LOGGER:** S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
					POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM) Gray, wet, very dense, fine to medium grained sand, fine to coarse round to subround gravel, est. 10% fines, 10-15% gravel	
45		DM	4	50/5" (50/5")	POORLY GRADED SAND (SP) Gray, wet, very dense, fine to medium grained sand, trace fines	
50		DM	4	50/4" (50/4")	GRAVELLY WELL GRADED SAND WITH SILT (SW-SM) Gray, wet, very dense, fine to coarse round to subround gravel, est. 5-10% fines, 30-40% gravel	
55		DM	6	50/6" (50/6")	POORLY GRADED SAND (SP) Gray, wet, very dense, fine to medium grained sand	
60		DM	6	50/6" (50/6")		59': Driller states a little more gravel

CH2MHILL

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-1A
Sheet: 4 of 5

SOIL BORING LOG

PROJECT: N. Sequalitchew Creek Wetland **LOCATION:** ~100' S. of Edmond Marsh Trail
ELEVATION: **DRILLING CONTRACTOR:** Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log **START:** 12/11/02 **FINISH:** 12/11/02 **LOGGER:** S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
					POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM) Gray, wet, very dense, fine to medium grained sand, fine to medium round to subround gravel, est. 10-15% fines, 5-10% gravel	
65		DM	5	50/5" (50/5")	WELL GRADED SAND WITH GRAVEL TO WELL GRADED SAND WITH SILT AND GRAVEL (SW/SW-SM) Gray, wet, very dense, fine to coarse grained sand, fine to medium round to subround gravel, est. 5-10% fines, 20-30% gravel	
70		DM	5	50/5" (50/5")	POORLY GRADED SAND (SP) Gray, wet, very dense, medium to coarse grained round to subround sand, fine to medium round to subround gravel, est. <5% fines, 5-10% gravel	
75		DM	6	50/6" (50/6")	WELL GRADED SAND WITH GRAVEL TO WELL GRADED SAND WITH SILT AND GRAVEL (SW/SW-SM) Gray, wet, very dense, fine to coarse grained sand, fine round to subround gravel, est. 5-10% fines, 10-15% gravel	
80		DM	5	50/5" (50/5")		

CH2MHILL

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-1A
Sheet: 5 of 5

SOIL BORING LOG

PROJECT: N. Sequalitchew Creek Wetland **LOCATION:** ~100' S. of Edmond Marsh Trail
ELEVATION: **DRILLING CONTRACTOR:** Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log **START:** 12/11/02 **FINISH:** 12/11/02 **LOGGER:** S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
					POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM) Gray, wet, very dense, fine grained sand, fine to medium round to subround gravel, est. 10-15% fines, 20-30% gravel	
						83': Driller states into silts
85		DM	4	50/4" (50/4")	SILT (ML) Gray, moist to wet, hard	
90		DM	4	50/4" (50/4")	SILT (ML) -Similar to above, gray, moist to wet, hard, fine to medium sand seams	Bottom of boring at 89.3' at 1300 on 12/11/02.
					BOTTOM OF BORING	Driller states not much heave while drilling
						Backfilled boring with grout. Could not install piezometer in this boring. Had to move 3' north and redrill to the bottom of the piezometer installation.
95						
100						

CH2MHILL

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-2
Sheet: 1 of 3

SOIL BORING LOG

GS elev = 212.1'

PROJECT: N. Sequalitchew Creek Wetland **LOCATION:** ~10' S. of Edmond Marsh Trail
ELEVATION: **DRILLING CONTRACTOR:** Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log **START:** 12/12/02 0934 **FINISH:** 12/12/02 1228 **LOGGER:** S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0					Ground Surface	
		DM	12	2-5-5 (10)	SILTY SAND WITH ORGANICS (SM) Dark brown, moist, loose, fine grained sand, trace fine to medium round to subround gravel, est. 30-40% fines, 20% organics (TOPSOIL)	Two piezometers installed in separate monuments. EM-2(S) is the shallow piezometer, and EM-2(D) is the deep piezometer
		DM	6	5-6-6 (12)	SANDY SILTY GRAVEL (GM) Dark brown, moist to wet, medium dense, well graded round to subround gravel, est. 20% fines, 30-40% sand, trace organics (FILL)	3': Driller states in gravel and a little water
		DM	18	3-1-1 (2)	SILTY SAND WITH GRAVEL (SM) Light brown, moist, medium dense, fine to medium grained sand, fine to medium round to subround gravel, est. 15-20% gravel, 20% fines, trace organics (FILL)	
5		DM	18	6-16-18 (34)		5': Driller states drilling in gravel
					PEAT (PT) Dark brown, wet, very soft, fiberous	
					SANDY SILTY GRAVEL (GM) Gray, moist, medium dense, well graded round to subround gravel, fine to medium grained sand, est. 20% fines, 30% sand	
		DM	12	18-21-15 (36)		8': Sampled, then loaded hole with water
10					SILTY SAND WITH GRAVEL (SM) Gray, wet, medium dense, fine to medium grained sand, fine to coarse round to subround gravel, est. 20-30% fines, 20-30% gravel, not compacted, soupy	
		DM	12	18-22-18 (40)	GRAVELLY WELL GRADED SAND (SW) Gray, wet, medium dense, round to subround sand and gravel, fine to medium gravel, trace coarse gravel, est. <5% fines, 30-40% gravel	13': Driller states from 8-13' pretty sandy, not much gravel 14': Sampler wet
15						
		DM	10	44-50/6" (50/6")	GRAVELLY WELL GRADED SAND (SW) Gray, moist to wet, very dense, fine to coarse grained sand, fine round to subround gravel, est. 30-35% gravel	18': Top of sample was heave
20						

PT
Qvl
GM/SM
Qvr

CH2MHILL

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-2
Sheet: 2 of 3

SOIL BORING LOG

PROJECT: N. Sequalitchew Creek Wetland **LOCATION:** ~10' S. of Edmond Marsh Trail
ELEVATION: **DRILLING CONTRACTOR:** Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log **START:** 12/12/02 0934 **FINISH:** 12/12/02 1228 **LOGGER:** S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		DM	12	24-26-30 (56)	GRAVELLY WELL GRADED SAND (GW) Gray, moist to wet, medium dense, fine to coarse grained sand, fine to coarse round to subround gravel, est. 30-40% gravel	20.5': Heave in sampler
		DM	12	34-50/6" (50/6")	SANDY WELL GRADED GRAVEL (GW) Gray, moist to wet, very dense, well graded sand, round to subround gravel, est. 30-35% sand	
25		DM	12	23-36-50/6" (86/12")	SANDY WELL GRADED GRAVEL (GW) -Similar to above, gray, moist to wet, dense to very dense, well graded sand, est. 30-40% sand, becomes siltier toward bottom of sample, est. up to 10% silt toward bottom of sample	25.5': Driller drained water out of samples before opening split spoon. Driller loads hole with water, difficult to determine if samples are wet from drilling water or groundwater. All heave in sample from 25.5'. Resampled.
30		DM	12	32-40-50/6" (90/12")	GRAVELLY WELL GRADED SAND (SW) Gray, moist to wet, very dense, fine to coarse grained sand, fine round to subround gravel, "clean"-little to no fines	
		DM	12	36-44-50/6" (94/12")	GRAVELLY WELL GRADED SAND (SW) -Similar to above	
35		DM	2	44-50/3" (50/3")	WELL GRADED SAND (SW) Gray, moist to wet, very dense, fine to coarse round to subround sand	
		DM	6	36-50/6" (50/6")	SANDY WELL GRADED GRAVEL (GW) Gray, moist to wet, very dense, well graded sand, round to subround gravel, est. 30-40% sand, est. 5% silt	
40		DM	3	33-40-50/6" (90/12")	POORLY GRADED SAND WITH GRAVEL (SP) Gray, moist to wet, very dense, fine to medium grained sand, coarse round to subround gravel, est. 15-20% gravel	38': 3" of heave in sampler

CH2MHILL

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-2
Sheet: 3 of 3

SOIL BORING LOG

PROJECT: N. Sequalitchew Creek Wetland **LOCATION:** ~10' S. of Edmond Marsh Trail
ELEVATION: **DRILLING CONTRACTOR:** Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log **START:** 12/12/02 0934 **FINISH:** 12/12/02 1228 **LOGGER:** S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		DM	10	16-38-50/6" (88/12")	**WELL GRAED SAND WITH GRAVEL (SW)** Gray, moist to wet, very dense, fine round to subround gravel, "clean", grades to **WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM)** 42' Gray, moist to wet, very dense, fine round to subround gravel, est. 15% gravel, 10-15% silt	
		DM	12	18-28-30 (58)	**POORLY GRADED SAND (SP)** Gray, moist to wet, fine to medium grained sand, trace fine to coarse round to subround gravel, est. 5% or less gravel	
45		DM	12	29-36-42 (78)	**POORLY GRADED SAND (SP)** -Similar to above, some gravels have brown staining surrounding the gravel and within the fine grained sand, fine gravel	
Qvr		DM	12	36-50/6" (50/6")	**POORLY GRADED SAND WITH GRAVEL (SP)** Gray, moist, very dense, fine to medium grained sand, fine to coarse round to subround gravel, gravel was packed in "tight", trace dark organics?, pockets/lenses of fine sand at 48'	48': Driller states it felt more compacted
50		DM	6	(100/6")		Bottom of boring at 51.7' at 1228 on 12-12-02
Qvt		SS	6	(100/8")	**SILTY WELL GRADED SAND WITH GRAVEL (SM)** Gray, moist to wet, very dense, some is compact where the sand is finer grained, est. 20-25% gravel	**Deep Piezometer Construction (EM-2(D))** +2.55-0' Steel riser, locking monument 0-2' Concrete 2-36' Quick grout 36-38' Bentonite chips 38-51.7' Lapis Lustre 2/12 silica sand 0-40' Blank pvc 40-50' 0.020 machine slot screen and cap
					SILTY SAND WITH GRAVEL (SM) Gray, moist, very dense, fine grained sand, fine round to subround gravel, est. 20-25% gravel, compacted looking	
55					BOTTOM OF BORING	**Shallow Piezometer Construction (EM-2(S))** Drilled and installed in a separate monument about 3 feet east of deep well 0-1' Concrete and riser 1-2' Bentonite chips 2-5' Lapis Lustre 2/12 silica sand 0-2.5' Blank pvc 2.5-5' 0.020 machine slot screen and cap
60						

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
040001	EM-3	1 of 1

Project Name: North Sequalichew Creek
Location: Fort Lewis, WA
Drilling Method: Hollow stem auger, 4" ID ; Holt Drilling
Sampling Method: 3" diameter D&M
Ground Elevation 214.63

Top of PVC Casing Elev. (ft mllw) 217.38
Depth to Water (ft BTC) 4.96
Start Date March 11, 2004
Finish Date March 11, 2004

Depth feet	Well Construction	Tests\Remarks	Blows/ 6"	Sample ID	Mtl. Graphic	Description
	5" diameter steel monument, 3' stickup; Concrete seal 0'-2'					Sod and dark brown organic soil
						FILL
		3/26/04 ▼				Gravel, some cobbles at 0.5'
			3 7 10	S-1		Medium dense, moist, dark brown, sandy GRAVEL with SILT and ORGANICS, trace wood
			3 6 8	S-2		Medium dense, wet, gray SAND and GRAVEL
5			6 2 1	S-3		MARSH DEPOSITS
		K Test K = 1x10^{-5} cm/s	1 1 9	S-4		Soft, wet, brown, slightly fibrous PEAT, trace gravel
			8 12 14	S-5		Medium dense, wet, brown, sandy GRAVEL to GRAVEL, trace silt
10	Bentonite chips 2'-13'		2 6 6	S-6		RECESSIONAL OUTWASH
			7 8 13	S-7		Medium dense, wet, gray SAND, trace gravel; sand fine to medium; 1/4" silt seam
			1 12 25	S-8		No recovery, coarse gravel in shoe of sampler
15			16 17 16	S-9		Dense, wet, brown, gravelly SAND to sandy GRAVEL
	10/20 silica sand filter pack 13'-20'		11 16 32	S-10		Dense, wet, sandy GRAVEL
	20-slot screen 15'-20'; slip cap with SS screw 20'-20.3'		15 25 35	S-11		
20						Bottom of boring at 20 feet.

Sampler Type (ST):
- 3.25" OD D & M Split-Spoon Ring Sampler
- No Recovery
- 2" OD Split-Spoon Sampler

PID - Photoionization Detector
▼ Water Level (ATD)
▽ Static Water Level

Logged by: RRH
Approved by: LJH
Figure No. B - 1

SEQUALICHEW CREEK.GPJ July 21, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
040001	HM-MW-1	1 of 1

Project Name: North Sequalitchew Creek
Location: DuPont, Washington
Drilling Method: Hollow Stem Auger - 4" ID ; Holt Drilling
Sampling Method: 3" Diameter D&M

Top of Casing Elev. (ft mllw): 221.06
Ground Surfave Elev. (ft): 217.75
Depth to Water (ft bgs): 5
Start Date: August 2, 2004
Finish Date: August 2, 2004

Depth feet	Well Construction	Tests\Remarks	Blows/ 6"	Sample ID	Mtl. Graphic	Description
1						Brown, slightly silty GRAVEL; gravel, predominantly coarse and cobbles (observed from drill action and cuttings) (GP)
2	5" diameter steel monument, cement seal 0'-4'					
3		18"/5"	3 27 30	2.5-4		Brown, moist, slightly silty to trace silt, sandy GRAVEL; sand medium to coarse; gravel fine to coarse, abundant cobbles, subangular to rounded (GW)
4						
5		8/2/04 ▼ 18"/8"	11 23 23	5-6.5		Brown to olive gray, wet, very sandy GRAVEL, trace silt; sand medium to coarse, predominantly medium; gravel fine to coarse with cobbles, subangular to subround; no apparent organization.
6	Bentonite Chips 4'-7.5'					
7						
8		18"/11"	19 22 24	7.5-9		Color change to olive gray; grades to medium to coarse sand and predominantly fine gravel; increase in silt (still trace silt), less cobbles.
9						
10		18"/6"	22 28 32	10-11.5		Olive gray to gray-green, wet, SAND; trace gravel; sand medium to coarse, occasional zones of fine to medium; gravel fine (SP-SW)
11	10/20 silica sand filter pack 7.5'-20.3'					
12						
13		18"/12"	21 30 35	12.5-14		Olive gray, wet, slightly silty, very sandy GRAVEL; gravel fine to coarse; with cobbles; sand predominantly medium to coarse (GW-GM)
14						
15	20-slot screen 10'-20'; slip cap with SS screw 20'-20.3'	18"/10"	21 31 44	15-16.5		Gray-green to olive gray, wet, SAND, trace gravel; sand predominantly medium to coarse; gravel fine (SW)
16						Olive gray, wet, very sandy GRAVEL, trace silt, sand medium to coarse, occasional fine, predominantly coarse; gravel fine to coarse (GW)
17						
18		18"/10"	26 50/6"	17.5-19		Gray-green, wet SAND; trace gravel; sand predominantly medium to coarse (SW)
19						Olive-gray, wet, very sandy GRAVEL, trace silt; gravel fine to coarse; sand predominantly medium to coarse (GW)
20		18"/11"	26 50/6"	20-21.5		Gray to olive gray, wet SAND; sand medium; homogenous (SP)
21						
22						Olive gray to gray, wet, sandy GRAVEL, trace silt; gravel fine to coarse; subrounded to rounded; sand medium to coarse, predominantly medium (GW)
23						Total depth = 20' drilled, 22.5' driven.
24						
25						
26						
27						
28						
29						

Sampler Type (ST):
- 3.25" OD D & M Split-Spoon Ring Sampler
- No Recovery
- 2" OD Split-Spoon Sampler

PID - Photoionization Detector
▼ Water Level (ATD)
▽ Static Water Level

Logged by: ILE
Approved by: LJH
Figure No. A-2

MW_GEOL S CRK.GPJ November 23, 2004

14P1

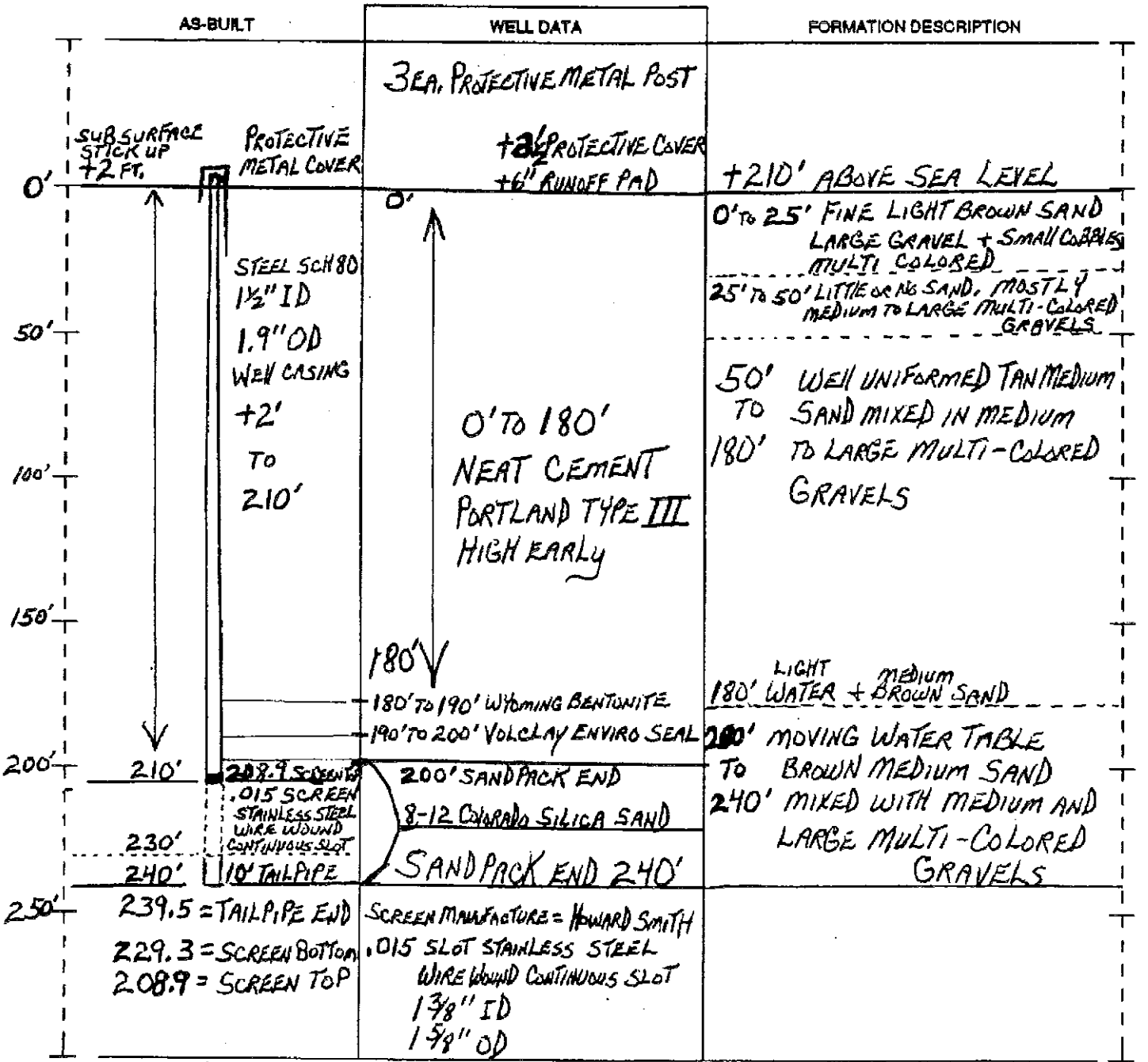
21 FEB 91

RESOURCE PROTECTION WELL REPORT

START CARD NO. 063977

PROJECT NAME: LONESTAR NW OBSERVATION WELL
WELL IDENTIFICATION NO. LONE STAR OB-1
DRILLING METHOD: REVERSE CIRCULATION ROTARY
DRILLER: DOUGLAS GRABOWSKI
FIRM: BECKER DRILLS INC.
SIGNATURE: William J. Flickey
CONSULTING FIRM: HART CROWSER
REPRESENTATIVE: TOM NOYES

COUNTY: PIERCE
LOCATION: SE¼ SW¼ Sec 14 Twn 19N R 1E
STREET ADDRESS OF WELL: NORTHWEST LANDING ANNEX DUPONT STEILACOOM ROAD DUPONT WASHINGTON
WATER LEVEL ELEVATION: 200FT. STATIC
GROUND SURFACE ELEVATION: +210
INSTALLED: FEBRUARY 15, 1991
DEVELOPED:



SCALE: 1" = 50 FEET

PAGE 1 OF 1

ECY 050-12 (Rev. 11/89)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
040001	SL-1	1 of 1

Project Name: North Sequalichew Creek
Location: Fort Lewis, WA
Drilling Method: Hollow stem auger, 4" ID ; Holt Drilling
Sampling Method: 3" diameter D&M
Ground Elevation 214.94

Top of PVC Casing Elev. (ft mllw) 217.74
Depth to Water (ft BTC) 6.25
Start Date March 11, 2004
Finish Date March 11, 2004

Depth feet	Well Construction	Tests\Remarks	Blows/ 6"	Sample ID	Mtl. Graphic	Description
	5" diameter steel monument, 3' stickup; Concrete seal 0'-2'					Grass, duff
						FILL
						Gravel up to 1-1/2" diameter, to a depth of 8" below ground surface
			4 3 3	S-1		Medium stiff, moist to very moist, dark brown, gravelly SILT with SAND
		3/26/04 ▼				
5			3 3 4	S-2		•Very gravelly drilling, no recovery
			9 8 11	S-3		Medium dense, wet, gray, sandy GRAVEL; sand medium to coarse, gravel fine to coarse
			4 6 6	S-4		•Low recovery, trace gravel in sampler
			7 7 7	S-5		RECESSIONAL OUTWASH Medium dense, wet, gray, very gravelly SAND; sand predominantly coarse
10	Bentonite chips 2'-13'		7 7 9	S-6		Medium dense, wet, gray-brown, sandy GRAVEL; sand predominantly coarse
			6 7 12	S-7		
			11 10 9	S-8		•Trace silt
15	10/20 silica sand filter pack 13'-20'		10 7 7	S-9		•Trace silt
	20-slot screen 15'-20'; slip cap with SS screw 20'-20.3'		4 6 7	S-10		
20						Bottom of boring at 20 feet.

Sampler Type (ST):
- 3.25" OD D & M Split-Spoon Ring Sampler
- No Recovery
- 2" OD Split-Spoon Sampler

PID - Photoionization Detector
▼ Water Level (ATD)
▽ Static Water Level

Logged by: RRH
Approved by: LJH
Figure No. B - 2

SEQUALICHEW CREEK.GPJ July 20, 2004
MW_GEOLG

Table E-1. Site Water Balance for Existing Conditions

Project No. 040001, DuPont, Washington

	Inflows			Outflows			
Year	Total Precipitation in inches	Total Surface Water Run-On in cfs	Groundwater Inflows in cfs	Evapo-transpiration in inches	Stormwater in cfs	Direct Groundwater Recharge in cfs	Total Groundwater Outflow in cfs
1901	40.83	0	6.9	21.75	0.14	0.92	7.96
1902	38.26	0	6.9	19.55	0.11	0.93	7.94
1903	35.03	0	6.9	16.33	0.11	0.93	7.94
1904	38.42	0	6.9	17.55	0.13	1.03	8.06
1905	25.71	0	6.9	14.10	0.06	0.58	7.54
1906	37.95	0	6.9	21.91	0.12	0.78	7.79
1907	38.20	0	6.9	16.92	0.13	1.05	8.08
1908	38.11	0	6.9	17.89	0.12	1.00	8.02
1909	53.09	0	6.9	25.48	0.18	1.35	8.43
1910	33.20	0	6.9	12.51	0.11	1.04	8.05
1911	48.37	0	6.9	20.55	0.19	1.36	8.44
1912	45.91	0	6.9	16.27	0.18	1.47	8.55
1913	32.51	0	6.9	15.47	0.10	0.85	7.85
1914	36.06	0	6.9	18.48	0.11	0.86	7.88
1915	46.92	0	6.9	21.81	0.16	1.24	8.29
1916	31.16	0	6.9	15.39	0.09	0.79	7.78
1917	50.58	0	6.9	19.90	0.19	1.51	8.60
1918	37.07	0	6.9	16.79	0.12	1.01	8.03
1919	38.67	0	6.9	17.95	0.13	1.02	8.05
1920	45.83	0	6.9	20.26	0.16	1.26	8.32
1921	41.45	0	6.9	18.25	0.14	1.15	8.19
1922	48.12	0	6.9	18.46	0.18	1.47	8.55
1923	34.20	0	6.9	16.99	0.10	0.86	7.86
1924	36.53	0	6.9	18.54	0.11	0.89	7.90
1925	45.82	0	6.9	21.91	0.15	1.18	8.23
1926	37.20	0	6.9	16.90	0.12	1.01	8.03
1927	41.37	0	6.9	19.19	0.14	1.10	8.13
1928	45.78	0	6.9	17.27	0.17	1.41	8.48
1929	51.97	0	6.9	25.28	0.18	1.31	8.38
1930	48.05	0	6.9	18.29	0.17	1.48	8.55
1931	37.66	0	6.9	15.49	0.13	1.10	8.13
1932	48.90	0	6.9	21.31	0.17	1.36	8.43
1933	62.18	0	6.9	22.37	0.26	1.95	9.11
1934	35.86	0	6.9	14.11	0.12	1.09	8.11
1935	52.09	0	6.9	20.01	0.20	1.59	8.68
1936	42.98	0	6.9	19.49	0.15	1.16	8.20
1937	49.63	0	6.9	21.90	0.17	1.37	8.44
1938	26.62	0	6.9	16.09	0.06	0.52	7.48
1939	46.62	0	6.9	23.06	0.15	1.16	8.21
1940	30.97	0	6.9	13.76	0.10	0.86	7.86
1941	43.78	0	6.9	19.73	0.15	1.18	8.24
1942	37.47	0	6.9	17.78	0.12	0.97	7.99
1943	49.82	0	6.9	20.25	0.18	1.46	8.54
1944	50.74	0	6.9	23.68	0.17	1.33	8.40
1945	40.83	0	6.9	16.73	0.14	1.20	8.24
1946	34.17	0	6.9	17.32	0.10	0.84	7.84

Table E-1. Site Water Balance for Existing Conditions

Project No. 040001, DuPont, Washington

	Inflows			Outflows			
Year	Total Precipitation in inches	Total Surface Water Run-On in cfs	Groundwater Inflows in cfs	Evapo-transpiration in inches	Stormwater in cfs	Direct Groundwater Recharge in cfs	Total Groundwater Outflow in cfs
1947	38.87	0	6.9	18.11	0.13	1.02	8.05
1948	43.71	0	6.9	18.59	0.16	1.23	8.29
1949	31.37	0	6.9	16.29	0.09	0.75	7.74
1950	42.12	0	6.9	20.24	0.13	1.08	8.12
1951	46.83	0	6.9	19.36	0.18	1.34	8.43
1952	53.37	0	6.9	20.03	0.22	1.63	8.75
1953	35.77	0	6.9	14.74	0.12	1.05	8.07
1954	39.97	0	6.9	20.58	0.12	0.96	7.98
1955	30.18	0	6.9	15.69	0.08	0.72	7.70
1956	44.18	0	6.9	20.40	0.15	1.17	8.22
1957	58.24	0	6.9	21.68	0.24	1.79	8.93
1958	52.59	0	6.9	19.25	0.21	1.64	8.75
1959	33.13	0	6.9	12.83	0.11	1.01	8.03
1960	55.41	0	6.9	22.14	0.22	1.63	8.75
1961	36.29	0	6.9	15.89	0.13	1.01	8.03
1962	36.22	0	6.9	19.15	0.10	0.85	7.85
1963	33.33	0	6.9	15.82	0.10	0.87	7.87
1964	57.69	0	6.9	23.56	0.24	1.66	8.80
1965	28.52	0	6.9	11.27	0.09	0.87	7.86
1966	38.98	0	6.9	20.63	0.12	0.90	7.92
1967	43.40	0	6.9	18.08	0.15	1.25	8.31
1968	37.92	0	6.9	18.86	0.11	0.94	7.96
1969	45.01	0	6.9	19.71	0.16	1.25	8.30
1970	44.55	0	6.9	17.55	0.17	1.33	8.40
1971	45.61	0	6.9	19.02	0.16	1.31	8.38
1972	51.44	0	6.9	17.60	0.21	1.67	8.78
1973	43.43	0	6.9	17.78	0.15	1.27	8.32
1974	45.51	0	6.9	19.86	0.16	1.26	8.32
1975	46.93	0	6.9	18.39	0.17	1.41	8.49
1976	36.53	0	6.9	16.71	0.11	0.99	8.00
1977	57.46	0	6.9	20.49	0.23	1.82	8.95
1978	35.73	0	6.9	15.88	0.11	0.99	8.00
1979	44.96	0	6.9	19.26	0.16	1.27	8.33
1980	42.56	0	6.9	17.97	0.15	1.22	8.27
1981	38.36	0	6.9	18.84	0.11	0.97	7.98
1982	48.39	0	6.9	19.70	0.18	1.42	8.49
1983	34.00	0	6.9	15.77	0.10	0.91	7.91
1984	38.65	0	6.9	17.77	0.13	1.03	8.06
1985	36.02	0	6.9	16.93	0.11	0.95	7.96
1986	39.21	0	6.9	17.69	0.13	1.06	8.10
1987	35.69	0	6.9	15.79	0.12	0.99	8.01
1988	36.33	0	6.9	17.25	0.12	0.94	7.96
1989	44.58	0	6.9	22.35	0.14	1.09	8.13
1990	47.15	0	6.9	16.93	0.18	1.50	8.58
1991	46.79	0	6.9	17.39	0.18	1.46	8.53
1992	52.29	0	6.9	22.48	0.19	1.47	8.56

Table E-1. Site Water Balance for Existing Conditions

Project No. 040001, DuPont, Washington

	Inflows			Outflows			
Year	Total Precipitation in inches	Total Surface Water Run-On in cfs	Groundwater Inflows in cfs	Evapo-transpiration in inches	Stormwater in cfs	Direct Groundwater Recharge in cfs	Total Groundwater Outflow in cfs
1993	44.54	0	6.9	15.32	0.17	1.46	8.52
1994	33.69	0	6.9	16.27	0.10	0.87	7.87
1995	61.78	0	6.9	20.71	0.26	2.02	9.18
1996	40.75	0	6.9	18.04	0.13	1.13	8.16
1997	43.33	0	6.9	19.88	0.14	1.16	8.20
1998	23.49	0	6.9	13.46	0.05	0.50	7.46
1999	44.25	0	6.9	23.38	0.14	1.02	8.06
2000	31.82	0	6.9	15.14	0.09	0.83	7.83
2001	41.20	0	6.9	18.33	0.14	1.13	8.17
2002	37.41	0	6.9	17.64	0.12	0.98	8.00
2003	46.97	0	6.9	19.04	0.17	1.38	8.45
2004	57.63	0	6.9	24.78	0.21	1.61	8.72
2005	43.60	0	6.9	15.75	0.15	1.39	8.45
2006	35.32	0	6.9	14.01	0.12	1.06	8.08
2007	37.55	0	6.9	17.85	0.12	0.97	7.99
2008	40.60	0	6.9	19.35	0.13	1.05	8.08
2009	35.07	0	6.9	16.35	0.11	0.93	7.94
2010	33.78	0	6.9	16.34	0.10	0.87	7.87
2011	34.09	0	6.9	17.15	0.11	0.83	7.84
2012	38.96	0	6.9	18.93	0.13	0.99	8.01
2013	30.12	0	6.9	14.01	0.09	0.80	7.79
2014	43.52	0	6.9	21.82	0.15	1.06	8.11
2015	25.74	0	6.9	11.70	0.07	0.71	7.68
2016	50.36	0	6.9	23.17	0.18	1.33	8.41
2017	56.54	0	6.9	19.80	0.23	1.81	8.94
2018	58.35	0	6.9	21.81	0.23	1.80	8.93
2019	43.38	0	6.9	17.78	0.15	1.27	8.32
2020	52.71	0	6.9	19.25	0.20	1.65	8.76
2021	37.15	0	6.9	18.10	0.11	0.95	7.96
2022	49.81	0	6.9	19.76	0.19	1.48	8.57
2023	37.80	0	6.9	18.08	0.12	0.97	8.00
2024	39.84	0	6.9	18.68	0.13	1.04	8.08
2025	45.58	0	6.9	20.38	0.15	1.24	8.30
2026	35.92	0	6.9	16.57	0.11	0.96	7.97
2027	31.55	0	6.9	17.24	0.08	0.72	7.69
2028	43.54	0	6.9	18.08	0.16	1.26	8.31
2029	47.68	0	6.9	20.22	0.17	1.35	8.42
2030	34.39	0	6.9	14.94	0.11	0.97	7.98
2031	35.52	0	6.9	18.28	0.10	0.86	7.86
2032	35.66	0	6.9	18.56	0.11	0.84	7.85
2033	43.89	0	6.9	21.58	0.14	1.10	8.14
2034	35.91	0	6.9	15.30	0.12	1.02	8.04
2035	45.85	0	6.9	20.68	0.16	1.24	8.30
2036	27.87	0	6.9	13.20	0.08	0.73	7.71
2037	48.88	0	6.9	20.58	0.19	1.39	8.47
2038	28.10	0	6.9	16.17	0.06	0.60	7.56

Table E-1. Site Water Balance for Existing Conditions

Project No. 040001, DuPont, Washington

	Inflows			Outflows			
Year	Total Precipitation in inches	Total Surface Water Run-On in cfs	Groundwater Inflows in cfs	Evapo-transpiration in inches	Stormwater in cfs	Direct Groundwater Recharge in cfs	Total Groundwater Outflow in cfs
2039	36.26	0	6.9	20.13	0.10	0.79	7.80
2040	33.69	0	6.9	16.62	0.10	0.85	7.85
2041	46.65	0	6.9	23.03	0.16	1.15	8.21
2042	53.77	0	6.9	22.52	0.19	1.54	8.64
2043	51.49	0	6.9	17.48	0.20	1.69	8.79
2044	51.64	0	6.9	21.40	0.19	1.49	8.58
2045	52.33	0	6.9	19.56	0.20	1.62	8.72
2046	36.35	0	6.9	15.18	0.12	1.06	8.08
2047	42.13	0	6.9	20.70	0.13	1.06	8.09
2048	41.81	0	6.9	18.00	0.15	1.18	8.22
2049	36.96	0	6.9	18.50	0.12	0.91	7.93
2050	46.15	0	6.9	19.94	0.16	1.30	8.36
2051	45.24	0	6.9	18.70	0.16	1.31	8.37
2052	48.60	0	6.9	20.18	0.17	1.41	8.48
2053	45.60	0	6.9	18.98	0.17	1.31	8.38
2054	37.71	0	6.9	18.78	0.11	0.94	7.95
2055	33.13	0	6.9	16.22	0.09	0.84	7.84
2056	46.21	0	6.9	21.31	0.16	1.22	8.28
2057	41.86	0	6.9	16.27	0.15	1.27	8.32
2058	67.38	0	6.9	24.61	0.29	2.08	9.27
Average	41.99	0	6.90	18.51	0.14	1.16	8.20
Average in inches	41.99	0	124.26	18.51	2.59	20.89	147.74

Notes:

1) Stormwater is the sum of surface runoff and interflow.

2) Under existing conditions, all stormwater infiltrates within the mine area or on the South Parcel.

3) Total Groundwater outflow is the sum of stormwater + direct groundwater recharge + groundwater inflows.

4) Average flows in cfs are converted to inches by calculating the total volume in cubic feet for the year, then dividing by the project area of 482.4 acres

Table E-2. Site Water Balance for Proposed Action

Project No. 040001, DuPont, Washington

	Inflows			Outflows			
Year	Total Precipitation in inches	Total Surface Water Run-On in cfs	Groundwater Inflows in cfs	Evapo-transpiration in inches	Stormwater in cfs	Direct Groundwater Recharge in cfs	Total Groundwater Outflow in cfs
1901	40.83	0	6.9	19.65	0.62	0.56	8.08
1902	38.26	0	6.9	19.29	0.43	0.62	7.95
1903	35.03	0	6.9	15.81	0.44	0.63	7.97
1904	38.42	0	6.9	16.50	0.56	0.66	8.12
1905	25.71	0	6.9	14.40	0.20	0.42	7.53
1906	37.95	0	6.9	20.60	0.45	0.52	7.86
1907	38.20	0	6.9	16.03	0.53	0.70	8.13
1908	38.11	0	6.9	17.11	0.51	0.65	8.07
1909	53.09	0	6.9	24.23	0.76	0.84	8.50
1910	33.20	0	6.9	11.88	0.49	0.69	8.08
1911	48.37	0	6.9	19.10	0.80	0.83	8.53
1912	45.91	0	6.9	15.18	0.81	0.90	8.61
1913	32.51	0	6.9	15.03	0.39	0.59	7.87
1914	36.06	0	6.9	17.78	0.45	0.57	7.91
1915	46.92	0	6.9	20.70	0.66	0.80	8.36
1916	31.16	0	6.9	15.12	0.32	0.57	7.79
1917	50.58	0	6.9	17.88	0.87	0.94	8.72
1918	37.07	0	6.9	16.10	0.48	0.69	8.06
1919	38.67	0	6.9	16.89	0.53	0.68	8.11
1920	45.83	0	6.9	19.35	0.66	0.81	8.37
1921	41.45	0	6.9	17.43	0.59	0.75	8.23
1922	48.12	0	6.9	17.15	0.81	0.91	8.62
1923	34.20	0	6.9	16.90	0.37	0.59	7.86
1924	36.53	0	6.9	17.69	0.43	0.62	7.95
1925	45.82	0	6.9	20.58	0.63	0.77	8.30
1926	37.20	0	6.9	16.23	0.48	0.68	8.06
1927	41.37	0	6.9	18.21	0.56	0.73	8.19
1928	45.78	0	6.9	15.90	0.78	0.88	8.56
1929	51.97	0	6.9	23.88	0.73	0.83	8.46
1930	48.05	0	6.9	17.46	0.76	0.94	8.60
1931	37.66	0	6.9	15.13	0.54	0.71	8.15
1932	48.90	0	6.9	20.00	0.74	0.87	8.50
1933	62.18	0	6.9	20.65	1.14	1.16	9.21
1934	35.86	0	6.9	13.56	0.52	0.72	8.14
1935	52.09	0	6.9	18.64	0.87	0.98	8.76
1936	42.98	0	6.9	18.66	0.61	0.74	8.25
1937	49.63	0	6.9	21.08	0.71	0.88	8.49
1938	26.62	0	6.9	15.91	0.19	0.41	7.49
1939	46.62	0	6.9	21.51	0.64	0.76	8.29
1940	30.97	0	6.9	13.15	0.40	0.59	7.89
1941	43.78	0	6.9	18.51	0.66	0.74	8.30
1942	37.47	0	6.9	17.09	0.49	0.65	8.03
1943	49.82	0	6.9	18.92	0.82	0.89	8.62
1944	50.74	0	6.9	22.60	0.71	0.85	8.46
1945	40.83	0	6.9	15.79	0.59	0.80	8.29
1946	34.17	0	6.9	17.10	0.36	0.59	7.85

Table E-2. Site Water Balance for Proposed Action

Project No. 040001, DuPont, Washington

	Inflows			Outflows			
Year	Total Precipitation in inches	Total Surface Water Run-On in cfs	Groundwater Inflows in cfs	Evapo-transpiration in inches	Stormwater in cfs	Direct Groundwater Recharge in cfs	Total Groundwater Outflow in cfs
1947	38.87	0	6.9	16.98	0.55	0.67	8.12
1948	43.71	0	6.9	17.19	0.72	0.75	8.37
1949	31.37	0	6.9	16.39	0.32	0.51	7.73
1950	42.12	0	6.9	19.23	0.54	0.73	8.17
1951	46.83	0	6.9	17.77	0.78	0.83	8.51
1952	53.37	0	6.9	18.69	0.96	0.97	8.83
1953	35.77	0	6.9	14.38	0.50	0.69	8.09
1954	39.97	0	6.9	19.95	0.47	0.64	8.01
1955	30.18	0	6.9	15.71	0.28	0.52	7.70
1956	44.18	0	6.9	19.04	0.65	0.75	8.30
1957	58.24	0	6.9	19.94	1.07	1.05	9.03
1958	52.59	0	6.9	17.77	0.97	0.96	8.83
1959	33.13	0	6.9	12.42	0.49	0.66	8.05
1960	55.41	0	6.9	20.71	0.97	0.96	8.83
1961	36.29	0	6.9	15.14	0.53	0.64	8.07
1962	36.22	0	6.9	19.22	0.36	0.58	7.84
1963	33.33	0	6.9	14.98	0.42	0.60	7.92
1964	57.69	0	6.9	21.39	1.06	0.95	8.92
1965	28.52	0	6.9	11.41	0.36	0.59	7.85
1966	38.98	0	6.9	19.52	0.49	0.59	7.98
1967	43.40	0	6.9	17.00	0.65	0.82	8.37
1968	37.92	0	6.9	18.21	0.45	0.65	7.99
1969	45.01	0	6.9	18.12	0.70	0.79	8.39
1970	44.55	0	6.9	16.44	0.74	0.82	8.46
1971	45.61	0	6.9	17.78	0.72	0.83	8.44
1972	51.44	0	6.9	16.26	0.94	1.01	8.85
1973	43.43	0	6.9	17.16	0.65	0.81	8.36
1974	45.51	0	6.9	18.84	0.69	0.79	8.38
1975	46.93	0	6.9	17.37	0.75	0.89	8.54
1976	36.53	0	6.9	16.37	0.43	0.69	8.02
1977	57.46	0	6.9	19.08	1.03	1.10	9.03
1978	35.73	0	6.9	15.40	0.46	0.67	8.03
1979	44.96	0	6.9	18.25	0.66	0.82	8.38
1980	42.56	0	6.9	17.22	0.63	0.78	8.31
1981	38.36	0	6.9	18.37	0.45	0.66	8.01
1982	48.39	0	6.9	18.34	0.79	0.88	8.57
1983	34.00	0	6.9	15.82	0.37	0.64	7.91
1984	38.65	0	6.9	16.62	0.54	0.68	8.12
1985	36.02	0	6.9	16.34	0.45	0.64	7.99
1986	39.21	0	6.9	16.73	0.56	0.69	8.15
1987	35.69	0	6.9	14.90	0.50	0.65	8.05
1988	36.33	0	6.9	16.58	0.46	0.64	8.00
1989	44.58	0	6.9	21.30	0.59	0.71	8.19
1990	47.15	0	6.9	15.40	0.79	0.97	8.66
1991	46.79	0	6.9	16.41	0.78	0.91	8.59
1992	52.29	0	6.9	21.48	0.78	0.93	8.61

Table E-2. Site Water Balance for Proposed Action

Project No. 040001, DuPont, Washington

	Inflows			Outflows			
Year	Total Precipitation in inches	Total Surface Water Run-On in cfs	Groundwater Inflows in cfs	Evapo-transpiration in inches	Stormwater in cfs	Direct Groundwater Recharge in cfs	Total Groundwater Outflow in cfs
1993	44.54	0	6.9	14.26	0.73	0.95	8.58
1994	33.69	0	6.9	16.06	0.38	0.60	7.88
1995	61.78	0	6.9	18.54	1.22	1.18	9.30
1996	40.75	0	6.9	17.66	0.54	0.74	8.18
1997	43.33	0	6.9	18.98	0.59	0.76	8.25
1998	23.49	0	6.9	13.95	0.15	0.38	7.43
1999	44.25	0	6.9	21.64	0.56	0.69	8.16
2000	31.82	0	6.9	14.33	0.37	0.60	7.87
2001	41.20	0	6.9	16.95	0.61	0.74	8.25
2002	37.41	0	6.9	17.01	0.50	0.63	8.03
2003	46.97	0	6.9	17.93	0.76	0.86	8.51
2004	57.63	0	6.9	23.43	0.90	1.00	8.80
2005	43.60	0	6.9	15.06	0.67	0.92	8.48
2006	35.32	0	6.9	13.53	0.50	0.71	8.11
2007	37.55	0	6.9	17.10	0.49	0.64	8.04
2008	40.60	0	6.9	18.40	0.55	0.69	8.13
2009	35.07	0	6.9	16.21	0.44	0.61	7.95
2010	33.78	0	6.9	15.96	0.39	0.60	7.89
2011	34.09	0	6.9	16.25	0.43	0.56	7.89
2012	38.96	0	6.9	17.90	0.52	0.65	8.07
2013	30.12	0	6.9	13.89	0.36	0.54	7.80
2014	43.52	0	6.9	20.23	0.62	0.68	8.19
2015	25.74	0	6.9	12.26	0.24	0.50	7.65
2016	50.36	0	6.9	21.46	0.79	0.81	8.50
2017	56.54	0	6.9	18.34	1.04	1.08	9.02
2018	58.35	0	6.9	20.40	1.05	1.05	9.01
2019	43.38	0	6.9	17.03	0.65	0.82	8.36
2020	52.71	0	6.9	18.40	0.92	0.99	8.81
2021	37.15	0	6.9	17.64	0.44	0.64	7.98
2022	49.81	0	6.9	18.08	0.85	0.91	8.66
2023	37.80	0	6.9	17.69	0.46	0.66	8.02
2024	39.84	0	6.9	17.46	0.55	0.69	8.14
2025	45.58	0	6.9	19.13	0.66	0.81	8.37
2026	35.92	0	6.9	15.90	0.44	0.67	8.01
2027	31.55	0	6.9	17.05	0.27	0.53	7.71
2028	43.54	0	6.9	16.21	0.69	0.83	8.42
2029	47.68	0	6.9	18.88	0.76	0.84	8.50
2030	34.39	0	6.9	14.73	0.41	0.68	7.99
2031	35.52	0	6.9	17.71	0.39	0.60	7.89
2032	35.66	0	6.9	17.56	0.43	0.58	7.91
2033	43.89	0	6.9	19.82	0.61	0.73	8.24
2034	35.91	0	6.9	14.71	0.51	0.67	8.08
2035	45.85	0	6.9	19.52	0.67	0.79	8.36
2036	27.87	0	6.9	13.06	0.32	0.50	7.72
2037	48.88	0	6.9	18.53	0.84	0.85	8.59
2038	28.10	0	6.9	16.42	0.19	0.46	7.55

Table E-2. Site Water Balance for Proposed Action

Project No. 040001, DuPont, Washington

	Inflows			Outflows			
Year	Total Precipitation in inches	Total Surface Water Run-On in cfs	Groundwater Inflows in cfs	Evapo-transpiration in inches	Stormwater in cfs	Direct Groundwater Recharge in cfs	Total Groundwater Outflow in cfs
2039	36.26	0	6.9	19.01	0.40	0.56	7.86
2040	33.69	0	6.9	15.82	0.40	0.59	7.89
2041	46.65	0	6.9	21.34	0.68	0.73	8.31
2042	53.77	0	6.9	21.07	0.87	0.95	8.72
2043	51.49	0	6.9	16.58	0.90	1.04	8.84
2044	51.64	0	6.9	19.94	0.83	0.93	8.66
2045	52.33	0	6.9	18.02	0.91	1.00	8.81
2046	36.35	0	6.9	14.98	0.50	0.69	8.09
2047	42.13	0	6.9	19.91	0.54	0.70	8.13
2048	41.81	0	6.9	17.02	0.62	0.76	8.28
2049	36.96	0	6.9	17.67	0.47	0.60	7.97
2050	46.15	0	6.9	18.99	0.68	0.83	8.41
2051	45.24	0	6.9	16.76	0.74	0.84	8.48
2052	48.60	0	6.9	19.39	0.73	0.89	8.52
2053	45.60	0	6.9	16.45	0.77	0.85	8.52
2054	37.71	0	6.9	18.67	0.41	0.65	7.96
2055	33.13	0	6.9	16.08	0.35	0.60	7.85
2056	46.21	0	6.9	19.74	0.68	0.79	8.37
2057	41.86	0	6.9	15.44	0.65	0.82	8.37
2058	67.38	0	6.9	22.01	1.35	1.17	9.42
Average	41.99	0	6.90	17.57	0.61	0.75	8.26
Average in inches	41.99	0	124.26	17.57	10.95	13.47	148.68

Notes:

1) Stormwater is the sum of surface runoff and interflow.

2) Under existing conditions, all stormwater infiltrates within the mine area or on the South Parcel.

3) Total Groundwater outflow is the sum of stormwater + direct groundwater recharge + groundwater inflows.

4) Average flows in cfs are converted to inches by calculating the total volume in cubic feet for the year, then dividing by the project area of 482.4 acres

Table E-3. Site Water Balance for No Action

Project No. 040001, DuPont, Washington

	Inflows			Outflows			
Year	Total Precipitation in inches	Total Surface Water Run-On in cfs	Groundwater Inflows in cfs	Evapo-transpiration in inches	Stormwater in cfs	Direct Groundwater Recharge in cfs	Total Groundwater Outflow in cfs
1901	40.83	0	6.9	17.80	0.61	0.67	8.18
1902	38.26	0	6.9	15.76	0.53	0.72	8.15
1903	35.03	0	6.9	13.02	0.48	0.74	8.12
1904	38.42	0	6.9	13.94	0.57	0.79	8.26
1905	25.71	0	6.9	11.59	0.32	0.47	7.68
1906	37.95	0	6.9	17.52	0.54	0.60	8.03
1907	38.20	0	6.9	13.57	0.55	0.82	8.27
1908	38.11	0	6.9	14.43	0.54	0.78	8.22
1909	53.09	0	6.9	20.53	0.77	1.04	8.71
1910	33.20	0	6.9	9.95	0.48	0.81	8.19
1911	48.37	0	6.9	16.48	0.74	1.03	8.67
1912	45.91	0	6.9	13.02	0.71	1.12	8.73
1913	32.51	0	6.9	12.67	0.45	0.65	8.00
1914	36.06	0	6.9	15.01	0.50	0.66	8.07
1915	46.92	0	6.9	17.27	0.69	0.95	8.55
1916	31.16	0	6.9	12.31	0.41	0.64	7.95
1917	50.58	0	6.9	15.58	0.79	1.16	8.84
1918	37.07	0	6.9	13.68	0.51	0.79	8.20
1919	38.67	0	6.9	14.68	0.54	0.79	8.23
1920	45.83	0	6.9	16.34	0.67	0.97	8.54
1921	41.45	0	6.9	14.75	0.59	0.89	8.38
1922	48.12	0	6.9	14.65	0.74	1.12	8.76
1923	34.20	0	6.9	13.86	0.46	0.67	8.03
1924	36.53	0	6.9	14.96	0.49	0.71	8.10
1925	45.82	0	6.9	17.56	0.66	0.91	8.47
1926	37.20	0	6.9	13.30	0.53	0.80	8.23
1927	41.37	0	6.9	15.24	0.60	0.85	8.35
1928	45.78	0	6.9	13.70	0.70	1.08	8.68
1929	51.97	0	6.9	20.14	0.77	1.00	8.67
1930	48.05	0	6.9	14.46	0.72	1.14	8.77
1931	37.66	0	6.9	12.52	0.54	0.85	8.30
1932	48.90	0	6.9	17.12	0.72	1.04	8.66
1933	62.18	0	6.9	17.58	0.98	1.49	9.38
1934	35.86	0	6.9	11.17	0.51	0.86	8.27
1935	52.09	0	6.9	16.05	0.80	1.21	8.90
1936	42.98	0	6.9	15.67	0.63	0.88	8.42
1937	49.63	0	6.9	17.60	0.72	1.06	8.68
1938	26.62	0	6.9	12.74	0.33	0.44	7.67
1939	46.62	0	6.9	18.46	0.66	0.91	8.46
1940	30.97	0	6.9	10.99	0.43	0.68	8.01
1941	43.78	0	6.9	15.70	0.65	0.91	8.46
1942	37.47	0	6.9	14.23	0.53	0.76	8.19
1943	49.82	0	6.9	16.31	0.75	1.11	8.76
1944	50.74	0	6.9	18.81	0.74	1.03	8.67
1945	40.83	0	6.9	13.28	0.59	0.94	8.43
1946	34.17	0	6.9	13.91	0.46	0.67	8.02

Table E-3. Site Water Balance for No Action

Project No. 040001, DuPont, Washington

	Inflows			Outflows			
Year	Total Precipitation in inches	Total Surface Water Run-On in cfs	Groundwater Inflows in cfs	Evapo-transpiration in inches	Stormwater in cfs	Direct Groundwater Recharge in cfs	Total Groundwater Outflow in cfs
1947	38.87	0	6.9	14.59	0.55	0.80	8.25
1948	43.71	0	6.9	14.87	0.66	0.94	8.50
1949	31.37	0	6.9	13.16	0.42	0.59	7.91
1950	42.12	0	6.9	16.19	0.60	0.84	8.34
1951	46.83	0	6.9	15.39	0.72	1.03	8.65
1952	53.37	0	6.9	15.86	0.85	1.23	8.98
1953	35.77	0	6.9	11.59	0.53	0.81	8.24
1954	39.97	0	6.9	16.73	0.54	0.75	8.19
1955	30.18	0	6.9	12.57	0.40	0.58	7.88
1956	44.18	0	6.9	16.18	0.66	0.90	8.45
1957	58.24	0	6.9	17.02	0.92	1.37	9.19
1958	52.59	0	6.9	15.27	0.81	1.26	8.97
1959	33.13	0	6.9	10.33	0.48	0.79	8.17
1960	55.41	0	6.9	17.86	0.86	1.23	8.99
1961	36.29	0	6.9	12.51	0.54	0.78	8.22
1962	36.22	0	6.9	15.53	0.49	0.66	8.05
1963	33.33	0	6.9	12.61	0.46	0.69	8.05
1964	57.69	0	6.9	18.56	0.92	1.25	9.07
1965	28.52	0	6.9	9.03	0.40	0.68	7.98
1966	38.98	0	6.9	16.62	0.55	0.69	8.14
1967	43.40	0	6.9	14.50	0.64	0.96	8.51
1968	37.92	0	6.9	15.10	0.53	0.74	8.17
1969	45.01	0	6.9	15.97	0.66	0.95	8.51
1970	44.55	0	6.9	14.03	0.68	1.02	8.59
1971	45.61	0	6.9	15.45	0.68	1.00	8.57
1972	51.44	0	6.9	14.04	0.82	1.26	8.98
1973	43.43	0	6.9	14.57	0.64	0.97	8.50
1974	45.51	0	6.9	15.92	0.69	0.95	8.54
1975	46.93	0	6.9	14.59	0.71	1.09	8.70
1976	36.53	0	6.9	13.24	0.52	0.77	8.19
1977	57.46	0	6.9	16.26	0.91	1.38	9.19
1978	35.73	0	6.9	12.85	0.51	0.76	8.17
1979	44.96	0	6.9	15.51	0.67	0.97	8.54
1980	42.56	0	6.9	14.51	0.63	0.93	8.46
1981	38.36	0	6.9	15.42	0.52	0.75	8.17
1982	48.39	0	6.9	16.01	0.72	1.07	8.70
1983	34.00	0	6.9	12.86	0.46	0.71	8.07
1984	38.65	0	6.9	14.19	0.57	0.79	8.26
1985	36.02	0	6.9	14.00	0.49	0.73	8.12
1986	39.21	0	6.9	14.05	0.58	0.81	8.30
1987	35.69	0	6.9	12.69	0.52	0.75	8.18
1988	36.33	0	6.9	13.88	0.52	0.72	8.15
1989	44.58	0	6.9	18.11	0.64	0.83	8.37
1990	47.15	0	6.9	13.12	0.72	1.17	8.79
1991	46.79	0	6.9	13.71	0.73	1.11	8.74
1992	52.29	0	6.9	17.95	0.79	1.11	8.81

Table E-3. Site Water Balance for No Action

Project No. 040001, DuPont, Washington

	Inflows			Outflows			
Year	Total Precipitation in inches	Total Surface Water Run-On in cfs	Groundwater Inflows in cfs	Evapo-transpiration in inches	Stormwater in cfs	Direct Groundwater Recharge in cfs	Total Groundwater Outflow in cfs
1993	44.54	0	6.9	12.23	0.68	1.12	8.69
1994	33.69	0	6.9	13.11	0.47	0.68	8.04
1995	61.78	0	6.9	16.24	1.01	1.52	9.43
1996	40.75	0	6.9	14.58	0.59	0.86	8.35
1997	43.33	0	6.9	16.08	0.62	0.89	8.41
1998	23.49	0	6.9	10.68	0.29	0.42	7.61
1999	44.25	0	6.9	18.54	0.63	0.80	8.33
2000	31.82	0	6.9	11.87	0.43	0.67	8.01
2001	41.20	0	6.9	14.60	0.60	0.87	8.38
2002	37.41	0	6.9	14.08	0.54	0.76	8.20
2003	46.97	0	6.9	15.14	0.72	1.05	8.67
2004	57.63	0	6.9	19.74	0.88	1.23	9.00
2005	43.60	0	6.9	12.37	0.65	1.08	8.63
2006	35.32	0	6.9	11.04	0.52	0.82	8.25
2007	37.55	0	6.9	14.31	0.54	0.75	8.19
2008	40.60	0	6.9	15.46	0.59	0.81	8.30
2009	35.07	0	6.9	13.14	0.50	0.71	8.12
2010	33.78	0	6.9	13.18	0.48	0.67	8.04
2011	34.09	0	6.9	13.76	0.48	0.65	8.03
2012	38.96	0	6.9	15.06	0.56	0.76	8.23
2013	30.12	0	6.9	11.39	0.42	0.62	7.94
2014	43.52	0	6.9	17.71	0.63	0.81	8.33
2015	25.74	0	6.9	9.40	0.35	0.56	7.81
2016	50.36	0	6.9	18.58	0.76	1.01	8.66
2017	56.54	0	6.9	15.78	0.89	1.38	9.16
2018	58.35	0	6.9	17.23	0.92	1.37	9.18
2019	43.38	0	6.9	14.12	0.64	0.99	8.52
2020	52.71	0	6.9	15.67	0.81	1.24	8.96
2021	37.15	0	6.9	14.75	0.51	0.73	8.14
2022	49.81	0	6.9	15.58	0.77	1.13	8.80
2023	37.80	0	6.9	14.65	0.52	0.76	8.19
2024	39.84	0	6.9	14.75	0.58	0.82	8.29
2025	45.58	0	6.9	16.51	0.65	0.97	8.51
2026	35.92	0	6.9	12.97	0.51	0.76	8.17
2027	31.55	0	6.9	14.07	0.40	0.57	7.87
2028	43.54	0	6.9	14.17	0.65	0.98	8.53
2029	47.68	0	6.9	16.24	0.72	1.03	8.65
2030	34.39	0	6.9	11.78	0.49	0.77	8.16
2031	35.52	0	6.9	14.83	0.48	0.67	8.05
2032	35.66	0	6.9	14.83	0.50	0.66	8.06
2033	43.89	0	6.9	17.36	0.62	0.85	8.37
2034	35.91	0	6.9	11.96	0.53	0.80	8.23
2035	45.85	0	6.9	16.49	0.68	0.95	8.53
2036	27.87	0	6.9	10.47	0.40	0.57	7.87
2037	48.88	0	6.9	16.44	0.75	1.05	8.70
2038	28.10	0	6.9	12.94	0.35	0.49	7.74

Table E-3. Site Water Balance for No Action

Project No. 040001, DuPont, Washington

	Inflows			Outflows			
Year	Total Precipitation in inches	Total Surface Water Run-On in cfs	Groundwater Inflows in cfs	Evapo-transpiration in inches	Stormwater in cfs	Direct Groundwater Recharge in cfs	Total Groundwater Outflow in cfs
2039	36.26	0	6.9	16.09	0.49	0.63	8.02
2040	33.69	0	6.9	13.50	0.45	0.68	8.02
2041	46.65	0	6.9	18.18	0.68	0.90	8.48
2042	53.77	0	6.9	17.80	0.80	1.20	8.90
2043	51.49	0	6.9	13.78	0.80	1.30	8.99
2044	51.64	0	6.9	17.17	0.77	1.14	8.81
2045	52.33	0	6.9	15.36	0.81	1.25	8.95
2046	36.35	0	6.9	12.28	0.52	0.82	8.24
2047	42.13	0	6.9	16.60	0.60	0.82	8.32
2048	41.81	0	6.9	14.25	0.62	0.91	8.43
2049	36.96	0	6.9	14.79	0.52	0.71	8.13
2050	46.15	0	6.9	15.87	0.68	1.00	8.58
2051	45.24	0	6.9	14.87	0.67	1.01	8.59
2052	48.60	0	6.9	16.45	0.71	1.08	8.69
2053	45.60	0	6.9	14.17	0.72	1.03	8.65
2054	37.71	0	6.9	15.06	0.51	0.75	8.16
2055	33.13	0	6.9	12.90	0.45	0.67	8.02
2056	46.21	0	6.9	16.88	0.68	0.95	8.53
2057	41.86	0	6.9	12.85	0.63	0.98	8.51
2058	67.38	0	6.9	19.34	1.10	1.57	9.57
Average	41.99	0	6.90	14.80	0.61	0.90	8.41
Average in inches	41.99	0	124.26	14.80	11.07	16.12	151.44

Notes:

1) Stormwater is the sum of surface runoff and interflow.

2) Under existing conditions, all stormwater infiltrates within the mine area or on the South Parcel.

3) Total Groundwater outflow is the sum of stormwater + direct groundwater recharge + groundwater inflows.

4) Average flows in cfs are converted to inches by calculating the total volume in cubic feet for the year, then dividing by the project area of 482.4 acres

CH2MHILL

Well Number: CHTW-1

Client: Glacier NW
Project: N Sequalichew Creek Aquifer Tests
Location: DuPont, Washington
Project Number: 151973.A2.AT

Driller: Hokkaido Drilling (Bob, Ron)
Drilling Method: Star 72 cable tool (12" bit/12" casing)
Sampling Method: Sand pump (water added)
Logged by: TNV
Start/Finish Date: 12/13/99 - 12/15/99

Depth (ft)	Sample Info: Sample #	Sample Info: STP (6"-6"-6")	Soil Log	Soil Description	Depth / Elev	Well Drawing	Well Construction Notes
-5					5 215		Welded Cap with 2" capped access
0				Ground Surface **Silty Sand (SM):** Dark brown sildy sand, dry.	2		NOTE: Sounding tube for pump test water levels (since removed) was roughly 3 feet above ground surface.
5				**Well-graded Sand (SW)** light brown well-graded sand with about 30% fine to coarse gravel, moist. At 9 feet - less gravel, easier drilling.	208		
10				At 18 feet - becomes grayish brown At 21 feet - becomes darker brown, moisture increase			Surface Seal (18) 50-lb bags bentonite chips (medi
15				At 22.5 feet - gravel increases			
20							Native formation sand and gravel
25					25		
				Well-Graded Sand with Silt (SW-SM): Gray brown well-graded sand with 30 to 40% fine gravel, occasional coarse gravel; wet.	185		
30							
35					35		
				Well-Graded Sand (SW): Gray brown fine to coarse sand with about 35% fine to coarse gravel, trace silt; wet. Large amount of water at 36 feet.	175		
40				At 43 feet - increased gravel, silt At 48 feet - increased silt, less dense			
45				At 58 feet - driller reports sand with silt. Casing is falling, difficult to obtain samples			
50				At 66 feet - decreases sand At 67 feet - increased gravel			
55							

CH2MHILL

Well Number: CHTW-1

Client: Glacier NW
Project: N Sequalichew Creek Aquifer Tests
Location: DuPont, Washington
Project Number: 151973.A2.AT

Driller: Hokkaido Drilling (Bob, Ron)
Drilling Method: Star 72 cable tool (12" bit/12" casing)
Sampling Method: Sand pump (water added)
Logged by: TNV
Start/Finish Date: 12/13/99 - 12/15/99

Depth (ft)	Sample Info: Sample #	Sample Info: STP (6"-6"-6")	Soil Log	Soil Description	Depth / Elev	Well Drawing	Well Construction Notes
60				**Well-Graded Sand (SW):** Gray brown fine to coarse sand with about 35% fine to coarse gravel, trace silt; wet. Large amount of water at 36 feet. At 43 feet - increased gravel, silt. At 48 feet - increased silt, less dense. At 58 feet - driller reports sand with silt. Casing is falling, difficult to obtain samples. At 66 feet - decreases sand. At 67 feet - increased gravel			8" Mild steel casing
65							
70							K-Packer; Riser (6" mild steel pipe)
75					75		
				Well-Graded Sand (SW): Dark red-brown fine to coarse sand with minor gravel and trace silt, peat or wood pieces.	135		Screen - 0.100-in slot width vee-wrap 6" pipe size stainless steel
80				**Poorly-Graded Gravel (GP):** Fine gravel with medium and coarse sand, trace silt; water is clean.			
85					87		Sump (6" mild steel pipe)
				Interbedded Sand/Silt/Clay (SP/ML): Interbedded fine to medium sand with silt and clay. Silt and clay layers contain small to medium wood pieces (Olympia Beds)	123		10-20 CSSI sand (5 50-lb bags)
90							
95					99		Hydrated medium bentonite chips (12 50-lb bags)
100				**Organic Silt and Clay (ML/OL):** Dark brown organic silt and clay with wood pieces and occasional fine sand; hard.	111		
105					108		
110				End of Log	102		
115							

CH2MHILL

Well Number: CHTW-2

Client: Glacier NW
Project: N Sequalitchew Creek Aquifer Tests
Location: DuPont, Washington
Project Number: 151973.A2.AT

Driller: Hokkaido Drilling (Bob, Ron)
Drilling Method: Star 72 cable tool (12" bit/12"casing)
Sampling Method: Sand pump (water added)
Logged by: TNV
Start/Finish Date: 12/13/99 - 12/15/99

Depth (ft)	Sample Info: Sample #	Sample Info: STP (6"-6"-6")	Soil Log	Soil Description	Depth / Elev	Well Drawing	Well Construction Notes
-5					5 210		Welded cap w/ 2" NPTaccess
0				Ground Surface **Silty Sand (SM):** silty sand with gravel - topsoil; dry.	2 203		NOTE: Sounding tube for pump test water levels (temporary) was 2.15' above ground surface.
5				**Gravel with Silt (GW-GM/GP-GM):** Light grayish brown fine gravel with sand, silt ranging from trace to 5%, loose to 14.5 feet, then dense, dry. At 19 feet - becomes wet.			
10							Surface Seal (11) 50-lb bags bentonite chips (medi
15							
20					22		
25				**Well-Graded Sand (SW):** Grayish brown fine to coarse sand with fine gravel, trace to 3% silt; wet. At 23.5 feet - increased silt, harder drilling At 25 feet - increased water.	183 30		
30				**Well-Graded Gravel (GW):** Gray with blue, black, red yellow fine to coarse gravel with fine to coarse sand, trace silt. At 33 and 37 feet - increased water, clear At 39 feet - drilling "tighter"	175		8" mild steel casing w/ drive shoe
35							Native formation sand and gravel
40					43		
45				**Well-Graded Sand with Silt (SW-SM):** Brownish fine to coarse sand with silt and up to 20% fine to coarse gravel. At 45 feet - increased water, easier drilling.	162		
50							
55					55		K packer
60				**Well-Graded Gravel (GW):** Brownish fine to coarse gravel with fine to coarse sand, occasional cobbles, trace silt. Increased water.	150 60 145		Riser (6" pipe size, mild steel) Screen (6" pipe size, mild steel, vee-wrap wire, 0.150-inch slot
65				**Well-Graded Sand (SW):** Medium brown fine to coarse sand with fine gravel, less water.	66 139		

CH2MHILL

Well Number: CHTW-2

Client: Glacier NW
Project: N Sequalitchew Creek Aquifer Tests
Location: DuPont, Washington
Project Number: 151973.A2.AT

Driller: Hokkaido Drilling (Bob, Ron)
Drilling Method: Star 72 cable tool (12" bit/12"casing)
Sampling Method: Sand pump (water added)
Logged by: TNV
Start/Finish Date: 12/13/99 - 12/15/99

Depth (ft)	Sample Info: Sample #	Sample Info: STP (6"-6"-6")	Soil Log	Soil Description	Depth / Elev	Well Drawing	Well Construction Notes
70				**Well-Graded Gravel (GW):** Greenish gray fine to coarse gravel with sand.	72		Sump (6" pipe size, mild steel)
				Silty Sand (SM): Gray fine to coarse sand with fine gravel.	133 76		
75				**Poorly-Graded Sand with Silt (SP-SM):** Gray fine sand with about 10% silt. At 78 feet - gray silt chunks. At 79 feet - water decreased	129 80		10-20 CSSI sand
80					125		Betonite chips - medium, hydrated
				Silt (ML): Gray-brown mottled silt in chunks, hard. Feels greasy (clay?).	87		
85				**Silty Sand (SM):** Dark gray silty fine sand.	118 90		
				Poorly-Graded Sand with Silt (SP-SM): Dark gray fine sand with silt, small wood pieces.	115 96		
90				**Well-Graded Sand with Silt (SW-SM):** Dark gray sand with silt, wood pieces.	109		
95				**Silt/Clay (ML/CL):** Dark reddish brown silt/clay, hard, with wood fragments. At 102 feet - becomes dry (moist)	104		
				Poorly-Graded Sand w/ Silt (SP-SM): Dark gray fine sand with occasional small gray silt chunks; wet. Interlayered with:	101 109		
100				**Silty Sand (SM):** Dark gray silty fine sand with silt chunks, wood debris.	96		
					117		
105				End of Log	88		
110							
115							
120							
125							
130							
135							

CH2MHILL

Well Number: CHTW-3

Client: Glacier NW
Project: N Sequalitchew Creek Aquifer Tests
Location: DuPont, Washington
Project Number: 151973.A2.AT

Driller: Hokkaido Drilling (Bob, Ron)
Drilling Method: Star 72 cable tool (12" bit/12"casing)
Sampling Method: Sand pump (water added)
Logged by: TNV
Start/Finish Date: 12/13/99 - 12/15/99

Depth (ft)	Sample Info: Sample #	Sample Info: STP (6"-6"-6")	Soil Log	Soil Description	Depth / Elev	Well Drawing	Well Construction Notes
-5					5 222		Welded cap w/ 2" NPT access NOTE: Sounding tube for pump test water levels (since removed) was about 1.3 feet above ground surface
0				Ground Surface **Topsoil**	2		
5				**Well-Graded Sand with Silt (SW-SM):** Light gray brown fine to coarse sand with silt and fine gravel. At 16 feet - becomes moist	215		Surface seal 50-lb bags bentonite chips (medium)
10							
15							
20					23		
25				**Silty Sand (SM):** Gray brown fine to coarse sand with gravel; wet	194		
30							
35					35		
40				**Poorly-Graded Gravel (GP):** Fine gravel with fine to coarse sand, trace silt.	182		8" mild steel casing
45					45		
50				**Silty Sand (SM):** Gray brown fine to coarse sand with silt, fine to coarse gravel.	172 52		
55				**Well-Graded Sand with Silt (SW-SM):** Gray brown fine to coarse sand with fine to coarse gravel, silt up to 15%.	165		
60							

CH2MHILL

Well Number: CHTW-3

Sheet: 2 of 2

Client: Glacier NW
Project: N Sequalitchew Creek Aquifer Tests
Location: DuPont, Washington
Project Number: 151973.A2.AT

Driller: Hokkaido Drilling (Bob, Ron)
Drilling Method: Star 72 cable tool (12" bit/12"casing)
Sampling Method: Sand pump (water added)
Logged by: TNV
Start/Finish Date: 12/13/99 - 12/15/99

Depth (ft)	Sample Info: Sample #	Sample Info: STP (6"-6"-6")	Soil Log	Soil Description	Depth / Elev	Well Drawing	Well Construction Notes
					62		
				Well-Graded Sand with Silt (SW-SM): Gray brown fine to coarse sand with silt and fine gravel.	155		
65					68		
				Poorly-Graded Gravel with Sand (GP-GM	~~149~~ 70		
70				Blue-gray fine gravel with sand.	147		K Packer
				Well-Graded Sand (SW): Dark gray fine to coarse sand with 25% gravel, trace silt.	75		Riser (6" mild steel pipe with weldring
75				**Poorly-Graded Gravel (GP):** Dark gray fine gravel, about 20% sand, no silt.	142 80		Screen 150-slot vee-wrap 6" pipe size, stainle
80				**Well-Graded Sand with Silt (SW-SM):** Light brown fine to coarse sand with about 25% fine gravel, silt.	137 84		
85				**Silty Gravel (GM):** Medium brown-red silty fine to coarse gravel with fine to coarse sand.	133 87 130 90		Sump (6" mild steel pipe with bailbottc
90				**Silty Sand (SM):** Medium brown silty fine to medium sand with occasional gravel.	127 94		10-20 CSSI sand (6- 50 lb bags)
95				**Poorly-Graded Sand (SP):** Gray fine to medium sand with gravel.	123		
				Silty Sand (SM): Gray silty fine to medium sand, silt clumps, wood pieces.	100		Hydrated bentonite chips, medium (1'
100				**Poorly-Graded Sand with Silt (SP-SM):** Dark gray fine sand w/ silt, wood pieces.	117 107		
105				**Well-Graded Sand (SW):** Gray brown fine to coarse sand with fine gravel and wood debris, interbedded with silty fine sand.	110 110 107		Total depth = 111' BGS
110				End of Log			
115							
120							
125							

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S. WY 007

Ground Elevation: 210

Date Drill: Oct 12, 1988
Drilling starting 8:20

Boring Location: N 658500 E 463000

Elevation Water Table: Not reached
Backfilled previously - 2-22-89

Sampled by:

Depth	Strata	Sample Interval	Description/Drilling Notes
			Organic top soil - Organic, sandy gravel.
5			1' Sandy gravel, gravel Co to fn, slightly silt coating, subround to round, 70 to 80%; sand-md to fn, loose dry, light brown
		8	
10			8' to 10' Sand 50 to 60%, md to fn
			Below 10' Sand fn 30 to 40%
15			
		18	
20			
		24	24' Sandy gravel, gravel mostly fn (<1"), silt coated, subround to round, 60 to 70%, sand co to fn
25			
		28	loose, moist, md, gray brown
30			
35			
			Few oversize, sand increasing, grading to
		38	38' Gravelly sand, sand co to fn, 50 to 60% gravel mostly fn,
40			loose, moist, gray brown.
45			
		48	
50			
55			
		58	58 Grades back to sandy gravel, same as 24' to 38'
60			occasional sm cobble.
65			

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y 007

Ground Elevation: 210

Date Drill: [illegible]

Boring Location: N 658500 E 463000

Elevation Water Table:

Sampled by:

Depth	Strata	Sample Interval	Description/Drilling Notes
		68	Sandy gravel as above
70			
75			Below 78' slightly more sand; gravel slightly coarser, [illegible]
		78	
80			
85			
		88	Below 90' gravel finer (<1"), 50 to 60% sand content increasing
90			
95			
		98	98' to 100' [illegible] gravel, [illegible]
100			Gravel [illegible] 50 to 60%, sand [illegible] to fn
105			
		108	Sand finer, gravel 60 to 70%, few oversize
110			
115			
		118	
120			
125			
		128	
130			

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y 007 Boring Location: N 658500 E 463000

Ground Elevation: 210 Elevation Water Table: _____

Date Drill: Oct. 12, 1988 Sampled by: _____

Depth	Strata	Sample Interval	Description/Drilling Notes
			Same as above
135			
		138	
140			Gravel mostly fn, silt coated, 50 to 60%; sand intervals - sand content increasing with depth
145			
		148	
150			Grading to Gravelly sand, sand mg, gravel mostly fn, loose moist, gray brown
155			
		158	
160			
			Below 160' gravel coarsing, 50 to 60%
165			
		168	
170			
175			
			subangular to rounded,
180	Kitsap Salmon Sp. 3021.	180	180' Sandy gravel, gravel co to fg, slightly silty, 75 to 80%, sand md to fg, some wood fragments; occ silty balls, mod dense moist, yellow to gray brown - Kitsap?
185		185	184' - very dense, sandy peat
		188	185' ~~Gravelly~~ Peat with silt bands
190		190	188 - Silt, compact, moist, yellow brown, below 189 gravelly sand and sandy gravel.
195			Bottom Hole 190'

210 - 180 / 30

Purple ?

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.WY 013

Boring Location: N 659000 E 462500

Ground Elevation: 163

Elevation Water Table: -5

Date Drill: Oct. 18, 1995

Sampled by:

Engr. #132 light rain

Depth	Strata	Sample Interval	Description/Drilling Notes
			0.2' Organic topsoil, [illegible] slightly [illegible]
5			0.2' Sandy gravel, gravel mostly fn, few co, subround to round, 70 to 80%; sand md to fn; loose, slightly moist, light brown
		8	Recovery poor to fair -
10			Same as above - gravel thinly coated with silt
15			
		18	
20			22' Sandy gravel, gravel mostly fn, subround to round, 70 to 80%; sand co to fn, loose, moist, gray brown
25			
		21	
30			Gravel content increasing slightly, mostly fine (<1")
35			
		38	
40			Gravel coarser, few small cobbles, some oversize (+2½"), all silt coated - Recovery fair
45			
		48	
50			48' Small pieces of organic matter; gravel mostly fn, some oversize and cobbles (broken) 70 to 80%, gravel silt coated
55			
		58	
60			Gravel very fine 60 to 70%, sand co to fn
65			

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y 013 Boring Location: N 659000 E 462500

Ground Elevation: 163 Elevation Water Table: -5

Date Drill: Oct. 18, 1988 Sampled by: _____

Depth	Strata	Sample Interval	Description/Drilling Notes
70		68	Gravel co to fn, thin silt coating, 60 to 70%; few small cobbles (broken)
75			
80		78	Same as above - No cobbles noted
85			
90		88	92' to 100' Gravel fine, 60 to 70%; Sand co to fn
95			
100		98	100' to 110' Gravel co to fn, 65 to 75%, silt coated thining; some drilling difficulties, recovery poor.
105			
110		108	Gravel fn, some crushing, 60 to 70% Recovery fair to poor
115			
120		118	Gravel co to fn, thin silt coating, 70 to 80%
125			
130		128	

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y 013 Boring Location: N 659000 E 462500

Ground Elevation: 163 Elevation Water Table: -5

Date Drill: Oct. 17, 1988 Sampled by:

Depth	Strata	Sample Interval	Description/Drilling Notes
135			Gravel co to fn silt coated, [illegible], few small cobbles; some crushing
140		138	Gravel co to fn 60 to 70%, sand co to fn
145			
150		148	
155			Same as above, occasional cobble
160		158	
165			Gravel slightly finer, 65 to 75%
170		168	168' Groundwater Gravel finer than above with occasional oversize, 65 to 75%
175			
180		178	Gravel co to fn, slightly coarser than above 65 to 75%
185		188	
190			Gravel co to fn, some slight staining, 65 to 75% sand mostly med to fn with minor laminae of predominantly sand
195			

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.WY 013

Boring Location: N 559000 E 462500

Ground Elevation: 163

Elevation Water Table: -5

Date Drill: [illegible]

Drilling [illegible]

Sampled by:

Depth	Strata	Sample Interval	Description/Drilling Notes
			Occasional [illegible] small cobble
		198	
200			
			Same as above, gravel 60 to 70%
205			
		208	
210			Same as above
215			
		218	Water orange color 218' to 219'
220			Gravel [illegible] to fn, appears slightly stained, [illegible]
			[illegible]
225			
		228	228' Water [illegible] brown
230			229' Lost [illegible] very hard, 230' water
			returned [illegible] to dk brown
235			Gravel [illegible] organics or
			manganese.
		238	
240			Bottom [illegible] 238'

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L. S WY 032

Boring Location: N 655000 E 467000

Ground Elevation: 214

Elevation Water Table: 214-17-197
Caved in at 8.5' 2-23-89

Date Drill: Dec 2, 1988
Began 2 P.M

Sampled by:

Depth	Strata	Sample Interval	Description/Drilling Notes
			Topsoil - organic silty sandy gravel loose, [illegible]
5		1	1' [illegible] gravel, gravel co to mostly fn, subround to round, thin silt coating, 50 to 60%; sand md; loose moist, [illegible] brown; below 8' occasional small cobble
10		12	12' Sandy gravel, gravel mostly fn, round, siltcoated, increasing from 60 to 70% to 70 to 80%. below 16'; sand md; loose, moist to very moist, md brown.
15		2	
			Below 17' gravel [illegible] drill one foot -
20		22	Effluent at 22'
			22 Sandy gravel, gravel co to fn, round, heavy silt coat -
25		3	70 to 80%; sand md, loose, saturated, brown
			Few oversize (broken)
		28	
30			Below 30' sticky sands - gravel co to fn, 65 to 75%; sand [illegible] brown,
35		4	intervals silt; sand, sand 70 to 80, silt 10% [illegible] gravel.
		38	Below 38' very soup, 10 to 20% superfines being
40			washed out of sample. Sample - sandy gravel gravel [illegible] sand fn, silt [illegible]
45		5	
		48	Gravel co to [illegible] fine, 65 to 75%
50			
55		6	Below 55' [illegible] gray
		58	Below 55' effluent [illegible] light chocolate brown (butterscotch),
60			gravel co to fn (heavy pea gravel), 70 to 80%; occasional
214 62 142 / 1	~~Sat. Spn.~~ Vo 142	62 7	oversize [illegible] being washed out. clasts stained
65			and oxidized - with depth (below 62')

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S. WY 033

Boring Location: N 656500 E 467500

Ground Elevation: 218

Elevation Water Table:

Date Drill: Dec 3, 1988

Sampled by:

Depth	Strata	Sample Interval	Description/Drilling Notes
		66	66' Gravelly sand, sand mid to fn, 60 to 70%; gravel fine gravel content increasing below 69'
70		70	70' Sandy gravel, gravel co to fn, mostly 60 to 70%, sand may occasional oversize, sand interbeds – some clasts oxidized, stained
75			
		78	
80			80' Sand, co to fn, 10% fn gravel; gravelly interbeds with gravel mostly <1", yellow brown
85			
	30	88	87' Sandy gravel, gravel mostly fn (<5/8"), 65 to 75%; sand co to fn,
90			
			Below 94' effluent becoming reddish chocolate brown
95			
100		100	100' Gravelly sand, sand co to fn, gravel fn 20 to 30%; loose, saturated, yellowish to reddish brown
105			
110		110	110' Sand, mid to fn, gray brown
115			
		118	118' Sandy gravel, gravel mostly fn (<5/8"), 50 to 60%; sand co to fn; loose, saturated, gray brown.
120	K-loop?		Below 120' effluent yellowish brown
125			125' Gravelly sand, sand co to fn, 50 to 60%; gravel fn fine gravel interbeds
		128	
130			

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y [illegible]

Boring Location: N 656500 E 467500

Ground Elevation: _____

Elevation Water Table: _____

Date Drill: _____

Sampled by: _____

[illegible]

Depth	Strata	Sample Interval	Description/Drilling Notes
			Continuation of above
135			
		138	Strong water flow from cyclone
[illegible]			Bottom Hole 138'
			Bottom called as practical mining depth

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.WY 034

Boring Location: N 656000 E 467500

Ground Elevation: 218

Elevation Water Table: 218-28 = 190

Date Drill: Began drilling 12:50

Sampled by: C.W. - 22' - Caved in at 42' 2-23-89 (196'ct)

Depth	Strata	Sample Interval	Description/Drilling Notes
			Organic top soil - gravel fn +50%, sand, organic
5			1' Sandy gravel, gravel co to mostly fn, subround to round, thin silt coating, 60 to 70%; sand md to fn, loose, moist, md brown
		8	
10			Below 8' gravel finer, 65 to 75%, lighter brown
			Below 12' gravel 60 to 70%
15			
		18	
20			Below 18' gravel v. moist to wet, 60 to 70%, co to fn with occasional cobble
25			
		28	
30			Slightly more oversize, gravel 65 to 75%
35			Below 35' moisture increasing
		38	Effluent at 38', zones few soupy
40			Gravel co to fn; 70 to 80%; some oversize
45			
		48	
50			Same as above, appears grayish
55			
		58	
60			Gravel co to [illegible] interbeds of most pea gravel 65 to 75%, [illegible] co to fn.
65			

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.WY 034

Boring Location: N [illegible] E [illegible]

Ground Elevation: 218

Elevation Water Table:

Date Drill:

Sampled by:

Depth	Strata	Sample Interval	Description/Drilling Notes
		68	Gravel co to fn 60 to 70%; 3 to 5% oversize
75	[illegible]	78	77' Gravelly sand, sand md to fn, 50 to 60%; gravel co to fn, interbeds very gravelly to sandy gravel, loose, saturated, brown with yellowish cast.
85			Gravel content increasing below 87'
		88	88' Sandy gravel, gravel mostly fn, 60 to 70%.
90			91' - Some light gray silt interbeds
		93	93' [illegible] effluent; gravel mostly fn, 60 to 70%; yellowish-brown to gray brown
		98	
			Few 2½" gravel, 98' to 100'
105		107	
			107' Sand, md to fn, 10% fn gravel, few [illegible]
		118	
			Bottom hole 118'

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.WY 035

Boring Location: N 656000 E 467000

Ground Elevation: 215

Elevation Water Table: Caved in at 14' - 2.23.89

Date Drill: Dec 4, 1988
Drilling completed 10:45AM

Sampled by:

Depth	Strata	Sample Interval	Description/Drilling Notes
		68	Few sand interbeds, sand md to fn, ±1' thick
70			68 - gravel co to fn with much <1/2", 60 to 70%, sand md.
			72' few cobbles
75			74 Sand interbed, sand md 80 to 90%; gravel fn.
	Vs.		77' Sand.
		78	78' Gravel co to fn, 70 to 80%, gray brown.
80	8.16.89		
	~~Sol Gr~~		Below 84' Reddish-brown - butterscotch effluent. Gravel
85	131 Du Pont		reddish brown cast. Some Gravel stained, oxidized.
		87.5	Sample 87 to 88 contained some silt balls - contact approximated
	127		87.5' Silt, yellowish brown.
90		91.	
			Bottom Hole 91'
95			
100			

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.WY 036

Boring Location: N 655500 E 466500

Ground Elevation: 214.*

Elevation Water Table: 88'
Caved in at 12' 2-23-89

Date Drill: Dec. 4, 1988
Drilling started 12:00 PM

Sampled by:

* Point in bottom of fill rise - reduced to 214' elev. to place collar elev. at original surface.

Depth	Strata	Sample Interval	Description/Drilling Notes
			Sandy gravel, gravel co to fn, subround to round,
5		6	slightly silt coated, 50 to 60%, sand md to fn, loose,
			moist, dark brown; occasional large cobble
			below 2' md brown,
10		12	6' Sandy gravel, gravel mostly fn, 50 to 60%; sand md fn;
			loose, damp, md light brown; below 10' gravel coarser, 60-70%;
15		16	few broken cobbles; below 12' gravel co to fn, 65 to 75%
			with some broken cobbles
			16' Sand, md fn, 80 to 90%; gravel co to fn; slightly silty
20		22	Below 18' gravel content increasing - grading to -
			22' Sandy gravel, gravel co to fn, silt coated, 60 to 70%;
25			sand md; loose, moist, brown; 5 to 70% +2" gravel
		28	26 to 28' gravel mostly ±1", 65 to 75%; very moist.
			silt coated. Effluent at 28'
30			Below 28' gravel co to fn. 60 to 70%, sand co.,
			few oversize.
35			
		38	
40			38' to 40' Soupy sand, sand md to fn
			Below 40' gravel co to fn, 65 to 75%; sand md to fn,
45			silty. few broken cobbles, material semi soupy
		48	
50			Below 48' gravel finer 60 to 70%; sand md to co.
55			Below 54' gravel coarser, 70 to 80%, silt coated; semi soupy
		58	
60			Gravel becoming finer, 60 to 70%; interval
			gray-brown, soupy due to high silty sands
65			

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y 036

Boring Location: N 655500 E 466500

Ground Elevation: 214

Elevation Water Table: 188'

Date Drill:

Sampled by:

Dr[illegible]

Depth	Strata	Sample Interval	Description/Drilling Notes
		68	Below 68' sand, silt increasing
70	VD, ~~Sal Gr~~ 147 DuPont	72	72' Silty, sandy gravel, gravel co to fn, round, 60 to 70%; sand [illegible] to fn, silt coating gravel, mixed with sand (to form soft silty sand balls) ±10%, loose, saturated, brown; intervals maybe silty fine sand <1' thick
75		78	Little or no water return to 78'; below 78' heavy return, gravel mostly fn, 65 to 75%, sand co to fn, brown with slightly reddish cast, gravel generally clean [illegible] silt
80			
85		88	87' effluent light chocolate brown
90		92	92' Brown silt, slightly sandy interbeds <1' thick Gravel fine, sand co to fn below 93'; slightly silty
95		98	97.5' Silty sand, sand v. fn (+100 mech), 80 to 90%; silt interspersed, [illegible] thin silt beds <6" thick and silt balls, occasional small gravel, yellowish brown, very soft (soupy)
100			Below 105' [illegible] interbeds, gravel fn 60 to 70% with some [illegible]
		108	
			Bottom Hole 108'

214
64
146

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L. S. W Y 037

Boring Location: N 655500 E 467000

Ground Elevation: 215

Elevation Water Table: ~~187~~ 197

Date Drill: Dec 5, 1988
Began [illegible]

Sampled by:

Depth	Strata	Sample Interval	Description/Drilling Notes
			Sandy gravel, gravel co to fn, subround to round,
5			55 to 65%; sand md to fn. organic, loose, moist, dk brown
			±2' Sandy gravel, gravel co to fn, 70 to 80%; sand md-fn,
		8	loose, damp, brown,
10			Below 12' few small cobbles (broken), gravel coarser,
			60 to 70%.
15			
		16	16' Sandy gravel, gravel co to fn, silt coated, 70 to 80%;
			sand co to md, loose, very moist, brown;
20			
			Occasional cobble below 18', heavy silt coating
25			
		28	Groundwater 27.5', good effluent at 28'
30			Gravel co to fn, 60 to 70%; sand mostly co.
			28' to 32' soupy; below 32' saturated; very little effluent
35			~~to~~ 38'
40		41	
			41' Gravelly sand, sand md to fn, 70 to 80%;
45			gravel mostly fn., (soupy) soft, saturated, brown
		47	
			47' Sandy gravel, gravel co to fn, 65 to 75%, sand co
50			to mostly fn; loose, saturated, brown,
			Below 50' few broken cobbles
55			Gravel content increasing 70 to 80%; intervals soupy
			from fine sand and silt (5 to 10%), gray brown
		58	
60			1st good water return below 60', gravel co to
			fn (finer than above) with coarse intervals, 60 to 70%;
65			sand co to fn, brown gray

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: S.W.Y 037

Boring Location: N 655500 E 467000
caved in at 4' - 2-23-89

Ground Elevation: 215

Elevation Water Table:

Date Drill:

Sampled by:

Finished drilling 10:25

Depth	Strata	Sample Interval	Description/Drilling Notes
215 / 52 / 148	? Du Pont 148	67	67' Sandy gravel, gravel fn with coarse gravel and cobbles below 72'; 70 to 80%, sand mostly fn, silty with silt coatings; loose to semi soupy, saturated, light brown
70			
75	139	76	76' Sandy gravel, gravel fn (mostly <1/2"), 50 to 60%; Sand co.; loose, wet, md rust brown; below 77 some coarse gravel, darker (soupy) brown (md dk chocolate) Effluent md-dk brown below 77' - slightly silty (±5%), color due to organic?
80		80	80' Sandy gravel, gravel mostly fn 50 to 60%, sand co to fn gray brown, reddish cast.
85		86	85' Thin silt bed (<6" thick)
90		89	86' Gravel mostly <3/4", 70 to 80%, few large gravels/small cobbles (broken) Effluent yellow brown
95			89' Gravelly sand, sand co to md, 50 to 60%, gravel fn coarsing with depth - md dense, saturated gray brown
100		98	96' contact gradational Sandy gravel, gravel co to fn (avg <5/8"), 60 to 70%; sand co to md; md. dense, yellow brown, gravel content increase to ±80% 96' to 98'
		101	
105		104	Below 98' gravel very silty, some silt balls, lost effluent; drilled hard.
110			Bottom Hole 104'
			Bottom 10' section of drill pipe filled with fn silty brown sand followed by 2.5' dense, gray, fn sandy silt
			Lost 1 hour cleaning pipe

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y 038

Boring Location: N 655000 E 466500

Ground Elevation: 215

Elevation Water Table: 200
Water 11.5, caved, at 12.5' 2-23-89

Date Drill: Dec. 5, 1988

Sampled by:

Drilling began 12:25 PM

El 215

Depth	Strata	Sample Interval	Description/Drilling Notes
			Sandy gravel, gravel mostly fn, round, 50 to 60%; sand md to fn; slightly silty (3-5%), organic, loose, very moist, dark brown
5			32' Sandy gravel, gravel mostly fn, subround to round, thin silt coating, 50 to 60%; sand co to md; few small cobbles; loose, moist, brown; below 9' few more broken cobbles
		8	
10			Moisture increasing below 13', gravel generally finer.
			Water return at 15', silt content increasing.
15			
		18	
20			Below 18' gravel co to mostly fn, 50 to 60%; sand co to md; slightly silty (≤5%) wet, sticky, becoming gray brown
			20' gray brown, md sand interbed
25			21' gravel coarser
		28	
30			28' Gravel co to fn, 50 to 60%, some gravel broken, angular most round; sand mostly v. fn. (soupy), some silt; few small cobbles.
35			
		38	38' gravelly sand, sand fn, 80 to 90%; gravel mostly fn; loose, soupy, saturated, brown
40			
		43	
45			43' Sandy gravel gravel mostly fn, 60 to 70%; sand co to fn; silty; occasional small cobble; gravel coarsing with depth.
		48	
50			Gravel mostly fn 65 to 75%; sand co to md; few oversize; sand becoming finer (md to fn) below 50'
55			
		58	
60			Gravel mostly fn (<3/4"), 10% 2 1/2", gravel 60 to 70%; sand mostly md to fn with few thin ~~fn~~ interbeds, predominantly co sand (50 to 60) with fn gravel
65			

(HTW-4 15) Screened 27 - 32'

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y. 038

Boring Location: N 655000 E 466500

Ground Elevation: 215

Elevation Water Table:

Date Drill:

Sampled by:

Depth	Strata	Sample Interval	Description/Drilling Notes
215 70 145 70	145 Vo	70	70' Gravelly sand, sand md to fn, 60 to 70% gravel co to mostly fn; loose, saturated brown. Few interbeds high gravel concentrations; sand coarsing below 75'
75			materials becoming more stained and oxidized -
	~~[illegible]~~ 137	78	77 - hoot water.
80			Pipe plugged off at 78' - drilled to 83' worked for ± 2 hrs trying to unplug - recovered co sand, fn gravel
		83'	At 83' bits of silt. After pulling pipe recovered
85			co gravel packed with silty sand.
			Bottom Hole 83' - Bit penetrated to 88' with no recovery
90			

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L. S WY 032

Boring Location: N 655000 E 467000

Ground Elevation: 214

Elevation Water Table: 214-17-197
Caved in at 8.5' 2-23-89

Date Drill: Dec 2, 1988
Began 2 P.M

Sampled by:

Depth	Strata	Sample Interval	Description/Drilling Notes
			Topsoil - organic silty sandy gravel loose, [illegible]
5		1	1' [illegible] gravel, gravel co to mostly fn, subround to round, thin silt coating, 50 to 60%; sand md; loose moist, [illegible] brown; below 8' occasional small cobble
10		12	12' Sandy gravel, gravel mostly fn, round, siltcoated, increasing from 60 to 70% to 70 to 80%. below 16'; sand md; loose, moist to very moist, md brown.
15		2	
			Below 17' gravel [illegible] drill one foot -
20		22	Effluent at 22'
			22 Sandy gravel, gravel co to fn, round, heavy silt coat -
25		3	70 to 80%; sand md, loose, saturated, brown
			Few oversize (broken)
		28	
30			Below 30' sticky sands - gravel co to fn, 65 to 75%; sand [illegible] brown,
35		4	intervals silt; sand, sand 70 to 80, silt 10% [illegible] gravel.
		38	Below 38' very soup, 10 to 20% superfines being
40			washed out of sample. Sample - sandy gravel gravel [illegible] sand fn, silt [illegible]
45		5	
		48	Gravel co to [illegible] fine, 65 to 75%
50			
55		6	Below 55' [illegible] gray
		58	Below 55' effluent [illegible] light chocolate brown (butterscotch),
60			gravel co to fn (heavy pea gravel), 70 to 80%; occasional
214 62 142 / 1	~~Sat. Spn.~~ Vo 142	62 7	oversize [illegible] being washed out. clasts stained
65			and oxidized - with depth (below 62')

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S. WY 033

Boring Location: N 656500 E 467500

Ground Elevation: 218

Elevation Water Table:

Date Drill: Dec 3, 1988

Sampled by:

Depth	Strata	Sample Interval	Description/Drilling Notes
		66	66' Gravelly sand, sand mid to fn, 60 to 70%; gravel fine gravel content increasing below 69'
70		70	70' Sandy gravel, gravel co to fn, mostly 60 to 70%, sand may occasional oversize, sand interbeds – some clasts oxidized, stained
75			
		78	
80			80' Sand, co to fn, 10% fn gravel; gravelly interbeds with gravel mostly <1", yellow brown
85			
	30	88	87' Sandy gravel, gravel mostly fn (<5/8"), 65 to 75%; sand co to fn,
90			
			Below 94' effluent becoming reddish chocolate brown
95			
100		100	100' Gravelly sand, sand co to fn, gravel fn 20 to 30%; loose, saturated, yellowish to reddish brown
105			
110		110	110' Sand, mid to fn, gray brown
115			
		118	118' Sandy gravel, gravel mostly fn (<5/8"), 50 to 60%; sand co to fn; loose, saturated, gray brown.
120	K-loop?		Below 120' effluent yellowish brown
125			125' Gravelly sand, sand co to fn, 50 to 60%; gravel fn fine gravel interbeds
		128	
130			

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y [illegible]

Boring Location: N 656500 E 467500

Ground Elevation: _____

Elevation Water Table: _____

Date Drill: _____

Sampled by: _____

[illegible]

Depth	Strata	Sample Interval	Description/Drilling Notes
			Continuation of above
135			
		138	Strong water flow from cyclone
[illegible]			Bottom Hole 138'
			Bottom called as practical mining depth

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.WY 034

Boring Location: N 656000 E 467500

Ground Elevation: 218

Elevation Water Table: 218-28 = 190

Date Drill: Began drilling 12:50

Sampled by: C.W. - 22' - Caved in at 42' 2-23-89 (196'ct)

Depth	Strata	Sample Interval	Description/Drilling Notes
			Organic top soil - gravel fn +50%, sand, organic
5			1' Sandy gravel, gravel co to mostly fn, subrounded to
			rounded, thin silt coating, 60 to 70%; sand md to fn,
		8	loose, moist, md brown
10			Below 8' gravel finer, 65 to 75%, lighter brown
			Below 12' gravel 60 to 70%
15			
		18	
20			Below 18' gravel v. moist to wet, 60 to 70%, co to
			fn with occasional cobble
25			
		28	
30			Slightly more oversize, gravel 65 to 75%
35			Below 35' moisture increasing
		38	Effluent at 38', zones few soupy
40			Gravel co to fn; 70 to 80%; some oversize
45			
		48	
50			Same as above, appears grayish
55			
		58	
60			Gravel co to [illegible] interbeds of most pea gravel
			65 to 75%, [illegible] co to fn.
65			

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.WY 034

Boring Location: N [illegible] E [illegible]

Ground Elevation: 218

Elevation Water Table:

Date Drill:

Sampled by:

Depth	Strata	Sample Interval	Description/Drilling Notes
		68	Gravel co to fn 60 to 70%; 3 to 5% oversize
75	[illegible]	78	77' Gravelly sand, sand md to fn, 50 to 60%; gravel co to fn, interbeds very gravelly to sandy gravel, loose, saturated, brown with yellowish cast.
85			Gravel content increasing below 87'
		88	88' Sandy gravel, gravel mostly fn, 60 to 70%.
90			91' - Some light gray silt interbeds
		93	93' [illegible] effluent; gravel mostly fn, 60 to 70%; yellowish-brown to gray brown
		98	
			Few 2½" gravel, 98' to 100'
105		107	
			107' Sand, md to fn, 10% fn gravel, few [illegible]
		118	
			Bottom hole 118'

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.WY 035

Boring Location: N 656000 E 467000

Ground Elevation: 215

Elevation Water Table: Caved in at 14' - 2.23.89

Date Drill: Dec 4, 1988
Drilling completed 10:45AM

Sampled by:

Depth	Strata	Sample Interval	Description/Drilling Notes
		68	Few sand interbeds, sand md to fn, ±1' thick
70			68 - gravel co to fn with much <1/2", 60 to 70%, sand md.
			72' few cobbles
75			74 Sand interbed, sand md 80 to 90%; gravel fn.
	Vs.		77' Sand.
		78	78' Gravel co to fn, 70 to 80%, gray brown.
80	8.16.89		
	~~Sol Gr~~		Below 84' Reddish-brown - butterscotch effluent. Gravel
85	131 Du Pont		reddish brown cast. Some Gravel stained, oxidized.
		87.5	Sample 87 to 88 contained some silt balls - contact approximated
	127		87.5' Silt, yellowish brown.
90		91.	
			Bottom Hole 91'
95			
100			

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.WY 036

Boring Location: N 655500 E 466500

Ground Elevation: 214.*

Elevation Water Table: 88'
Caved in at 12' 2-23-89

Date Drill: Dec. 4, 1988
Drilling started 12:00 PM

Sampled by:

* Point in bottom of fill rise - reduced to 214' elev. to place collar elev. at original surface.

Depth	Strata	Sample Interval	Description/Drilling Notes
			Sandy gravel, gravel co to fn, subround to round,
5		6	slightly silt coated, 50 to 60%, sand md to fn, loose,
			moist, dark brown; occasional large cobble
			below 2' md brown,
10		12	6' Sandy gravel, gravel mostly fn, 50 to 60%; sand md fn;
			loose, damp, md light brown; below 10' gravel coarser, 60-70%;
15		16	few broken cobbles; below 12' gravel co to fn, 65 to 75%
			with some broken cobbles
			16' Sand, md fn, 80 to 90%; gravel co to fn; slightly silty
20		22	Below 18' gravel content increasing - grading to -
			22' Sandy gravel, gravel co to fn, silt coated, 60 to 70%;
25			sand md; loose, moist, brown; 5 to 70% +2" gravel
		28	26 to 28' gravel mostly ±1", 65 to 75%; very moist.
			silt coated. Effluent at 28'
30			Below 28' gravel co to fn. 60 to 70%, sand co.,
			few oversize.
35			
		38	
40			38' to 40' Soupy sand, sand md to fn
			Below 40' gravel co to fn, 65 to 75%; sand md to fn,
45			silty. few broken cobbles, material semi soupy
		48	
50			Below 48' gravel finer 60 to 70%; sand md to co.
55			Below 54' gravel coarser, 70 to 80%, silt coated; semi soupy
		58	
60			Gravel becoming finer, 60 to 70%; interval
			gray-brown, soupy due to high silty sands
65			

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y 036

Boring Location: N 655500 E 466500

Ground Elevation: 214

Elevation Water Table: 188'

Date Drill:

Sampled by:

Dr[illegible]

Depth	Strata	Sample Interval	Description/Drilling Notes
		68	Below 68' sand, silt increasing
70	VD, ~~Sal Gr~~ 147 DuPont	72	72' Silty, sandy gravel, gravel co to fn, round, 60 to 70%; sand [illegible] to fn, silt coating gravel, mixed with sand (to form soft silty sand balls) ±10%, loose, saturated, brown; intervals maybe silty fine sand <1' thick
75		78	Little or no water return to 78'; below 78' heavy return, gravel mostly fn, 65 to 75%, sand co to fn, brown with slightly reddish cast, gravel generally clean [illegible] silt
80			
85		88	87' effluent light chocolate brown
90		92	92' Brown silt, slightly sandy interbeds <1' thick Gravel fine, sand co to fn below 93'; slightly silty
95		98	97.5' Silty sand, sand v. fn (+100 mech), 80 to 90%; silt interspersed, [illegible] thin silt beds <6' thick and silt balls, occasional small gravel, yellowish brown, very soft (soupy)
100			Below 105' [illegible] interbeds, gravel fn 60 to 70% with some [illegible]
		108	
			Bottom Hole 108'

214
64
146

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L. S. W Y 037

Boring Location: N 655500 E 467000

Ground Elevation: 215

Elevation Water Table: ~~187~~ 197

Date Drill: Dec 5, 1988
Began [illegible]

Sampled by:

Depth	Strata	Sample Interval	Description/Drilling Notes
			Sandy gravel, gravel co to fn, subround to round,
5			55 to 65%; sand md to fn. organic, loose, moist, dk brown
			±2' Sandy gravel, gravel co to fn, 70 to 80%; sand md-fn,
		8	loose, damp, brown,
10			Below 12' few small cobbles (broken), gravel coarser,
			60 to 70%.
15			
		16	16' Sandy gravel, gravel co to fn, silt coated, 70 to 80%;
			sand co to md, loose, very moist, brown;
20			
			Occasional cobble below 18', heavy silt coating
25			
		28	Groundwater 27.5', good effluent at 28'
30			Gravel co to fn, 60 to 70%; sand mostly co.
			28' to 32' soupy; below 32' saturated; very little effluent
35			~~to~~ 38'
40		41	
			41' Gravelly sand, sand md to fn, 70 to 80%;
45			gravel mostly fn., (soupy) soft, saturated, brown
		47	
			47' Sandy gravel, gravel co to fn, 65 to 75%, sand co
50			to mostly fn; loose, saturated, brown,
			Below 50' few broken cobbles
55			Gravel content increasing 70 to 80%; intervals soupy
			from fine sand and silt (5 to 10%), gray brown
		58	
60			1st good water return below 60', gravel co to
			fn (finer than above) with coarse intervals, 60 to 70%;
65			sand co to fn, brown gray

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: S.W.Y 037

Boring Location: N 655500 E 467000
caved in at 4' - 2-23-89

Ground Elevation: 215

Elevation Water Table:

Date Drill:

Sampled by:

Finished drilling 10:25

Depth	Strata	Sample Interval	Description/Drilling Notes
215 / 52 / 148	? Du Pont 148	67	67' Sandy gravel, gravel fn with coarse gravel and cobbles below 72'; 70 to 80%, sand mostly fn, silty with silt coatings; loose to semi soupy, saturated, light brown
70			
75	139	76	76' Sandy gravel, gravel fn (mostly <1/2"), 50 to 60%; Sand co.; loose, wet, md rust brown; below 77 some coarse gravel, darker (soupy) brown (md dk chocolate) Effluent md-dk brown below 77' - slightly silty (±5%), color due to organic?
80		80	80' Sandy gravel, gravel mostly fn 50 to 60%, sand co to fn gray brown, reddish cast.
85		86	85' Thin silt bed (<6" thick)
90		89	86' Gravel mostly <3/4", 70 to 80%, few large gravels/small cobbles (broken) Effluent yellow brown
95			89' Gravelly sand, sand co to md, 50 to 60%, gravel fn coarsing with depth - md dense, saturated gray brown
100		98	96' contact gradational Sandy gravel, gravel co to fn (avg <5/8"), 60 to 70%; sand co to md; md. dense, yellow brown, gravel content increase to ±80% 96' to 98'
		101	
105		104	Below 98' gravel very silty, some silt balls, lost effluent; drilled hard.
110			Bottom Hole 104'
			Bottom 10' section of drill pipe filled with fn silty brown sand followed by 2.5' dense, gray, fn sandy silt
			Lost 1 hour cleaning pipe

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y 038

Boring Location: N 655000 E 466500

Ground Elevation: 215

Elevation Water Table: 200
Water 11.5, caved, at 12.5' 2-23-89

Date Drill: Dec. 5, 1988

Sampled by:

Drilling began 12:25 PM

El 215

Depth	Strata	Sample Interval	Description/Drilling Notes
			Sandy gravel, gravel mostly fn, round, 50 to 60%; sand md to fn; slightly silty (3-5%), organic, loose, very moist, dark brown
5			32' Sandy gravel, gravel mostly fn, subround to round, thin silt coating, 50 to 60%; sand co to md; few small cobbles; loose, moist, brown; below 9' few more broken cobbles
		8	
10			Moisture increasing below 13', gravel generally finer.
			Water return at 15', silt content increasing.
15			
		18	
20			Below 18' gravel co to mostly fn, 50 to 60%; sand co to md; slightly silty (≤5%) wet, sticky, becoming gray brown
			20' gray brown, md sand interbed
25			21' gravel coarser
		28	
30			28' Gravel co to fn, 50 to 60%, some gravel broken, angular most round; sand mostly v. fn. (soupy), some silt; few small cobbles.
35			
		38	38' gravelly sand, sand fn, 80 to 90%; gravel mostly fn; loose, soupy, saturated, brown
40			
		43	
45			43' Sandy gravel gravel mostly fn, 60 to 70%; sand co to fn; silty; occasional small cobble; gravel coarsing with depth.
		48	
50			Gravel mostly fn 65 to 75%; sand co to md; few oversize; sand becoming finer (md to fn) below 50'
55			
		58	
60			Gravel mostly fn (<3/4"), 10% 2 1/2", gravel 60 to 70%; sand mostly md to fn with few thin ~~fn~~ interbeds, predominantly co sand (50 to 60) with fn gravel
65			

(HTW-4 15) Screened 27 - 32'

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y. 038

Boring Location: N 655000 E 466500

Ground Elevation: 215

Elevation Water Table:

Date Drill:

Sampled by:

Depth	Strata	Sample Interval	Description/Drilling Notes
215 70 145 70	145 Vo	70	70' Gravelly sand, sand md to fn, 60 to 70% gravel co to mostly fn; loose, saturated brown. Few interbeds high gravel concentrations; sand coarsing below 75'
75			materials becoming more stained and oxidized -
	~~[illegible]~~ 137	78	77 - hoot water.
80			Pipe plugged off at 78' - drilled to 83' worked for ± 2 hrs trying to unplug - recovered co sand, fn gravel
		83'	At 83' bits of silt. After pulling, pipe recovered
85			co gravel packed with silty sand.
			Bottom Hole 83' - Bit penetrated to 88' with no recovery
90			

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y 045

Boring Location: N 657500 E 464000

Ground Elevation: 168

Elevation Water Table: ~~± 9 ft~~ 120 Cased in at 6' 2-24-89

Date Drill: Dec. 12, 1988

Sampled by:

Drilling began ±10 AM
Drilling completed 11:30 AM

weather - overcast, foggy, poor light

168
-120
48

Depth	Strata	Sample Interval	Description/Drilling Notes
5		8	Sandy gravel, gravel co (max 2"), f to m, silt coated, subrounded to round, 60 to 70%, sand m d, loose, moist; organic dark brown to 2', below 2, slightly organic, m d grayish brown
10			Below 8' gravel co to fn, coarser than above, 60 to 70% sand co to md.
15			(Note (3-18-89) S&C fresher looking w/ less oxidized/stained clasts than #12)
20		18	Below 21' gravel slightly finer, slightly lighter grayish brown
25			
30		28	Few small cobbles; gravel less silt coatings and sand finer below 35'
35	Gillespie		
40		38	Gravel co to fn, slightly coarser than above, 60 to 70% 42 to 46, gravel mostly 3/4 to 1/2", 80 to 90%, occasional large gravel sand co to md; few oversize 38 to 42
45			
50	VT	48	48 Sandy gravel, gravel co mostly, heavily silt coated (sticky) 65 to 75%, sand co to md, loose, wet gray brown, 49' gravel much finer, yellow brown (stained oxidized) (transition zone.)
55	Kitsap 114	54	54' Silt, brown organic 54 to 54, occasion gravel, slightly sandy
60			56' Silt greenish to purplish gray
65		68	64' Groundwater - low volume - Very little return thru cyclone 68' Bottom Hole. Enviroplug added 3 bags

168
-54
114

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y 047

Boring Location: N 657000 E 464500

Ground Elevation: 212

Elevation Water Table: 212-40 = 172
Caved in at 13.9' 2-26-89

Date Drill: Dec 13, 1988
Began drilling 9:10 AM.

Sampled by:

Depth	Strata	Sample Interval	Description/Drilling Notes
			Sandy gravel, gravel co (<2") to fn, subround to round,
5			silt coated, 60 to 70%; sand co to md, loose. v moist
			to moist, top 1' organic dk brown, below 1' md brown.
		8	
10			
			occasional oversize (+2½)
15			
		18	
20			Gravel <2", co to fn, 60 to 70%; below 21' wet.
			(perched water?)
25			
		28	
30			29 - Gravel coarser with some oversize, silt coated, wet
			Below 35 gravel becoming finer.
35			No return at 38' water
	Vs?	38'	Groundwater 40' (return when stopped 2 min. at this depth)
40			Below 38' gravel co (<1½") to fn, silty, 60 to 70%, sand
	VR?		coarse to md., wet; below 40 saturated, gravel 70 to 80%.
45			1 cobble, below 44 gravel co to fn, sticky, 60 to 75%.
			45 to 46 Sand with 1 cobble, sand md to fn.
		48	47' Gravel co to fn, sticky, 65 to 75%, heavy lt brown return.
50			Few stained, oxidized clasts -
			50' Sandy gravel, gravel co to fn, subround to
55			round, may be concentrated in interbed units w/ broken cobbles,
			60 to 70%, sand mostly md, may occurs as sand
		58	interbed at 60 to 80%; md dense, saturated, gray brown
60			
			Below 60' yellowish-gray brown, gravel co to fn mostly
65			50 to 60%, sand co to fn.

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y 047

Boring Location: N 657000 E 664500

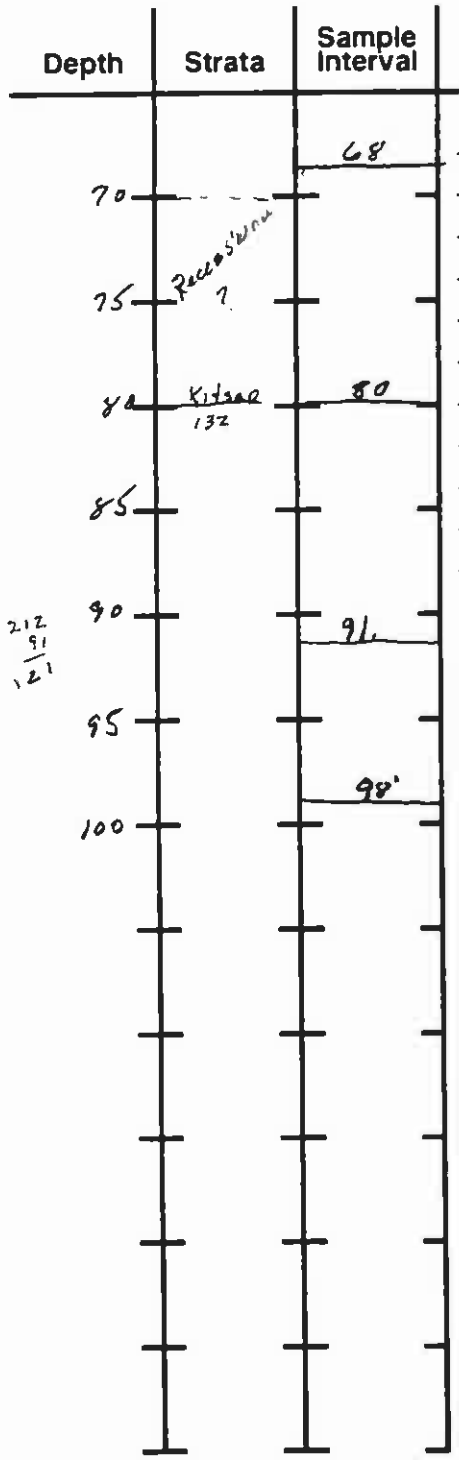
Ground Elevation: 212

Elevation Water Table: _____

Date Drill: _____

Sampled by: _____

Finished drilling 10:35



Gravel fn with coarse zones; 60 to 70%, sand co to fn. yellowish brown effluent, material gray brown. Amount of stained, oxidized clasts increasing with depth.

76 Gravelly sand, sand co to fn, 60 to 70%, gravel fn with sand co:, brown

80 Gravelly sand, sand md, 60 to 70%, gravel mostly fn with intervals co to fn and in heavy concentrations. md. dense, saturated, blue-gray ~ Kitsap.

Silt, blue-green with organic fragments 91 to 92' damp. md dense

Below 96 purplish cast. Ibey ENVIRONMENTAL

Bottom hole

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y 050

Ground Elevation: 214

Date Drill: Dec. 14, 1988
Began drilling ± 8:30

Boring Location: N 656500 E 465500

Elevation Water Table: [illegible] - 18[illegible]' (188)
Caved in at 14.9' deep -2 20-89

Sampled by:

Depth	Strata	Sample Interval	Description/Drilling Notes
			Sandy gravel, gravel mostly fn (avg <3/4"), subround to
5			round, 60 to 70%; sand co to md, silt coatings; loose, very moist
			organic, dark brown to 1', below 1' moisture decreasing, md. brown
		8	recovery fair
10			8' Gravelly sand, sand md to fn, 60 to 70%; gravel mostly fn
			(<5/8"), occasional very coarse gravel, loose, moist brown
		13	gravel content increasing
15			13' Sandy gravel; gravel co to mostly fn, silt coated, 60 to 70%
		18	occasional oversize or small broken cobble; sand md;
20			loose, moist, brown
			Below 18 sand finer.
25			Below 25 moisture increasing
		28	Groundwater - 28
30			Gravel co to mostly fn, 65 to 75%, occasional oversize
			or small cobble, top 3', very sandy, soupy
35			
		38	37 to 38 very sandy, soupy
40			Below 38 gravel co to fn, 65 to 75%, few interval
			high sand content, sand co to md, brown.
45	Vs - VR		Below 45 material gray brown, effluent yellow brown
		48	
50			Gravel coarser with more oversize & small cobbles than above
55			Below 42' gravel finer with interbeds of coarse gravel and
			fn gravelly [illegible] sand.
		58	
60			Below 58 gravel co to fn, 60 to 70%, few oversize and small
			cobbles; sand co to fn. gray brown mod. dense
65			

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y 050

Boring Location: N 656500 E 465500

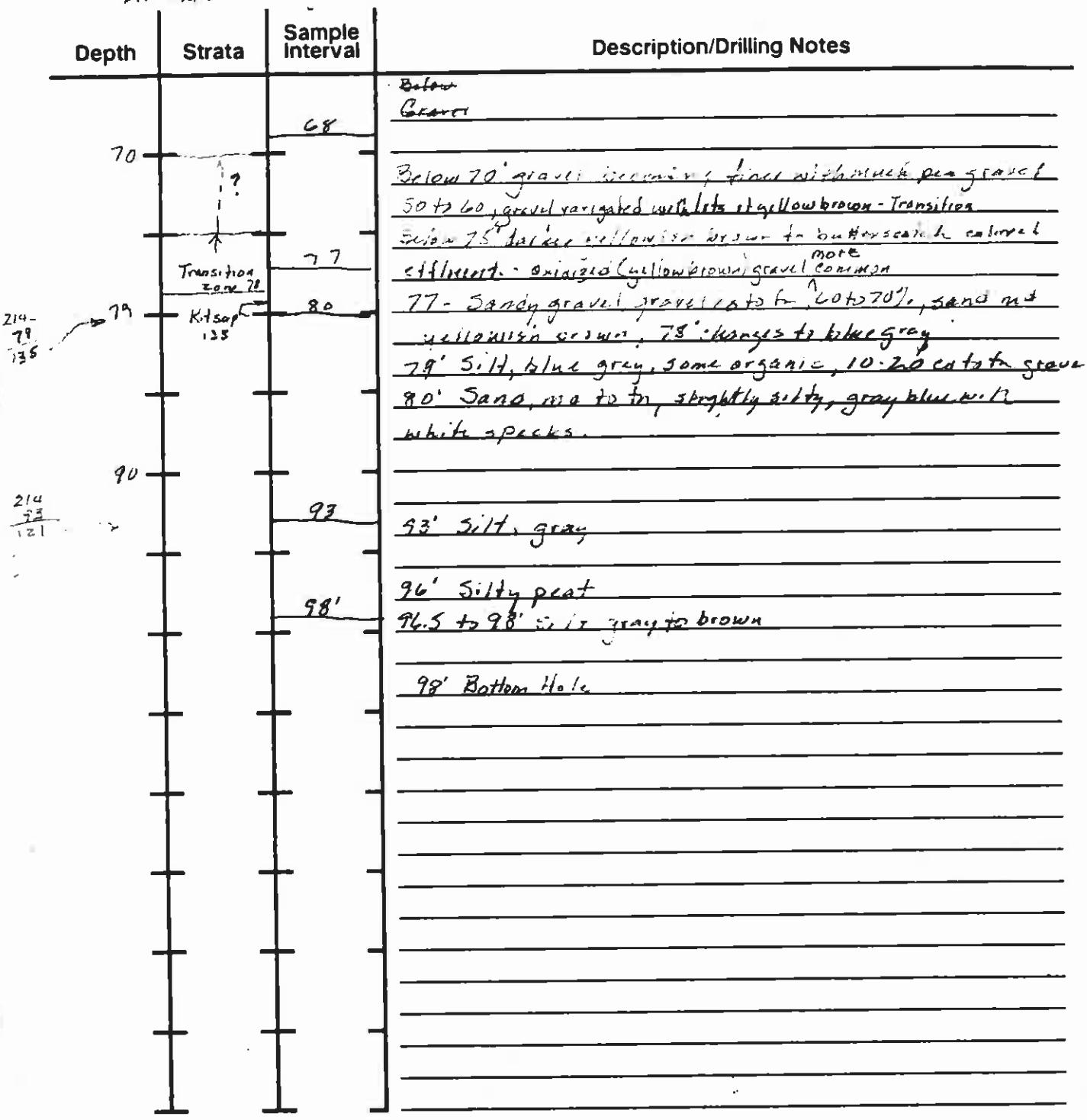
Ground Elevation: 214

Elevation Water Table: 186

Date Drill: Dec. [illegible]

Sampled by:

[illegible] 10.15AM



Depth	Strata	Sample Interval	Description/Drilling Notes
			~~Below~~ Gravel
		68	
70	?		Below 70' gravel becoming finer with much pea gravel 50 to 60, gravel varigated with lots of yellow brown - Transition
			Below 75' darker yellowish brown to butterscotch colored
	Transition zone 78	77	efflorescent - oxidized (yellow brown) gravel more common
214-79 135 → 79	Kitsap 135	80	77 - Sandy gravel, gravel co to fn, 60 to 70%, sand md yellowish brown, 78' changes to blue gray
			79' Silt, blue gray, some organic, 10-20 co to fn gravel - Kitsap
			80' Sand, md to fn, slightly silty, gray blue with white specks.
90			
214 93 121		93	93' Silt, gray
			96' Silty peat
		98'	96.5 to 98' Silt gray to brown
			98' Bottom Hole

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y. 075

Boring Location: N 658000 E 463500

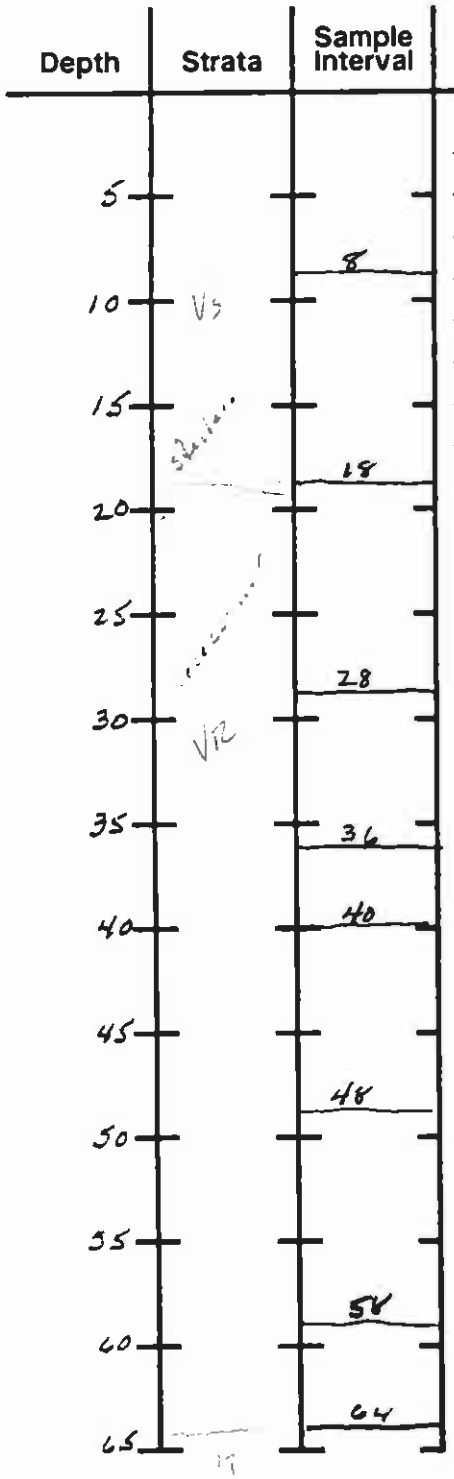
Ground Elevation: 212

Elevation Water Table: N/W
caved 42.3'-N/W-2-22-89

Date Drill: _____

Sampled by: _____

Started drilling 9:20 AM



Description/Drilling Notes

Sandy gravel, gravel mainly fn, silt coated, 70 to 80% sand co to md, loose, very moist, grayish brown

5' Sandy gravel, gravel fn, silt coated, 60 to 70%, sand mostly md, one small cobble

Below 8' sand md 40 to 50%

Below 10' gravel co to fn, silt coated, 60 to 70%, sand md, loose, moist, grayish brown

18 Sand, md to fn, 80 to 90%, gravel co to fn occurring as isolated clasts or in thin interbeds 5 to 10%, silt occurring with sand, increasing with depth content loose, moist, yellow brown - gravel increasing below 25'

28 Sandy gravel, gravel co to fn, silt coated (slightly sticky) 50 to 60%, sand fn to md, loose, moist, yellowish-brown

Below 30' moisture increasing, few small silt coated cobbles

34' to 36' very moist with silt more common

36 Gravelly Sand, sand mostly md, 50 to 60%, gravel co to ~~mostly~~ fn, silt coated, loose, moist, yellowish-brown

intervals very gravelly to predominant, silt interspersed; sand becoming finer, silty below 38'

40' Sandy gravel, gravel co to fn, silt coated, 60 to 70%; sand md to fn, loose, moist, yellowish brown

Same as above

Below 54 gravel becoming finer, 50 to 60%, sand co to fn few small cobbles, slightly silty

62 to 64 Sand md, sharp, 50 to 60%, grey mostly fn, loose damp, gray brown

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L. S. W. Y. 075

Boring Location: N 658000 E 463500

Ground Elevation: 212

Elevation Water Table:

Date Drill:

Sampled by:

Finished drilling ± 10:15

Depth	Strata	Sample Interval	Description/Drilling Notes
			Sandy gravel, gravel co to fn, silt coated, 60 to 70%
70		71	sand mostly fn, ~~slightly~~ silty, few oversize, md dense,
			damp, yellowish brown
			Below 71 gravel co to fn, more cleaved clasts, 65 to 75%, clasts stained;
75			yellow brown with orangist cast 71' to 72', bright yellowish brown
		78	below 72'; some stained, oxidized clasts
80	↓T?		
			Staining, oxidizing increasing
	Kitsap	84	84'
85	128		Silt, gray, dry; becoming lighter gray to yellowish brown below 86
		88	
90			88' Bottom Hole
95			
100			

212
84
128

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L S W.Y 099

Boring Location: N 665500 E 465000

Ground Elevation: 217

Elevation Water Table: 217 -16 = 201

Date Drill: Jan 24, 1989
Drilling started 9:20

Sampled by:

Depth	Strata	Sample Interval	Description/Drilling Notes
5			Sandy gravel, gravel co to mostly fn, silt coated, subround to round, 60 to 70%, sand md to mostly fn, loose, moist, top 2' organic, dk brown, below 2' brown
		8	
10			Gravel becoming coarser, sand coarser
15			Few small cobbles below 14'
		18	16' material wet, water return at 18.
20			Gravel co to fn, sticky silt coatings, 65 to 75%, sand mostly co.
25			
		29	
30			29 Sand, md to fn, 80 to 90%, slightly silty (5 to 10%) gravel co to fn, as interbeds, 5 to 10%, loose, saturated gray brown
35	1/2		
		38	38' Sandy gravel, gravel fn and coarsing, 50 to 60%, sand md to co, md dense, saturated, lt brown surface coatings
40	1'		40 Sandy Gravel, gravel co to fn, sticky silt coatings, 70 to 80% sand co, md dense, saturated, lt brown surface coatings
45	1/2		45 to 45 - Sandy sandy with silt
		48	48 Gravelly sand, sand md to fn, 50 to 60%, gravel co to fn, clean
50			51 Sandy gravel, gravel co to fn, clean to silt coated, 20 to 50%, some broken oversize and small cobbles (± 5%), sand co to fine, slightly silty, md dense, saturated, gray brown with lt brown coating
55			Below 44 Sandy
		54	Below 58 gravel 60 to 70%, few oversize
60			
65			(No strong water return)

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y. 099

Boring Location: N 655500 E 465000

Ground Elevation:

Elevation Water Table:

Date Drill: Jan. 24, 1989
Drilling complete 10:55

Sampled by:

217
- 82
135

Depth	Strata	Sample Interval	Description/Drilling Notes
		68	Gravel co to fn, clean to slightly silt coated, 65 to 75% sand mostly md to f. dk brown
70			
	Jsd JR		Same as above, few intervals with +2½" clasts.
75			Below 75 sand co to md
			Below 78 gravel co to fn 65 to 75%, sand co to fn,
80	Trans.		silt 10-15% as coatings - increasing with depth
217 82 135	Kitsap 135	82	81 Sand and silt content increasing.
			82' Silt, gray; some wood fragments - poor recovery.
85			
		88	88 Bottom Hole
90			

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.N.W. 101

Boring Location: N 656500 E 465000

Ground Elevation: 212

Elevation Water Table: 212 - 28 = 184
Measured at 16' - 2-24-89

Date Drill:

Sampled by:

Drilling began ± 3:10

Depth	Strata	Sample Interval	Description/Drilling Notes
5			Sandy gravel, gravel co to fn, some silt coatings, subround to round, 60 to 70%, sand mostly fn, slightly silty, Top 2' loose, organic very moist, dk brown; below 2' loose, moist grayish brown
		8	
10		10	8 Sand md fn 80 to 90%, gravel co to fn, loose, moist yellowbrown
			10 Sandy gravel, gravel mostly fn, silt coated, 60 to 70%,
15			sand md to fn, loose, moist, brown.
		18	Occasional oversize
20			
25			Moisture increasing, grayish brown below 25
		28	28 some water return - gravel co to fn, 50 to 60%, sand
30			co to md
			Below 32' gravel coarser, co to fn (40:60), slight sticky silt
35			coating, 70 to 80%, sand co to fn
		38	Below 38' gravel co to fn 65 to 75%; sand co to fn.
40			silt 10-25% interval semi liquid
45			
		48	
50			Sand md with 20 to 30% gravel interbedded with
			sandy gravel, gravel mostly co, 70 to 80%, relatively
55			clean, md dense, saturated, gray brown
			56 to 60 Sand md to fn
		58	Below 60 gravel mostly fn 55 to 65%, sand md to fn, slightly silty
60			
65			

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y. 101

Boring Location: N 656500 E 465000

Ground Elevation: 212

Elevation Water Table:

Date Drill: Jan. 24, 1989

Drilling complete 4:20

Sampled by:

Depth	Strata	Sample Interval	Description/Drilling Notes
	VR?		
		69	69 Yellowish brown to butterscotch return – material
70			coated with thin yellow brown soupy silt
	VR or VD		gravel co to fn, subangular to round, 65 to 75%,
75			sand co to fn, md dense, saturated (low return
	Recessive	78	flow), yellow brown (some clasts stained, oxidized)
			Below 78 gravel mostly fn, some weathered, stained 50 to 60%
80			sand md to fn clean, md dense, saturated, brown – Transitional?
		83	83 - Sandy gravel [illegible] co to fn, increase in Kitsap mineralogy
85			60 to 70%, sand co to fn, few oversize, soupy interval, = Transition or reworked?
212 / 87 / 125	Kitsap 125	87	87 Sand, mostly fn, few gravel, slightly silty, loose
90	122	90	saturated, gray blue.
		92	89. Few silt layers in sand
			90' Silt gray to brown with organics common – several
95			large wood chips.
		98	92 Sand, md to fn, dry. purple with red specks, few wood chips.
101			98 Bottom Hole
			2-17-89
			Note Gravel surface [illegible] mostly fn sandy, sl. silty, brown, gray
			blue, yellow brown suggest VR

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y. 106

Boring Location: N 655000 E 465500

Ground Elevation: 218

Elevation Water Table: 218 - 25 = 193
Caved-in at 19 2-20-89

Date Drill: Jan. 26, 1989
Drilling started ± 10:30

Sampled by:

Depth	Strata	Sample Interval	Description/Drilling Notes
			Sandy gravel, gravel co to fn, slightly silt coated, subround to
5			round, 60 to 70%; sand md to fn; slightly silty, ±10%
			oversize, small cobbles, loose, moist, top 1' organic
		8	dk brown; below 1' brown - poor recovery
10			Below 8' gravel co to fn, silt coated, 65 to 75%; sand md to fn;
			few oversize and small (broken) cobbles (5 to 10%); loose,
15			moist, grayish brown.
			Below 16' moisture increasing
		18	Below 18' gravel finer, coated with sticky silt,
20			65 to 75%; sand mostly md; very moist, grayish brown.
		25	Below 25' wet, clasts coated in heavy sticky silt.
25			light brown
		28	
30			Gravel finer with occasional oversize. less sticky silt
			coating, gravel mostly fn, 60 to 70%; sand md to fn, some
35			breakage due to drilling; material md dense, saturated
		38	
40			41' - silty interbed, sticky
			Water return increasing - (very slight return)
45			44' Gravelly sand, sand md to fn, 70 to 80%; gravel
			co to fn; silt 10-20%; loose, (soupy) saturated, light brown.
		49	46' Sandy gravel - same as 38' to 41'
50			
			Below 52 - Soup fn, silty sand with gravel - same as 44' to 46'
55			
			Below 56' gravel content increasing
		58	Below 58 water return increasing - gravel co to fn, some
60			broken, clean, interval slightly concentrated, 60 to 70%; sand co to fn,
			intervals finer, few broken oversize, silt increasing slightly
65			as coating below 65', md dense, saturated, gray brown

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y. 106 Boring Location: N 655000 E 465500

Ground Elevation: 218 Elevation Water Table: _____

Date Drill: Jan 26, 1989 Sampled by: _____

2:20 - Pipe plugging
3:30 Pipe unplugged assumed at this time

Depth	Strata	Sample Interval	Description/Drilling Notes
		68	Continuation of above - see last page for description
70	Vs		Below 66' gravel mostly <1 1/4" with coarser intervals.
	144	72	65 to 75%; sand co to md, thin wet sticky silt coating
	Transitional		clasts. Below 72' soupy silty fn sand with gravel and oversize
75	Sat Spec? 141	77	76' gravel content increasing
			77 Gravel coarse, heavily coated with silt, dense, yellow brown
80	Vo	82	gravel co to fn 65 to 75%, sand co to fn, silt 10 to 15%. (DuPont)
			82' Sandy gravel, gravel co to fn, 60 to 70%, sand co to fn;
85			clean, md dense, saturated, yellowish brown, gravel
		88	stained, slightly oxidized
90			90' to 91' gravel coarse
			91' Gravelly sand, sand mostly md to fn, clean, 85 to 90%; gravel
95			mostly fn, md dense saturated, lt md brown with white specks -
		98	- Sand result of segregation from dragged pipe
100			Interval continuation of sandy gravel from 82' - Butterscotch colored return
		102	Gravel co to mostly fn 60 to 70%; clean, sand mostly md to fn,
105			saturated, brown
			102' Sand, mostly fn, 90 to 95%; occasional gravel; dispersed silt
		108	and sandy silt balls, occasional thin gravel interbed
110			loose to md dense, saturated, yellowish brown - some sample drag-ging
		111	Below 108' sandy gravel - see description @ 102'
			Below 111' silt content increasing - few silt balls - water return
115			thicker, dark butterscotch (low volume), material dense -
		117	gravel co to mostly fn, clean, 60 to 70%; sand co to fn
			Below 115' gravel co to fn, few oversize, clasts, fractured, angular
120			to round, 60 to 70%; sand co to fn, dense, saturated, brown
		122	122' Silty gravelly sand, silt content increasing, dark brown & water return
			gravel angular to round, co to fn, 60 to 70%; sand co to fn
125	Projection V92 Kitsap	126	122' Gravelly sand, sand md to fn 60 to 70%, gravel co to fn, saturated, brown
			126' Gravelly sand, sand mostly md to fn 70 to 80%, gravel mostly fn
130			loose, saturated, bluish-green

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y. 106

Boring Location: N 655000 E 465500

Ground Elevation: 218

Elevation Water Table: _____

Date Drill: Jan 26-27, 1989

Sampled by: _____

Drilling complete 8:35AM 1-27-89

Depth	Strata	Sample Interval	Description/Drilling Notes
218			
135	83	134	134' S/H. brown with gray interbed some organics and volcanic ashy, hard, very moist to moist
	79	137	137 Sand, md to fn, 5 to 10% fn gravel, some mud laymonds, small silt balls and interspersed silt (5 to 10%), purplish gray with red speckles
140			
145			
		148	
150			148' Bottom Hole

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y. 107

Boring Location: N 655500 E 466000

Ground Elevation: 212

Elevation Water Table: 212-12 = 200
Cave in 12.5 - water on top. 2-20-89

Date Drill: Jan 27, 1989
Drilling began ≈ 10:30

Sampled by:

Depth	Strata	Sample Interval	Description/Drilling Notes
			2' Topsoil showing in ditch beside boring
			Sandy gravel, gravel mostly <1 1/4", slightly silt coated, subround
5			to round, 55 to 65%, sand md to fn, slightly silty, loose, top 2'
			organic, moist, dk brown, below 2', moist, grayish brown, to 6, brown below 6
		8	Below 8' gravel co to fn, silt coated, 60 to 70%, sand mostly fn
10			
			Below 12 moisture increasing
15		15	15 water return, gravel co to fn, clean, 65 to 75%, sand fn.
20		20	Gravel co to fn, sticky silt coatings, increasing in concentration
			with depth, 70 to 80%; sand co to fn, few oversize (±5%)
25			loose, saturated, gray brown with brown coating
		28	Below 30 gravel co to fn, clean, 60 to 70%, few oversize (broken)
30			sand md to fn, silt <5%, gray brown with slight reddish cast
		34	Same as above with some sticky silt coating
35			slightly soupy.
		38	
40			
45			Below 45 material with less silt, cleaner, soupy interval 40' to 42'
		47	
			47 - Gravelly sand, sand md to fn, 60 to 70%, gravel co to fn,
50		50	loose, saturated, brown
			50 Sandy gravel, gravel co to fn, some co. interbeds, clean, 60 to 70%;
55	Sfoilacoom		sand mostly md to fn with coarser intervals, few oversize, some
			oxidized & stained clasts, md dense, saturated, gray brown
		58	strong water return
60	Sal Sprs	61	61' Sandy gravel, gravel mostly fn with coarser interbeds
212 / 61 / 151	151		stained, oxidized, 50 to 60%; sand mostly md to fn; slightly silty
	DuPont		yellowish brown paste (return), md dense, saturated, brown, yellow cast
65			61' to 65' heavy silt, yellow to reddish brown

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y. 107 Boring Location: N 655500 E 466000

Ground Elevation: 212 Elevation Water Table: _____

Date Drill: Jan 27, 1984 Sampled by: _____

Drilling began ±10:30

Depth	Strata	Sample Interval	Description/Drilling Notes
70		68	Gravel mostly fn, clean 50 to 60%, sand mostly md to fn slightly silty, md dense, saturated yellowish brown
75			few coarse gravel intervals
80		78	Below 78' sand intervals 50 to 60%. few small cobbles - gravel then interval mostly fn 50 to 60%
85			
90		88	(1 x ½") Gravel mostly fn 50 to 60%, sand md to fn.
95		93	93 Gravelly sand, sand mostly fn, 70 to 80%, silty 10 to 15% hard silt intervals, few gravel (5 to 10%), loose, saturated yellowish brown
100		100	100 Sandy gravel, gravel co to fn, max ±2", 55 to 65%; sand md to fn, slightly silty, 5 to 10%, md dense, saturated, yellowish gray brown
105			Water return good, yellowish brown (butterscotch) Below 106 gravel mostly fn, 50 to 60%, sand md to fn.
110		108	
115		114	112 Decomposed granite cobble or boulder 114 Gravelly sand, sand md to fn, 70 to 80%, gravel co to fn, clean, md dense, saturated, brown
120	Advance		117 Sandy gravel, gravel co to mostly fn, 50 to 60%, sand md to fn; clean, md dense, saturated, brown white specked.
125			
130	Riprap	127	127 Sand, md to fn 30 to 70%, gravel co to fn; clean md dense, saturated - gray blue

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L S W.Y. 107

Boring Location: N 655500 E 466000

Ground Elevation: 212

Elevation Water Table: _____

Date Drill: Jan 27, 1989
Drilling completed 1:55 1/27/89

Sampled by: _____

Depth	Strata	Sample Interval	Description/Drilling Notes
212		134	
134	78		134 - Silt, gray (about 'h' thick)
135			135 - Silty sand, sand fn, 80 to 90%, gray, saturated
			Below 137 v. fn sand and silt mixed
140			
		142	142 Silt, brown, last return
145			
		146	146 Sand fn. green, silty
212		148	
149	69		
150			Bottom Hole 148

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y. 119

Boring Location: N 656000 E 466000

Ground Elevation: 218

Elevation Water Table: 218 - 30 = 188
Corrected at 4.6' 2-24-89

Date Drill: Feb. 7
Drilling started 12:20 P.M

Sampled by:

Depth	Strata	Sample Interval	Description/Drilling Notes
5			Sandy gravel, gravel mostly fn, clean. 65 to 75%; sand co to fn, loose, moist; top 3' organics, dk brown, below 3' brown - poor recovery -
		8	
10			Below 8 gravel coarser, some silt coatings, some crushing (10 to 20%), 70 to 80%, some oversize and broken cobbles (±10%); sand most md to fn, loose, moist, brown
15			Below 15 silt coating increasing, oversize broken to round ±10%;
		18	moisture increasing.
20			
25			
30		30	30 Gravelly sand, sand md to fn, 50 to 60%, gravel co to fn loose, wet to saturated, brown, slightly silty.
35			few oversize and small cobbles
			Strong water return below 36'
40		40	40 Sandy gravel, gravel co to fn, subangular (some breakage) to round, slight wet sticky silt coatings 70 to 80%, sand co to md, md dense, saturated gray brown to brown
45			
50		48	Below 40 seeps, slightly more silt, few oversize, sand fines
55			
		58	
60			
65			

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y. 119

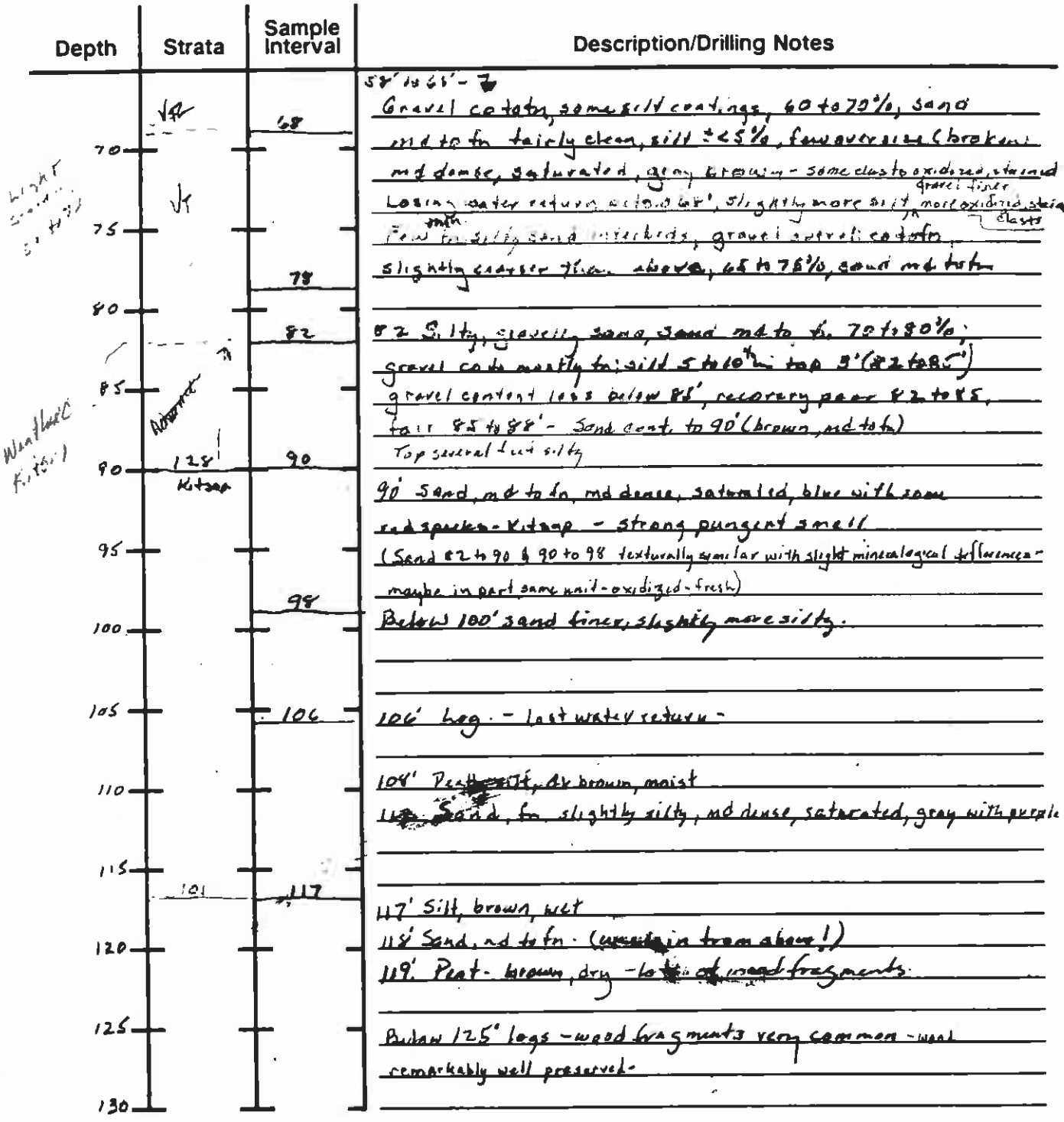
Boring Location: N 656000 E 466000

Ground Elevation: 218

Elevation Water Table: 188
Caved at 4.6' 2-24-89

Date Drill: Feb. 7

Sampled by:



LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y. 119

Boring Location: N 656000 E 460000

Ground Elevation: 218

Elevation Water Table: _____

Date Drill: Feb 7, 1985

Sampled by: _____

Depth	Strata	Sample Interval	Description/Drilling Notes
		131	131. Organic sandy gravel, gravel mostly fine, 50 to 60%, sand coarse to fine, dense, wet, dk brown - water returning
135		136	132 material gray, silt 10 to 20%, gravel angular to round
			Bit plugged 2' off bottom 129 to 131' deep. - cobbles & boulders.
140			Intervals very silty, gray with wood fragment, dense
			("Till-like - mudflow?)
			136 Bottom hole - 2 hrs spent trying to penetrate
			131' to 136'-

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y 120

Boring Location: N 655000 E 466000

Ground Elevation: 214

Elevation Water Table: 214-16=198 ✓2-20-89
water 12.5' 2-20-89 - Caved in at - 13.5

Date Drill: Feb. 8, 1989

Sampled by:

Depth	Strata	Sample Interval	Description/Drilling Notes
			Location approx 3' below original ground level. Area cut out for [illegible] building/railway N.W. of boring site
5			Sandy gravel, gravel co to fn, slightly silt coated, subrounded round, 65 to 75%; sand mostly fn, slightly silty (±5%), loose, moist, brown - Top 1 slightly organic - Occasional cobble
		8	
10			Below 9' small cobbles 8 to 10%, gravel slightly coarser
15		16	Below 16 slightly heavier silt coating, less oversize, gravel co to fn (finer than above) very moist to wet
20			sand co to fn
25		26	Below 26 few small cobbles
			Below 28 gravel becoming finer.
30		32	Below 32' soupy with silty fn sand common; gravel co to fn, 50 to 60%, sand md to mostly fn 30 to 40%, silt 10 to 20%
35			
40		40	Below 40 gravel co to fn 65 to 75%, sand co to fn, some sticky silt coatings, few oversize, md dense, saturated, brown
45			
		48	
50			Gravel co to fn with some fn gravel intervals. Sand md to fn with few soupy fn sand intervals, few isolated cobbles, md dense, saturated, brown to gray brown.
55			
		58	
60			Below 58 gravel co to fn, clean to silt coated, 65 to 75%; sand co to fn, md dense, saturated, gray brown
65			

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y. 120

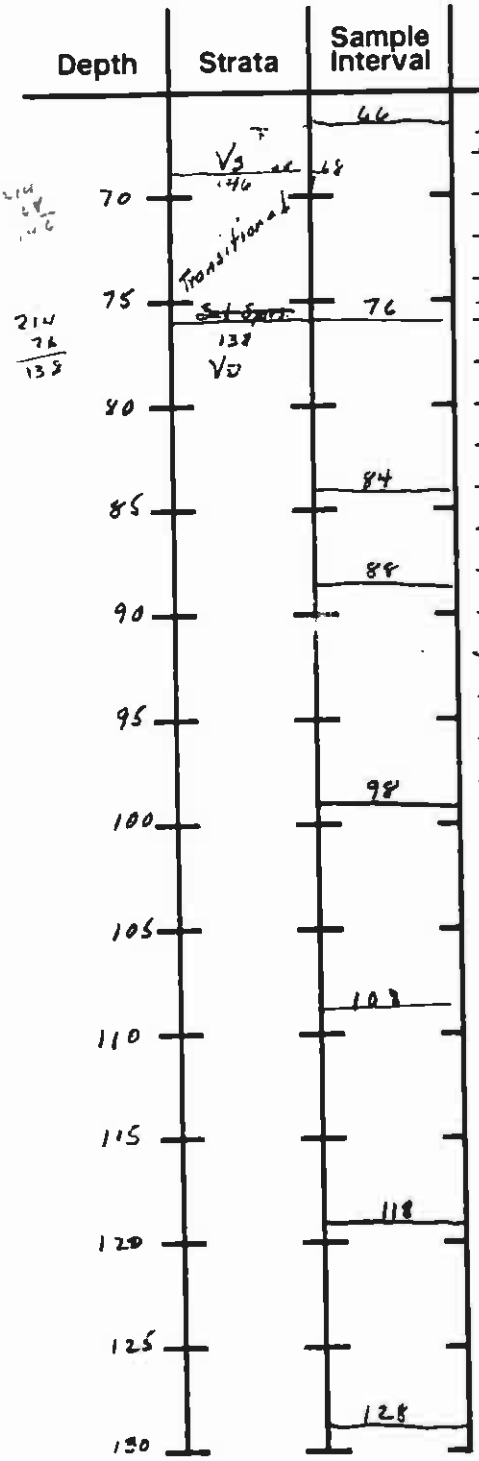
Boring Location: N 655000 E 466000

Ground Elevation: 214

Elevation Water Table: _____

Date Drill: _____

Sampled by: _____



Below 66' silt increasing

Below 68' gravel co to fn, 60 to 70%, sand co to fn, silt heavily coating clasts, 10 to 15%, md dense, saturated, brown

Transitional (Field exam. 3-16-89 - phreatic contact at 76')

76 Sandy gravel, gravel co to mostly fn, most < 2", few + 2", some staining, oxidized, many yellowbrown, 60 to 70%; sand co to fn; md dense, saturated (darker yellow brown effluent), brown with yellowish cast - Few cobbles below 82'

84' Gravelly sand, sand md to fn, 60 to 70%, gravel co to fn, occasional oversize, loose, saturated, brown - materials slightly oxidized

88 Sandy gravel, gravel co to mostly fn, few 2", 60 to 70%; sand mostly md to fn, loose to md dense, saturated, brown

82 to 85 predominantly sand md, 70 to 80%, gravel mostly fn.

Below 85' gravel mostly fn, stained, 50 to 60%, occasional oversize, sand mostly md to fn, yellow to red hue

sand content increasing - grading to

102 gravelly sand, sand md to fn, bids coarser, 60 to 70%; gravel mostly fn, concentrations as interbeds; loose to md dense, saturated, yellowish brown

1

Same as above - sand md to fn, 50 to 60%, gravel mostly fn, with some reddish brown below 112'

Below 114' greyish brown.

Same as above, few fn gravel interbeds

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y. 120

Boring Location: N 655000 E 466000

Ground Elevation: 214

Elevation Water Table:

Date Drill: Feb. 8, 1989

Drilling completed ± 2

Sampled by:

Depth	Strata	Sample Interval	Description/Drilling Notes
			Below 130' becoming gray, silty, losing water return.
135			Some co to fn gravel - grading to
			132 Sand, fn, silty, saturated, gray,
	75	139	139 Silt, brown
214 139 75 140	~~Rubble~~ Kitsap		
			Recovery poor - drilled tight
145		145	
			145' Bottom Hole
150			214 − 139 = 75

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y 122

Boring Location: N 656500 E 466500

Ground Elevation: 212

Elevation Water Table: 212 - 18 = 194'
Caved in at 18.1' 2-23-89

Date Drill: Feb 9
Drilling began 11:30 AM

Sampled by: _____

Depth	Strata	Sample Interval	Description/Drilling Notes
			Top Soil 1'-2'
			2' Sandy gravel, gravel co to mostly fn, slight silt coating, subround to round, 60 to 70%; sand md to fn, few oversize; loose, moist, brown
5		8	Below 8 gravel coarser
10			
15			16 to 18 coarse gravel common.
		18	
20			Below 18 wet, gravel finer, few broken cobbles, sand coarser. 18' water return - gravel co to mostly fn 60 to 70%, sand md, few sandy intervals, material clean loose, saturated, gray brown
25			
		28	
30			Below 28 clasts coated in silt, gravel co to fn, 65 to 75%, sand co to fn, oversize 5 to 10%; loose, sticky, gray brown
35			Below 35 material finer
		38	
40			Below 38 gravel finer, gravel co to fn, 60 to 70%, sand mostly md, (co to fn), 5 to 8% oversize, generally clean, gray brown
45			
		48	
50			Same as above
			Below 52 less oversize
55			
		58	
60			Gravel co to fn, 55 to 65%, sand mostly md to fn; clean
65			

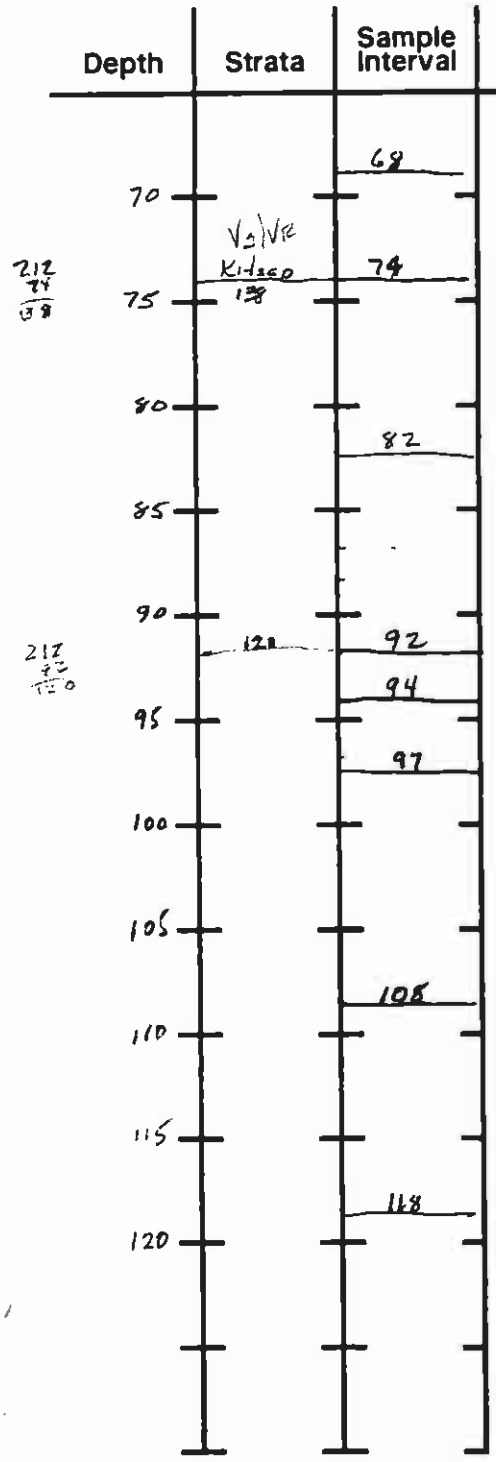
LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y 122 — Boring Location: N 656500 E 466500

Ground Elevation: 212 — Elevation Water Table: _____

Date Drill: Feb. 9, 1989 — Sampled by: _____

Drilling completed 1:40



212 74 138

217 92 TD

Below 65 few oversize. -

Gravel content increase, more volcanic materials, some stained oxidized

74 Effluent slightly darker brown - changing to olive below 76'

74' Sandy gravel, gravel co to fn, subround to round, few oxidized, 60 to 70%, sand co to fn, moist, clasts volcanic origin, md dense saturated bluish green

Below 78 bluish green with purple hue, gravel co to mostly fn 55 to 65%; sand co to fn, sharp to round, oversize 5 to 10%; md dense, saturated. -

82' Sand, md to fn, few gravel, cobbles (10 - 20% total) md dense, saturated greenish-blue white speckled (quartz)

Few gravel interbeds, wood 88 to 90'

92' (915) Peat. - Lost return at 92'

94' Silt, gray, organic; moist to damp - recovery poor

97' Sand, fn, few silt balls (<1"), purple; damp

Below 100' interval coarser, contains occasional fn pebble (hard) or silt ball (soft), becoming more bluish

Water return (chocolate brown when began at 105

113 Silt layers and interspersed with fine sand, saturated, brown

Below 116 sand coarsing

118' Bottom Hole.

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y. 124

Boring Location: N 658250 E 463250

Ground Elevation: 207

Elevation Water Table: Wet zone 124' to 127' depth
Cored in at 40' 2-22-89

Date Drill: Feb. 10
Drilling began ± 10:45

Sampled by:

Located between two kettles

Depth	Strata	Sample Interval	Description/Drilling Notes
5		6	Sandy gravel, gravel co to tn, 60 to 70%, sand md, loose, moist, yellowish brown - sand content increasing with depth
			6' Gravelly sand, sand md to mostly fn, 85 to 95%, gravel fn, loose, damp, brown
10		10	10' Sandy gravel, gravel co to fn, slightly silt coated, subrounded to rounded, 65 to 75%; sand mostly fn, loose, damp, brown
15			Below 15 some oversize
		18	
20			Below 22' occasional cobbles, damp.
25			
		28	28' Gravelly sand; sand md to fn, 50 to 60%, gravel co to fn, occasional cobble, clean, loose, moist, brown
30			
35			Few very gravelly interbeds
		38	38' Sandy gravel, gravel co to mostly fn, slightly silt coated, 50 to 60%; sand mostly fn, loose, damp, brown
40			
45			Below 45' gravel fn, 60 to 70%
		48	Below 48' gravel co to fn, 60 to 70%, occasional oversize or small cobble - becoming grayish brown
50			
55			
		58	58' to 60' co gravel, small cobbles
60			Below 60' gravel co to fn, relatively clean, 65 to 75%, sand md to fn, sharp, loose, dry, light brown; occasional oversize
65			

LONE STAR NORTHWEST
DUPONT PROJECT

Boring: L.S.W.Y 124

Boring Location: N 658250 E 463250

Ground Elevation: 207

Elevation Water Table: _____

Date Drill: Feb. 10, 1989
Finished drilling 12:40

Sampled by: _____

207 - 118 / 89

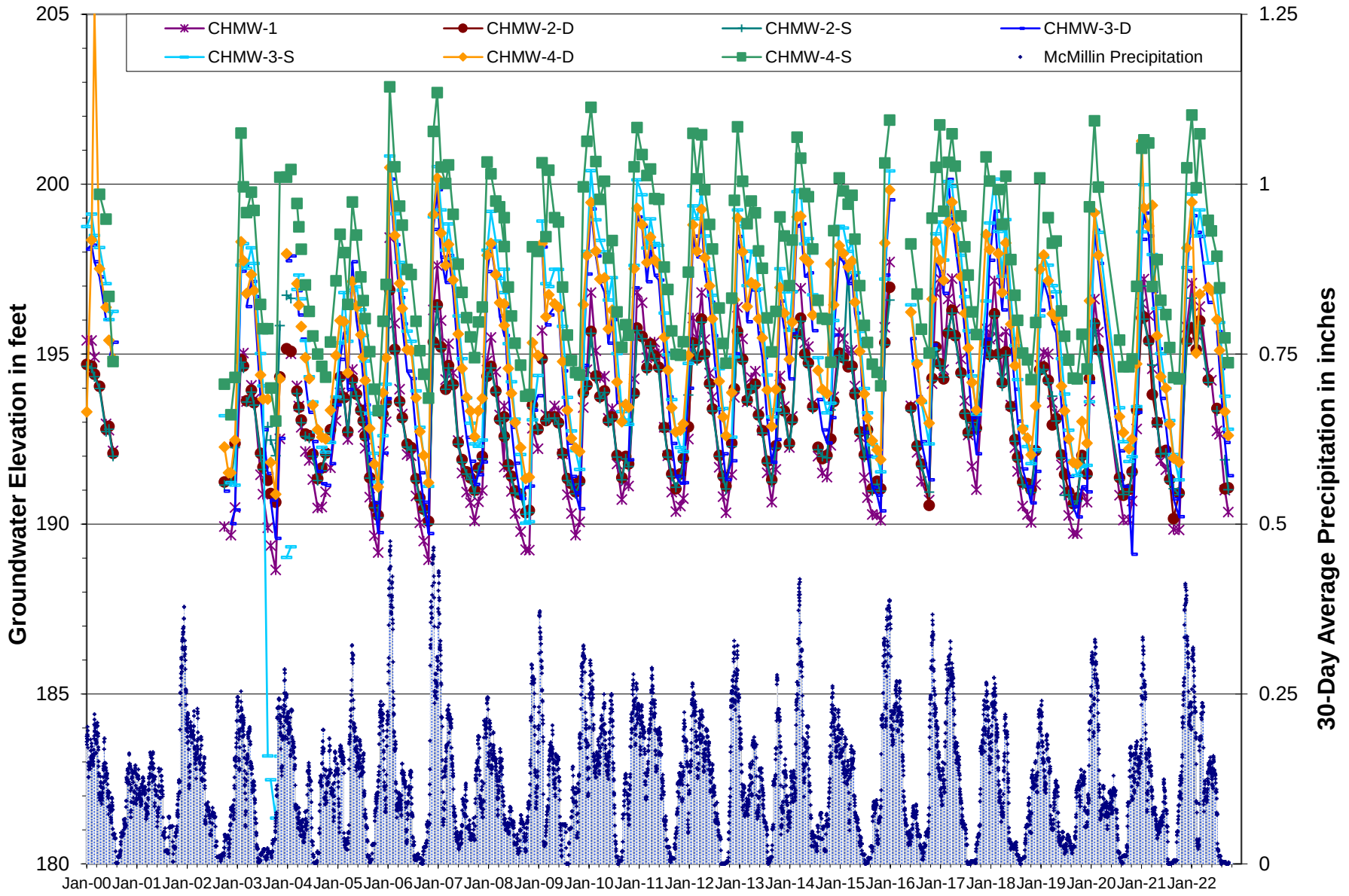
Depth	Strata	Sample Interval	Description/Drilling Notes
70		68	Below 70 gravel mostly fn, 60 to 65%, sand fn, occasional oversize damp, grey brown
75			
80		78	Below 78 gravel covering with more oversize
85			
90		88	88 Gravelly sand, sand mostly fn, 85 to 95%, gravel co to fn, mostly isolated; loose, damp brown
95			
100		97	97 Sandy gravel, gravel mostly fn, silt coated, 55 to 65%, sand fn becoming med to fn, loose, dry to damp, brown
105		104	104 Sand same as 88 to 97, slightly more moist slightly silty with few small silt balls
110		110	Below 110 gravel co to fn 30 to 40%, silty (10 to 20%)
115			
120	Kitsap 89	118	118 Sand, md to fn, occasional small gravel or wood fragment loose, moist, purple with red specks - Kitsap.
125	88 / 31		124 Water return 126 ~~Silt~~ Peat mixed with sand wet
130		127	127 Silt gray, very moist to wet becoming moist to damp below 132
		138	138' Bottom Hole

207 / 118 / 89

207 / 124 / 89

APPENDIX B

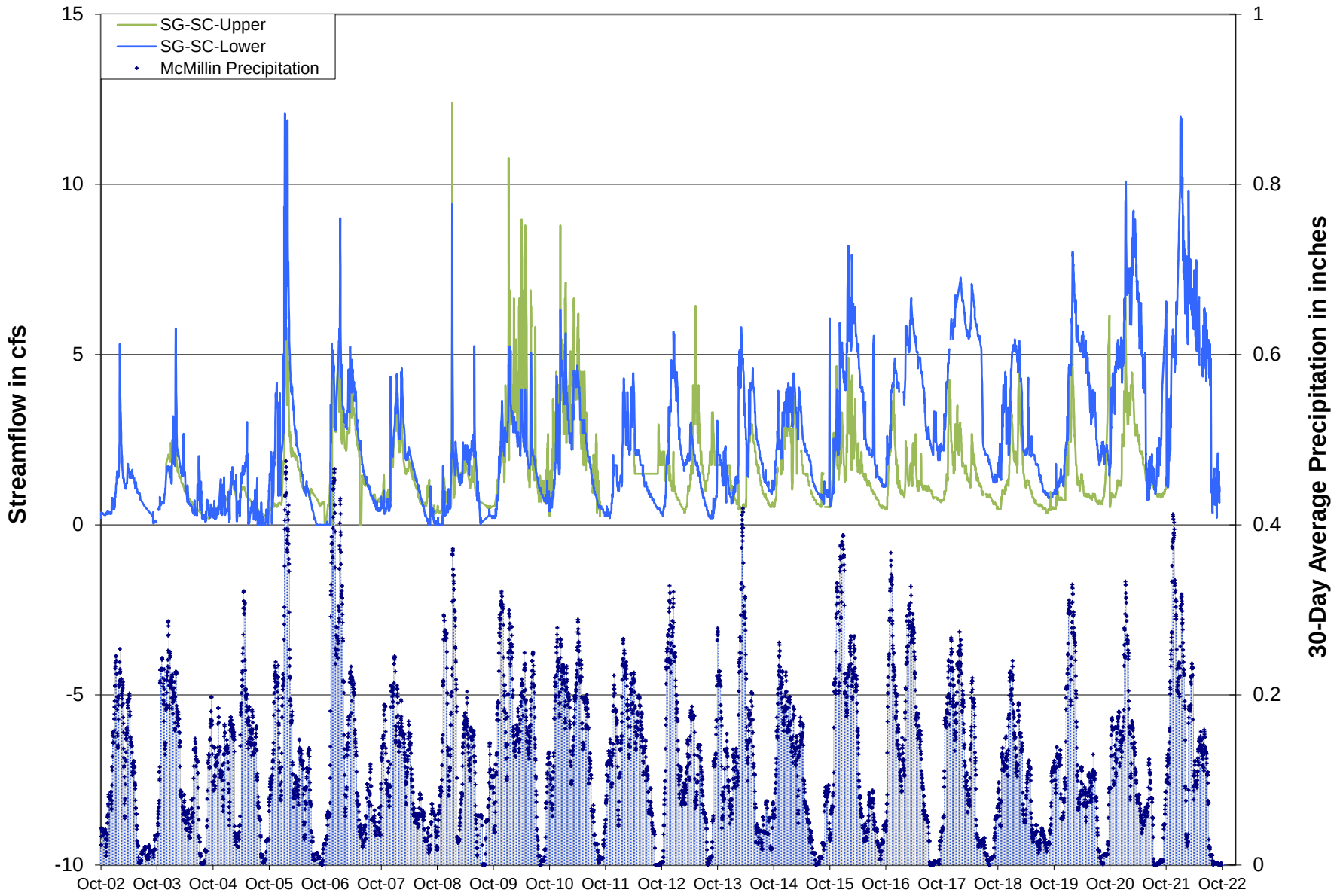
Hydrographs of Groundwater and Surface Water Monitoring Data



Aspect Consulting, LLC
10/28/2022
S:\CalPortland\DuPont\South Parcel\Data\Database\Water Level Elevation Graphs and Tables-Trends_v10_2022.xlsx

C-1 Vashon Aquifer Water Levels

Pioneer Aggregates South Parcel Project
DuPont, WA



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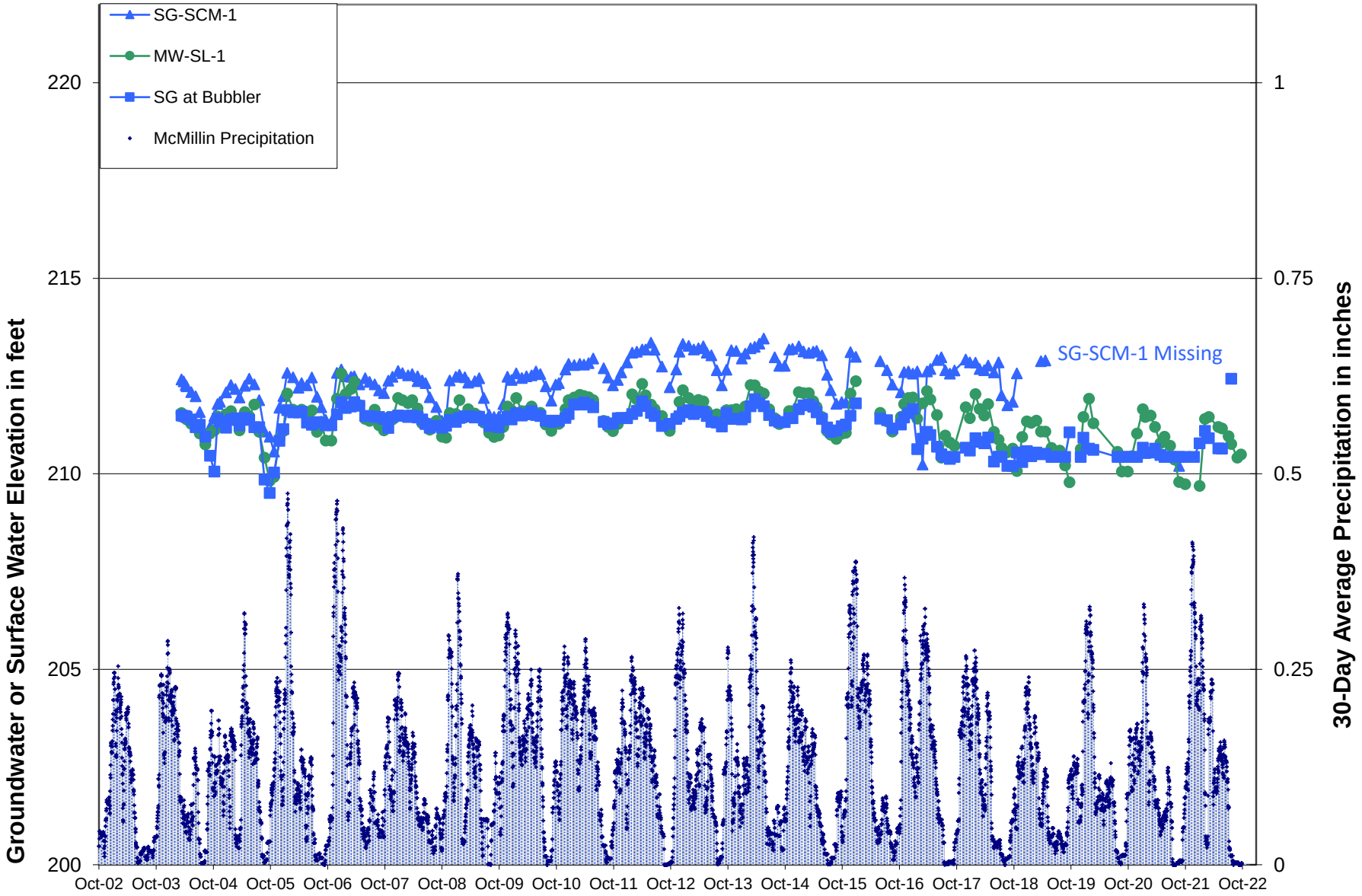
B-2 Sequalitchew Creek Hydrographs

Pioneer Aggregates South Parcel Project
DuPont, WA



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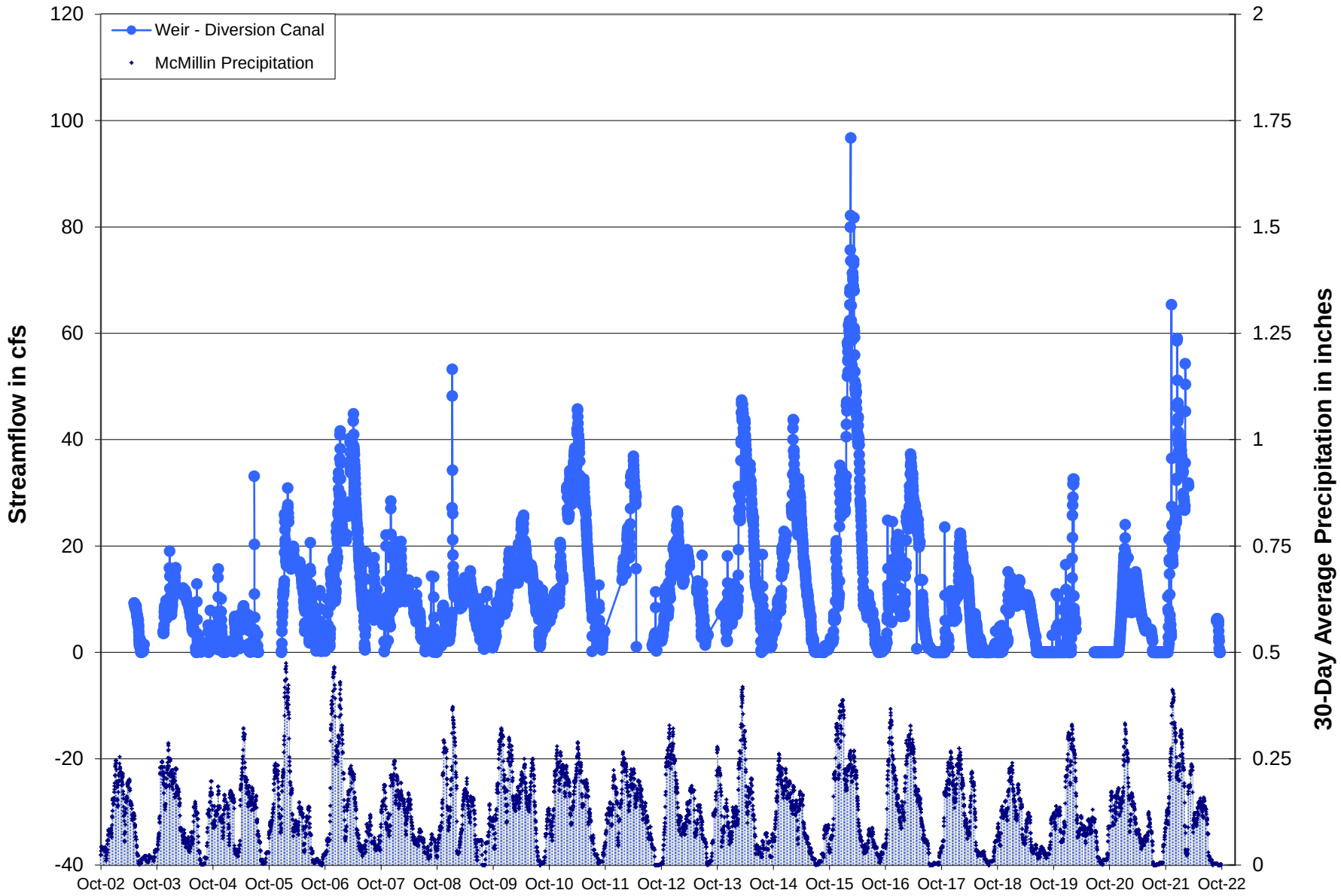
B-3 Sequalitchew Lake Area Water Levels

Pioneer Aggregates South Parcel Project
DuPont, WA



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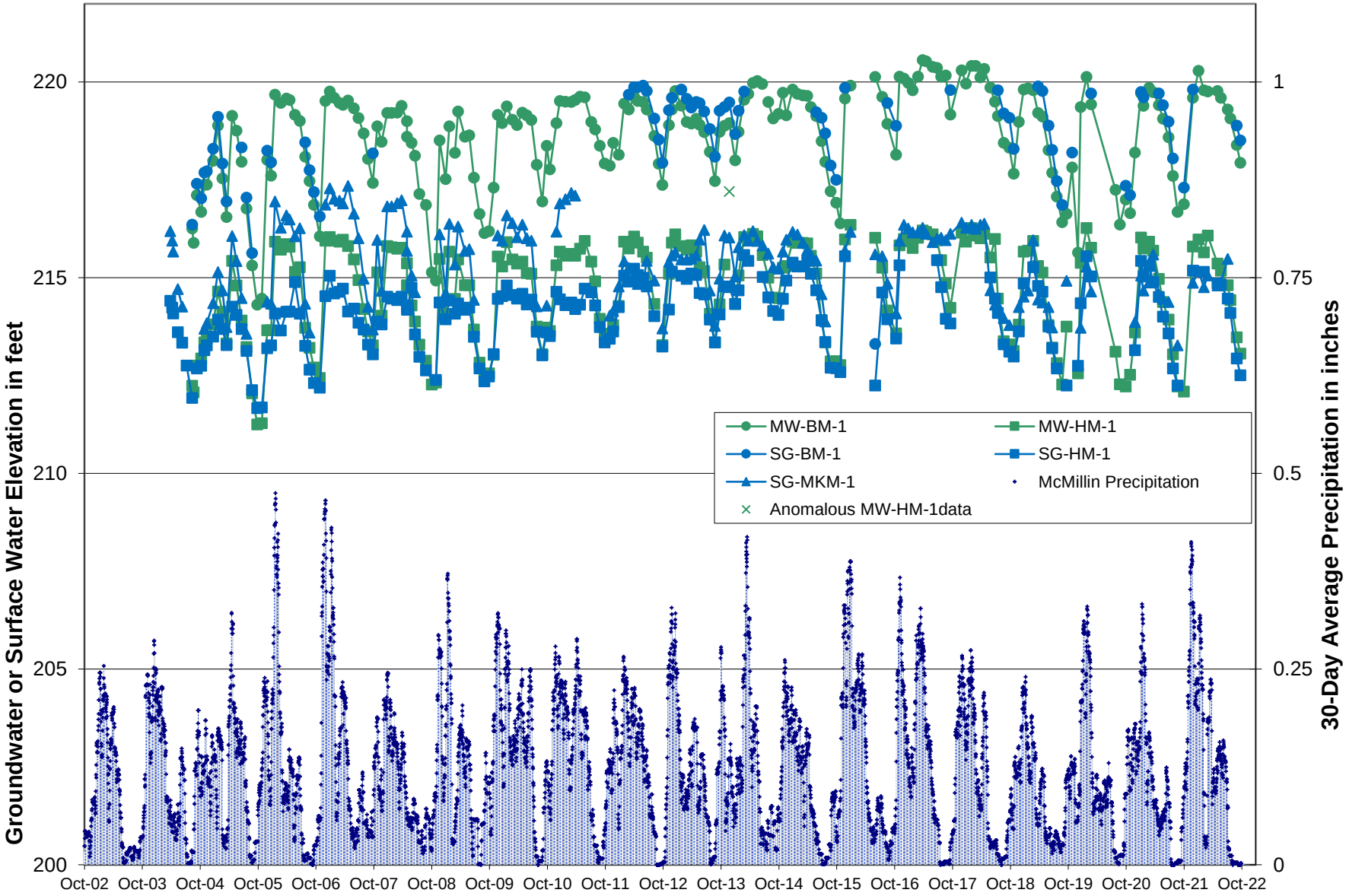
B-4 Diversion Weir Hydrograph

Pioneer Aggregates South Parcel Project
DuPont, WA



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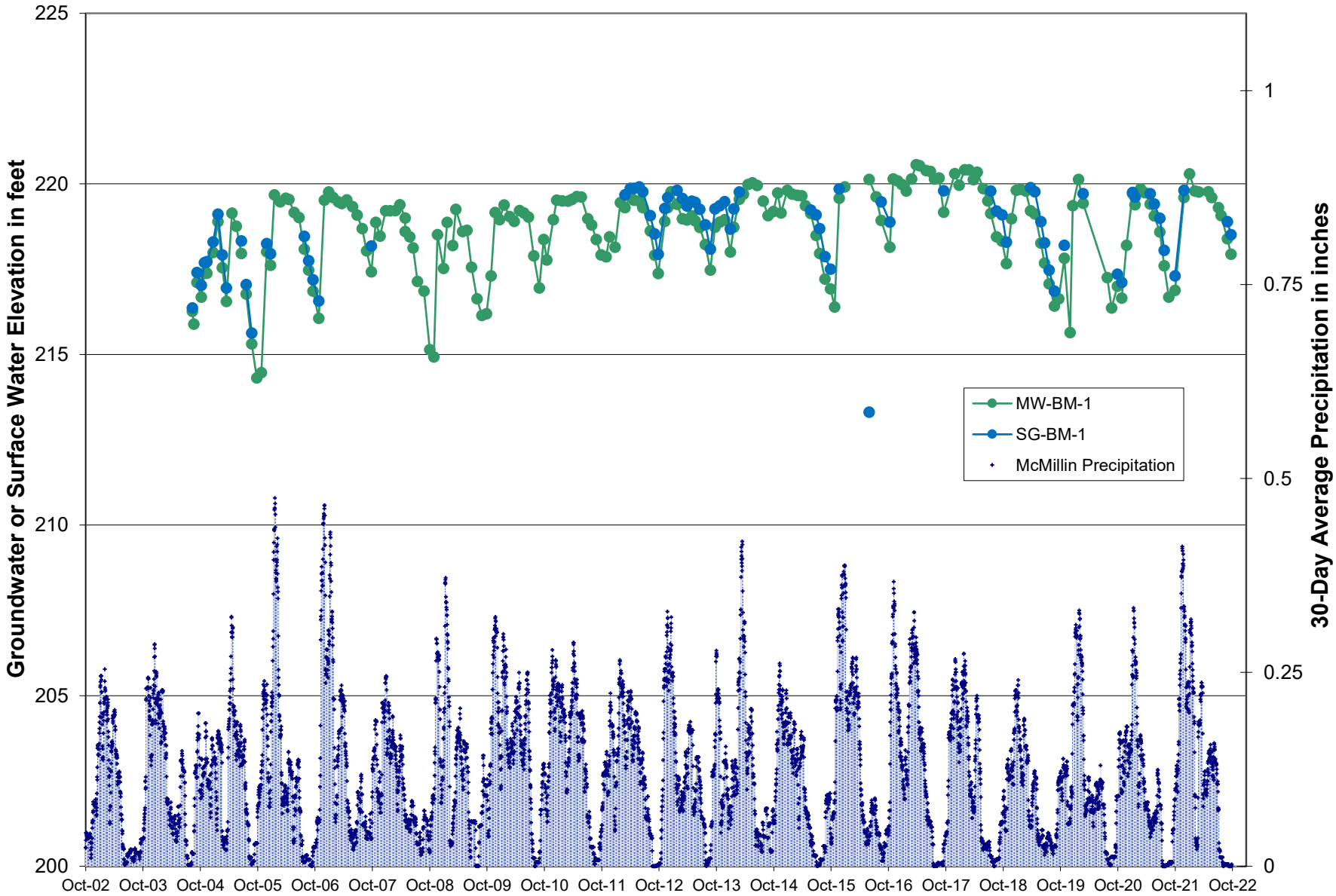
B-5 Bell, McKay, and Hamer Marsh Water Levels

Pioneer Aggregates South Parcel Project
DuPont, WA



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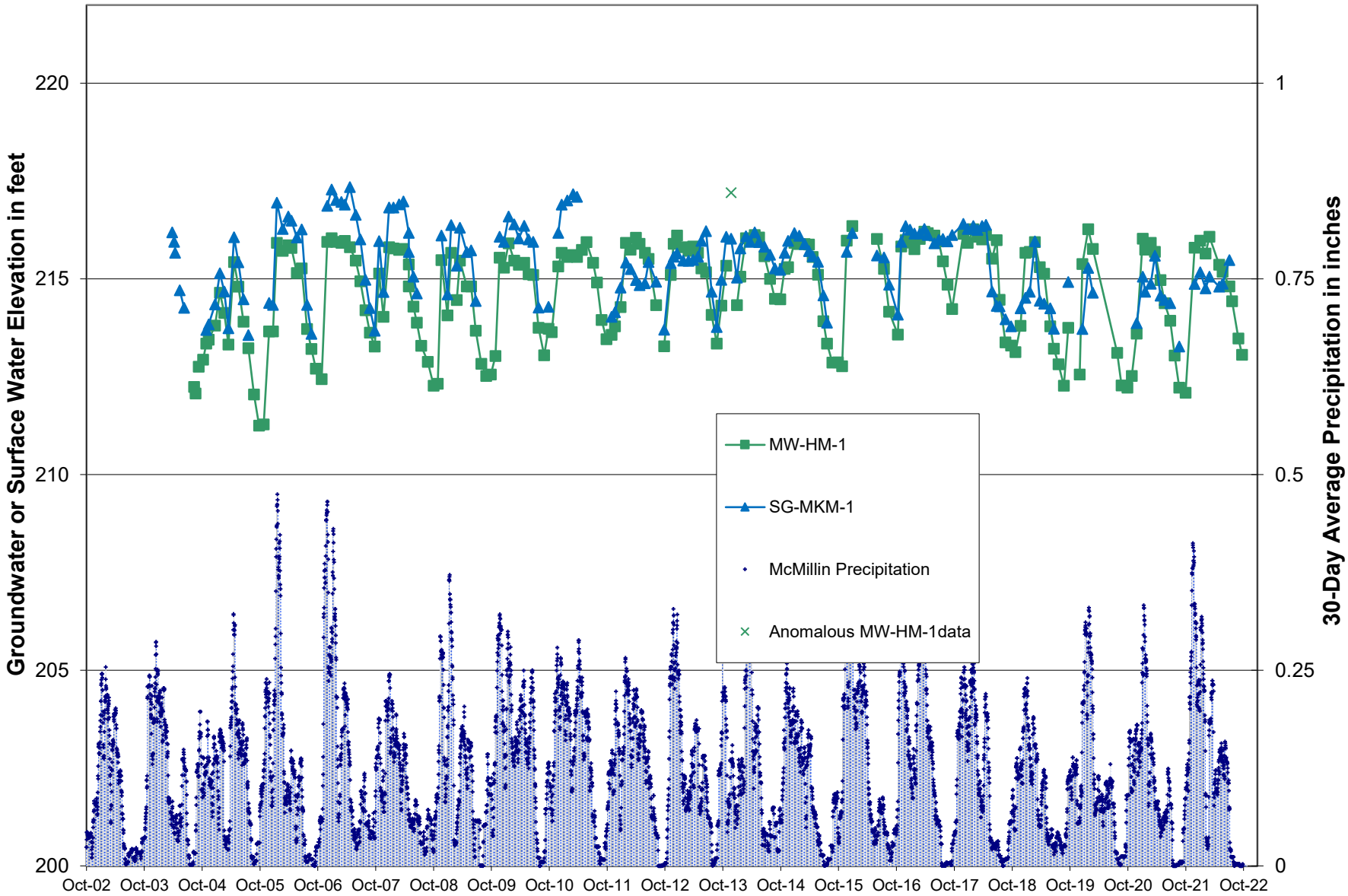
B-5a Bell Marsh Water Levels

Pioneer Aggregates South Parcel Project
DuPont, WA



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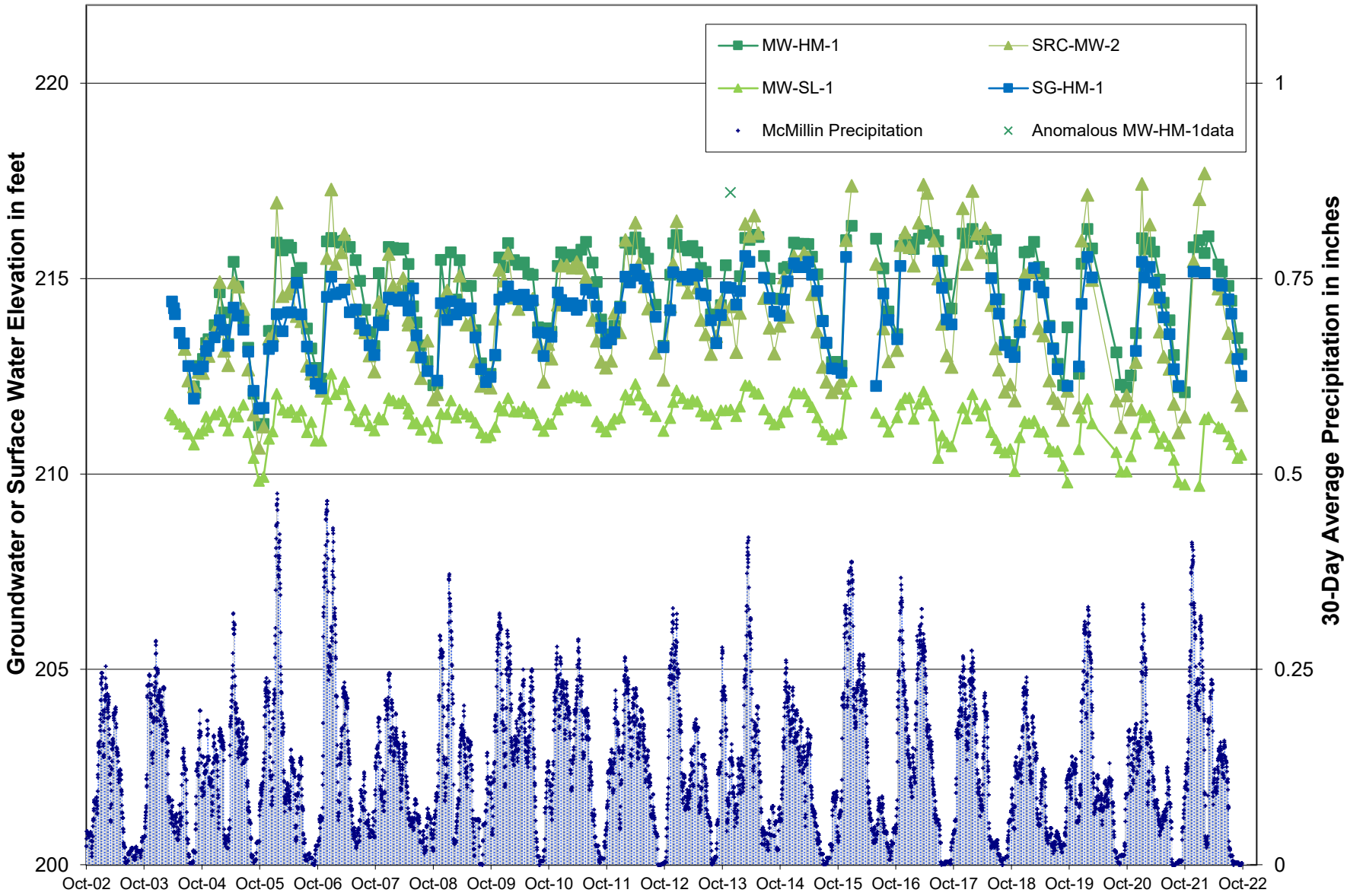
B-5b McKay Marsh Water Levels

Pioneer Aggregates South Parcel Project
DuPont, WA



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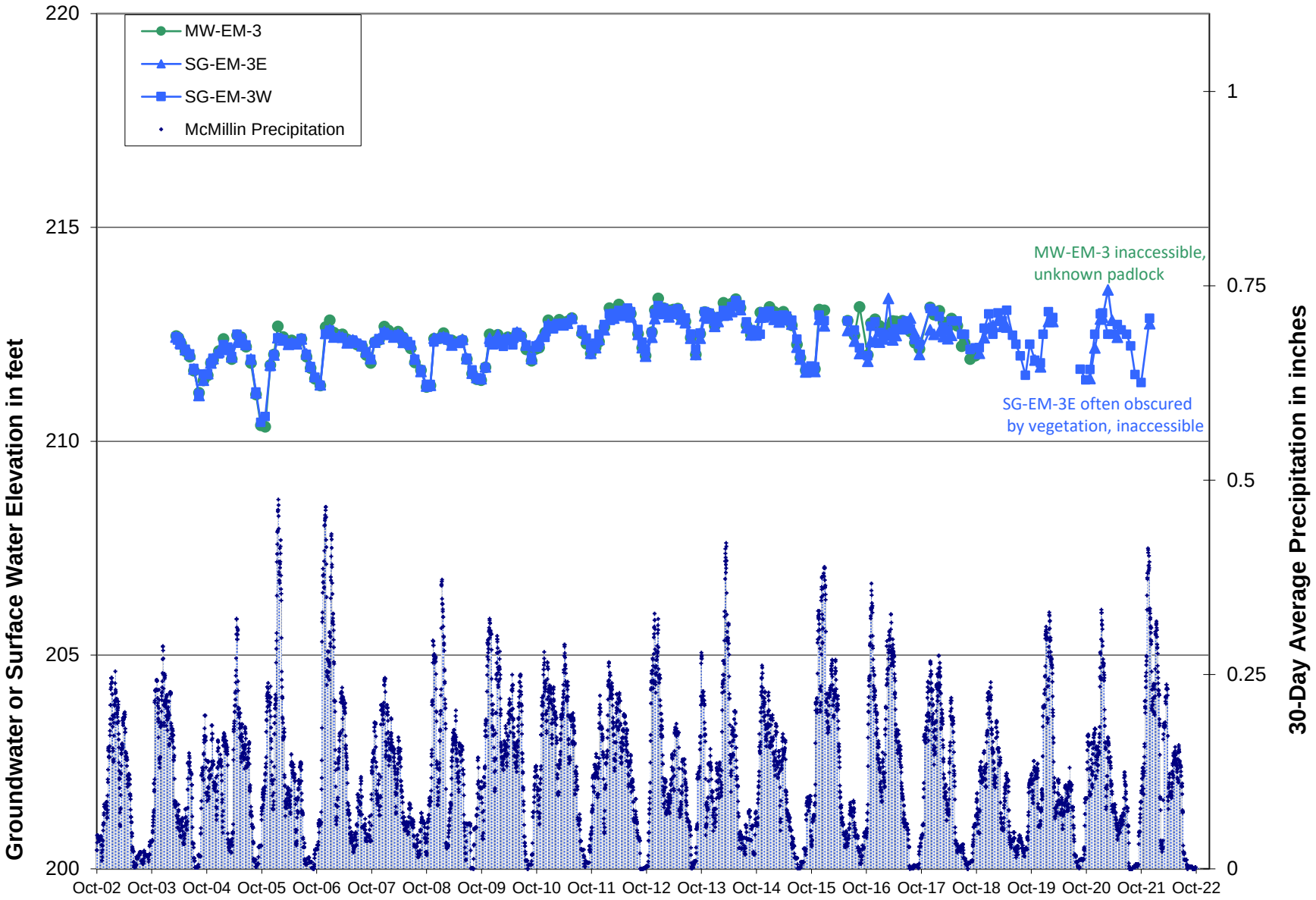
B-5c Hamer Marsh Water Levels

Pioneer Aggregates South Parcel Project
DuPont, WA



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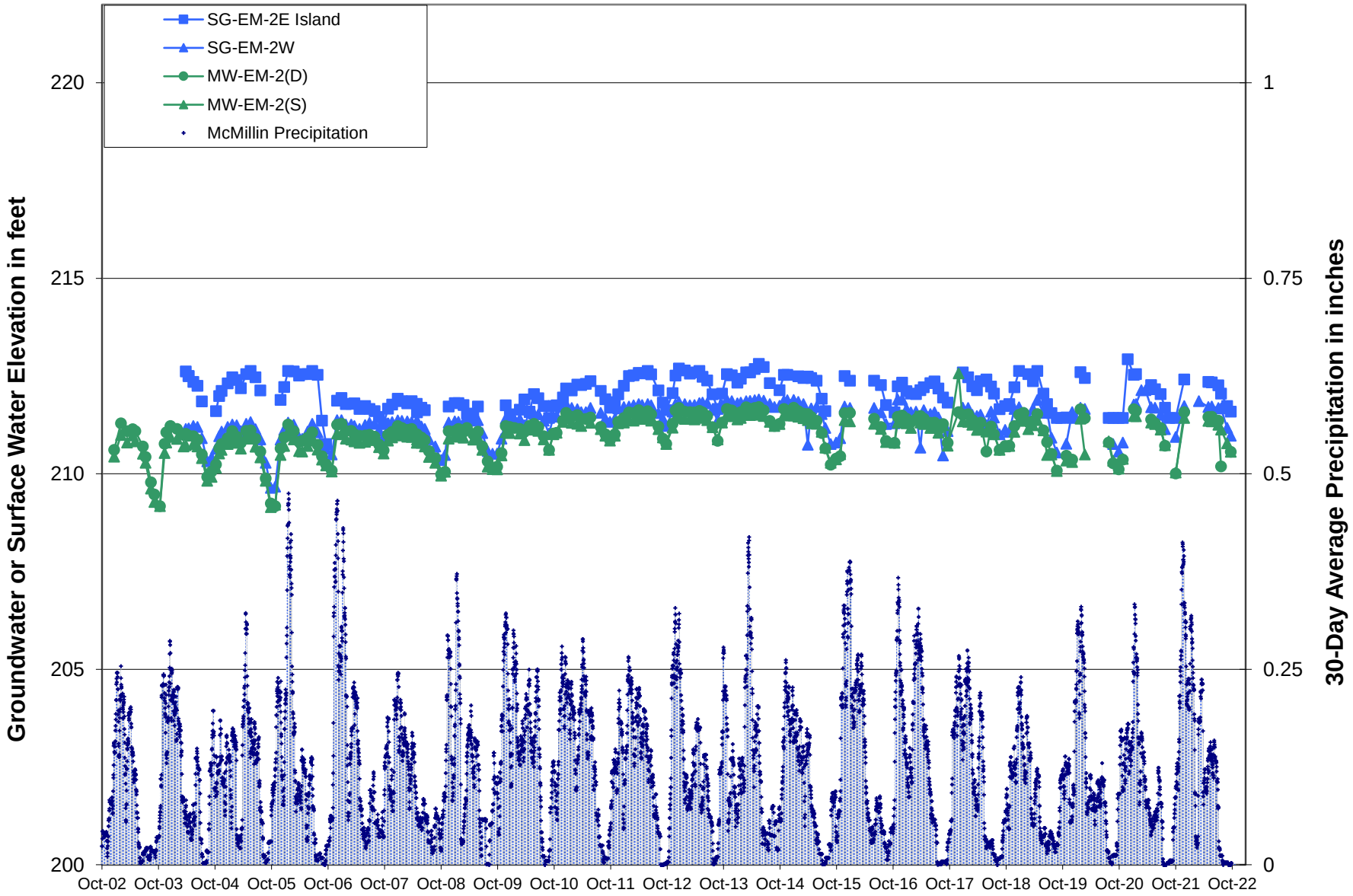
B-6 East Edmond Marsh Water Levels

Pioneer Aggregates South Parcel Project
DuPont, WA



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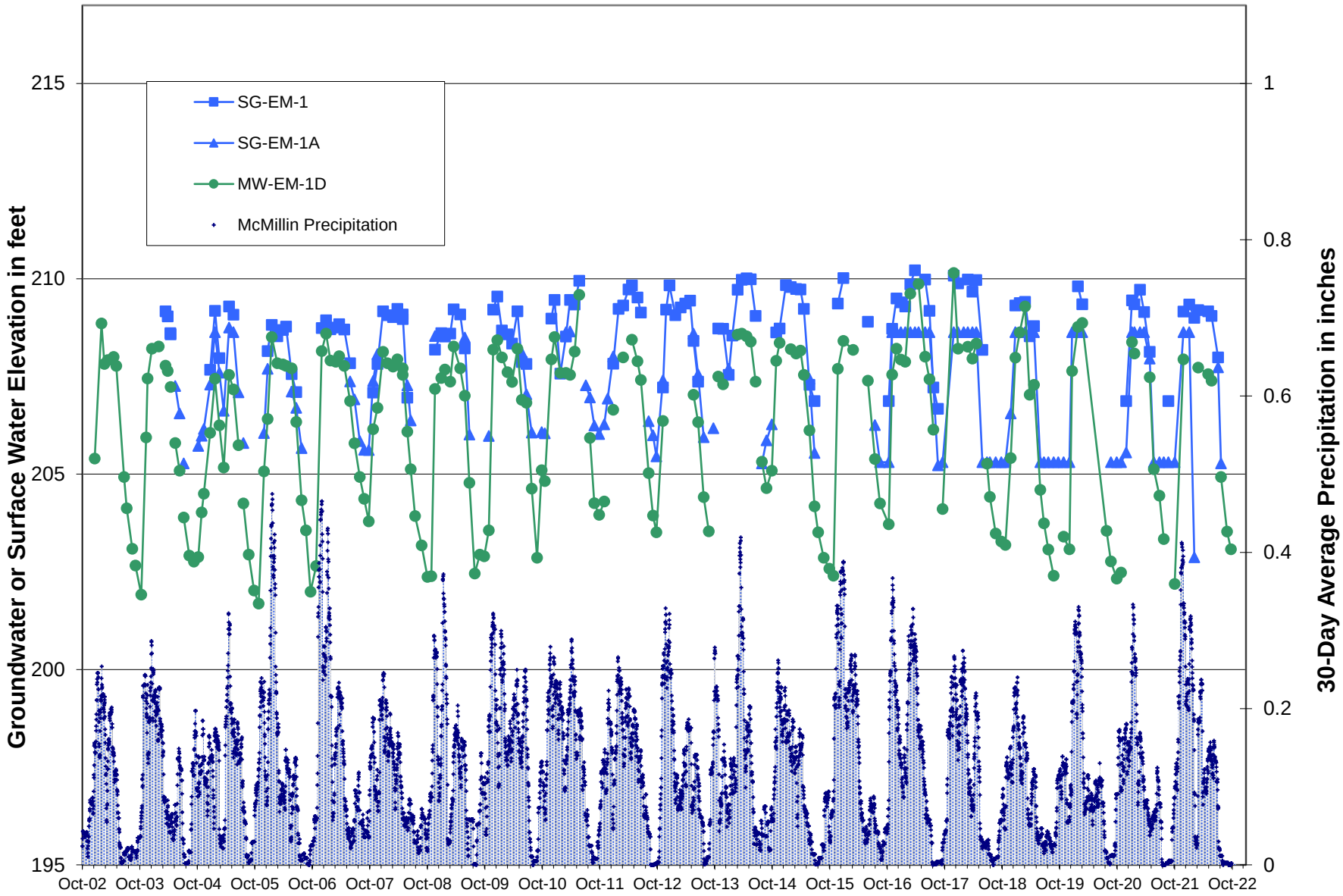
B-7 East Edmond Marsh Water Levels

Pioneer Aggregates South Parcel Project
DuPont, WA



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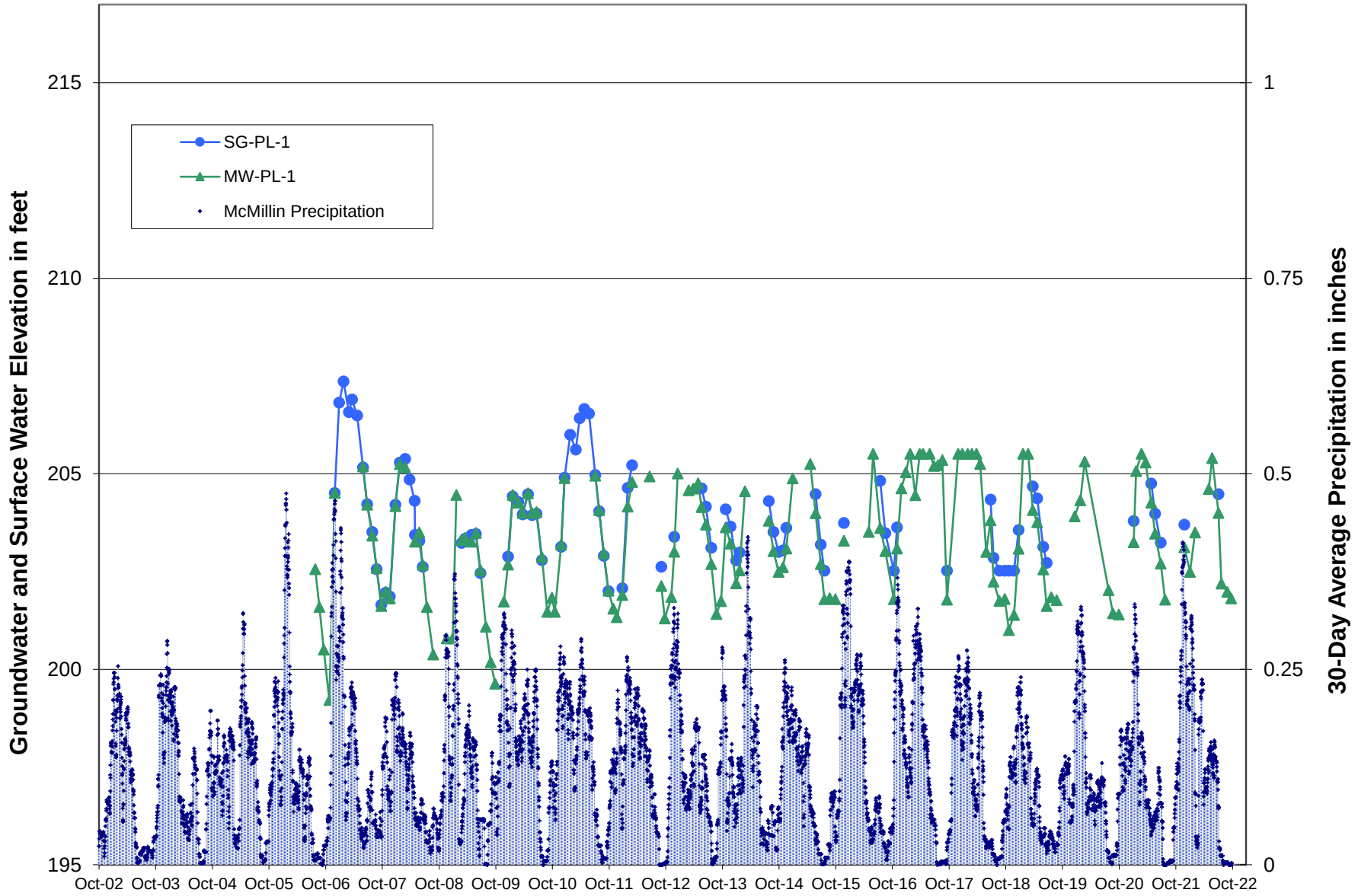
B-8 West Edmond Marsh Water Levels

Pioneer Aggregates South Parcel Project
DuPont, WA



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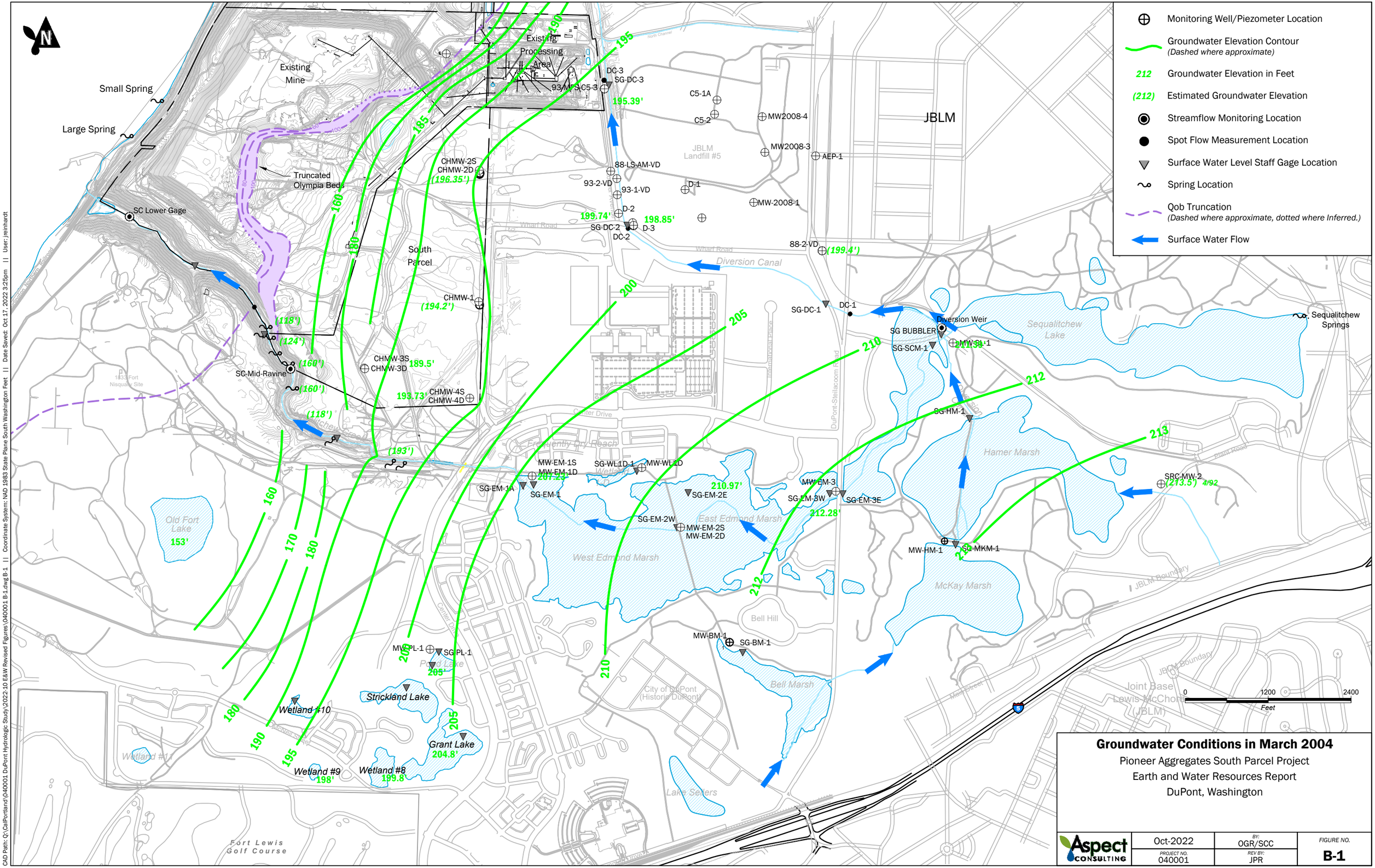
B-9 Pond Lake Water Levels

Pioneer Aggregates South Parcel Project
DuPont, WA

APPENDIX C

Groundwater Elevation Contour Maps



Groundwater Conditions in March 2004

Pioneer Aggregates South Parcel Project
Earth and Water Resources Report
DuPont, Washington

Aspect Consulting	Oct-2022	BY: OGR/SCC	FIGURE NO. B-1
	PROJECT NO. 040001	REV BY: JPR	

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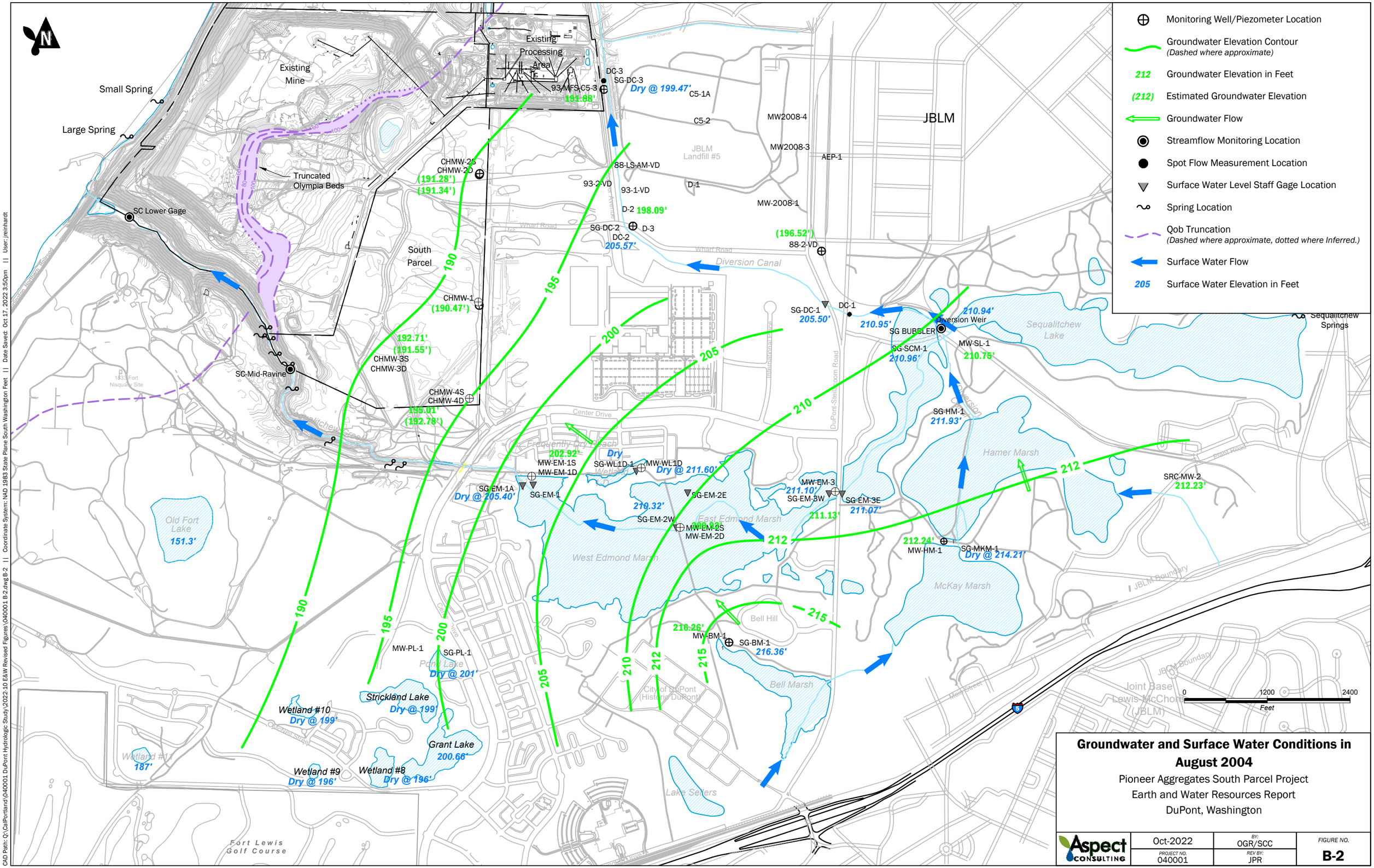

Groundwater and Surface Water Conditions in August 2004

Pioneer Aggregates South Parcel Project
Earth and Water Resources Report
DuPont, Washington

Aspect Consulting	Oct-2022	BY: OGR/SCC	FIGURE NO. B-2
	PROJECT NO. 040001	REV BY: JPR	

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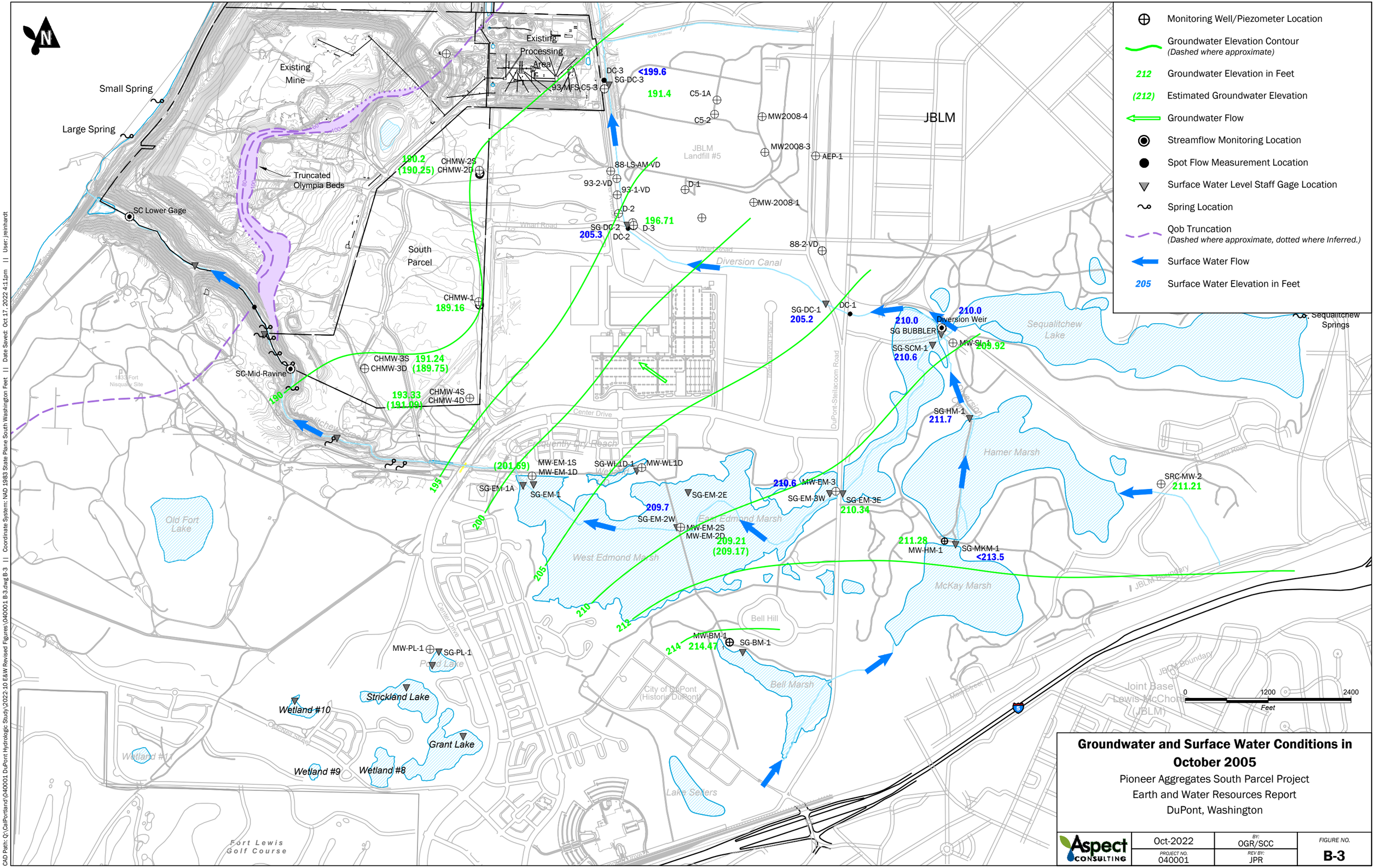

Groundwater and Surface Water Conditions in October 2005

Pioneer Aggregates South Parcel Project
Earth and Water Resources Report
DuPont, Washington

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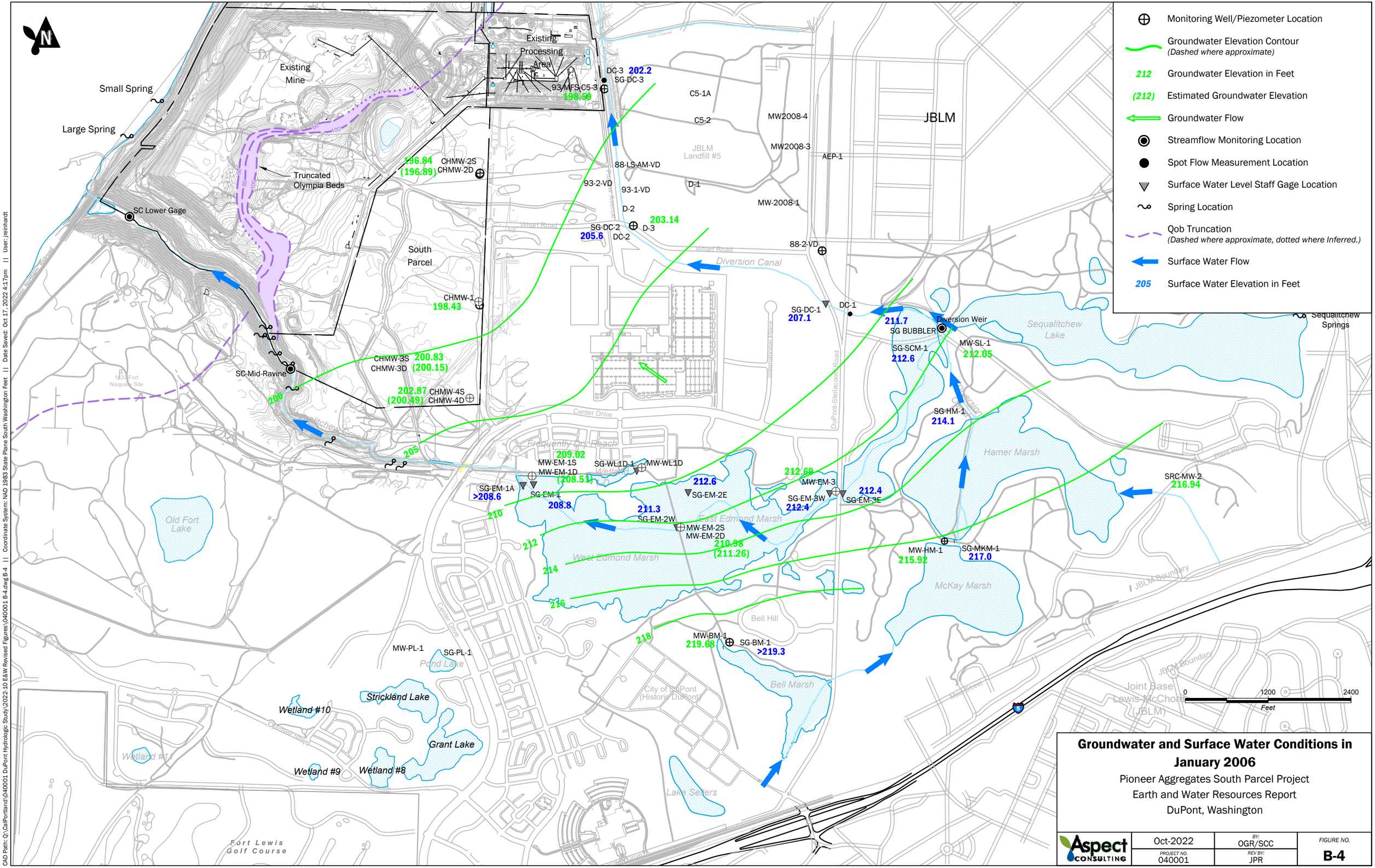

Groundwater and Surface Water Conditions in January 2006

Pioneer Aggregates South Parcel Project
Earth and Water Resources Report
DuPont, Washington

Aspect Consulting	Oct-2022	BY: OGR/SCC	FIGURE NO. B-4
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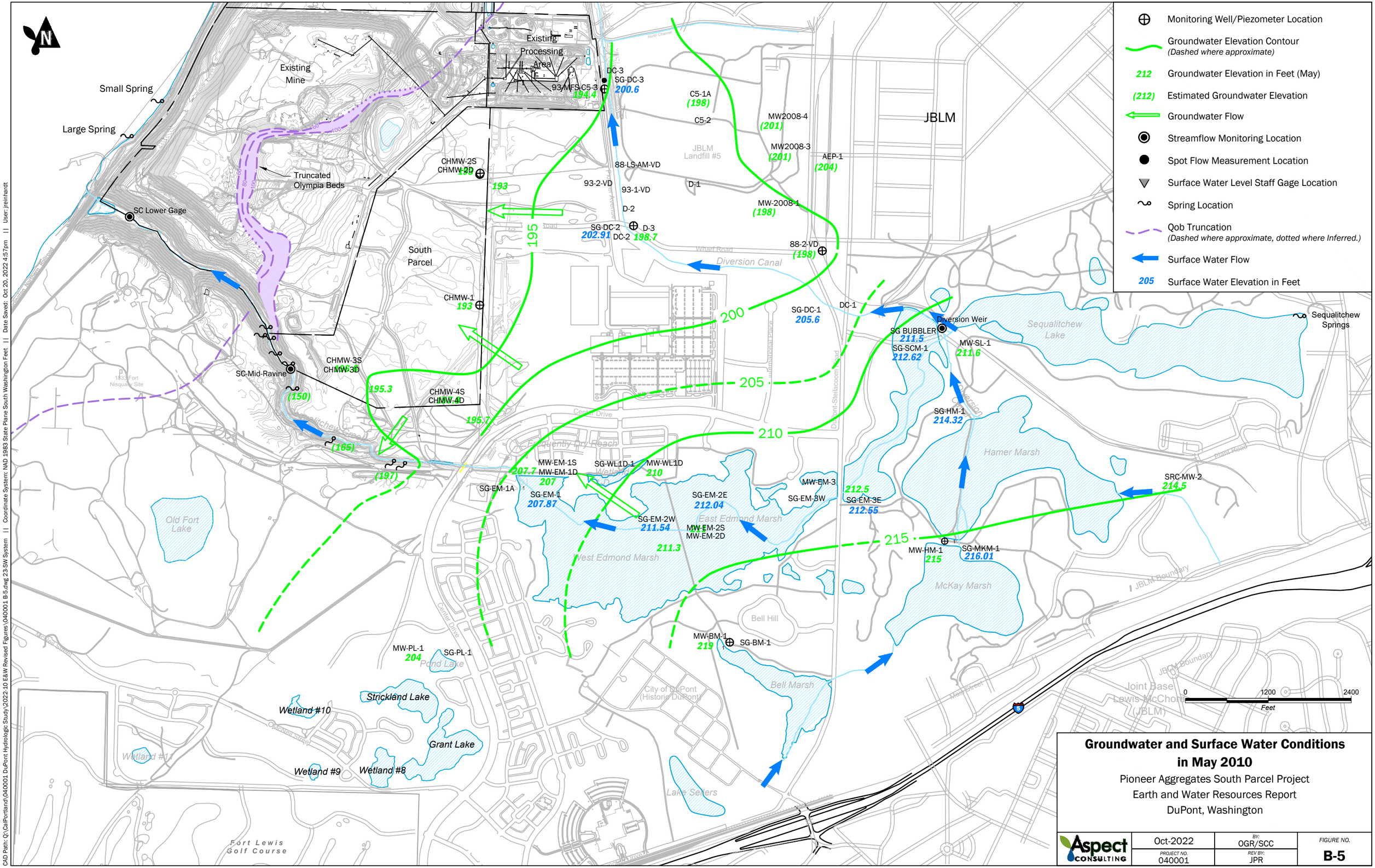

Groundwater and Surface Water Conditions in May 2010

Pioneer Aggregates South Parcel Project
Earth and Water Resources Report
DuPont, Washington

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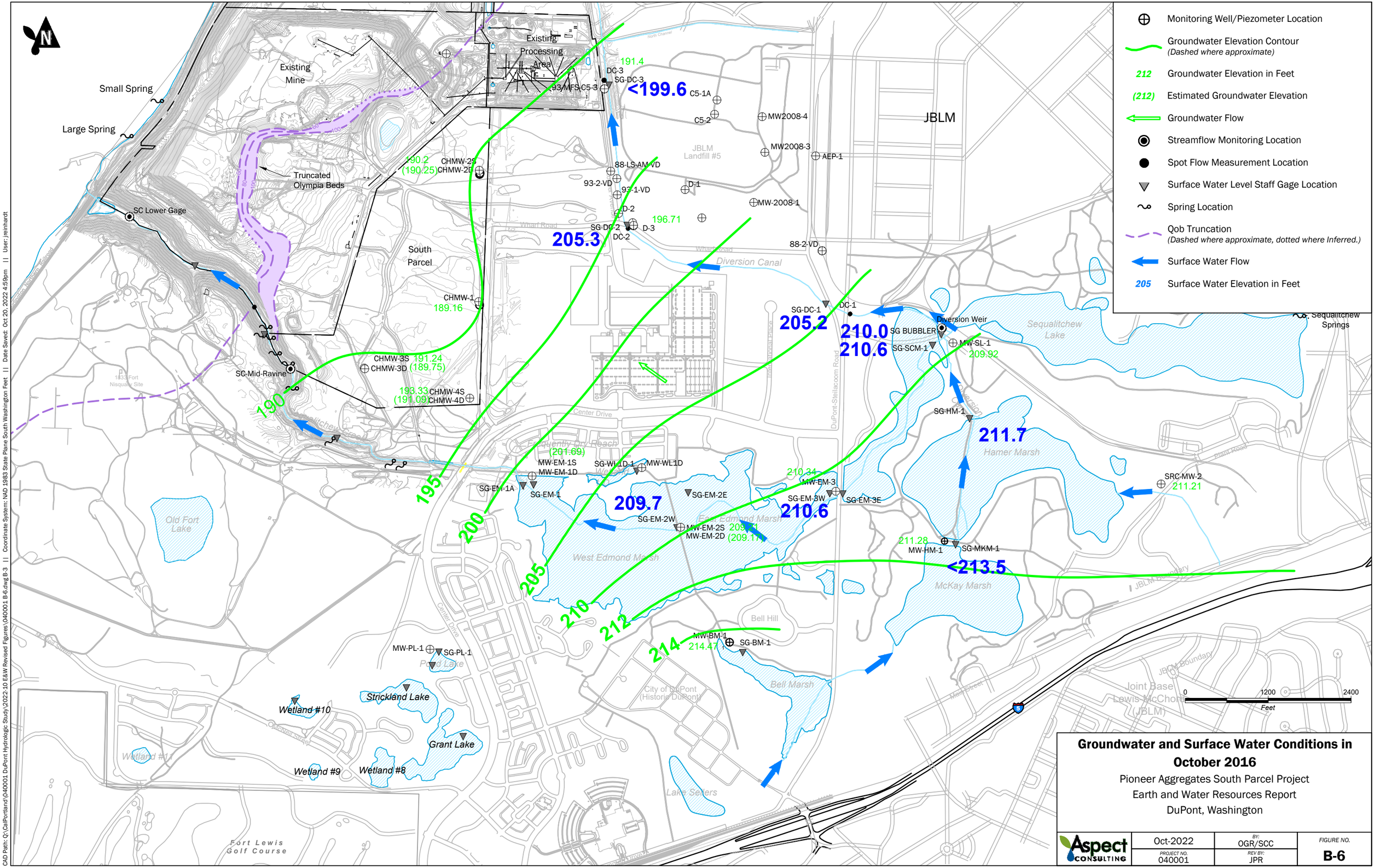

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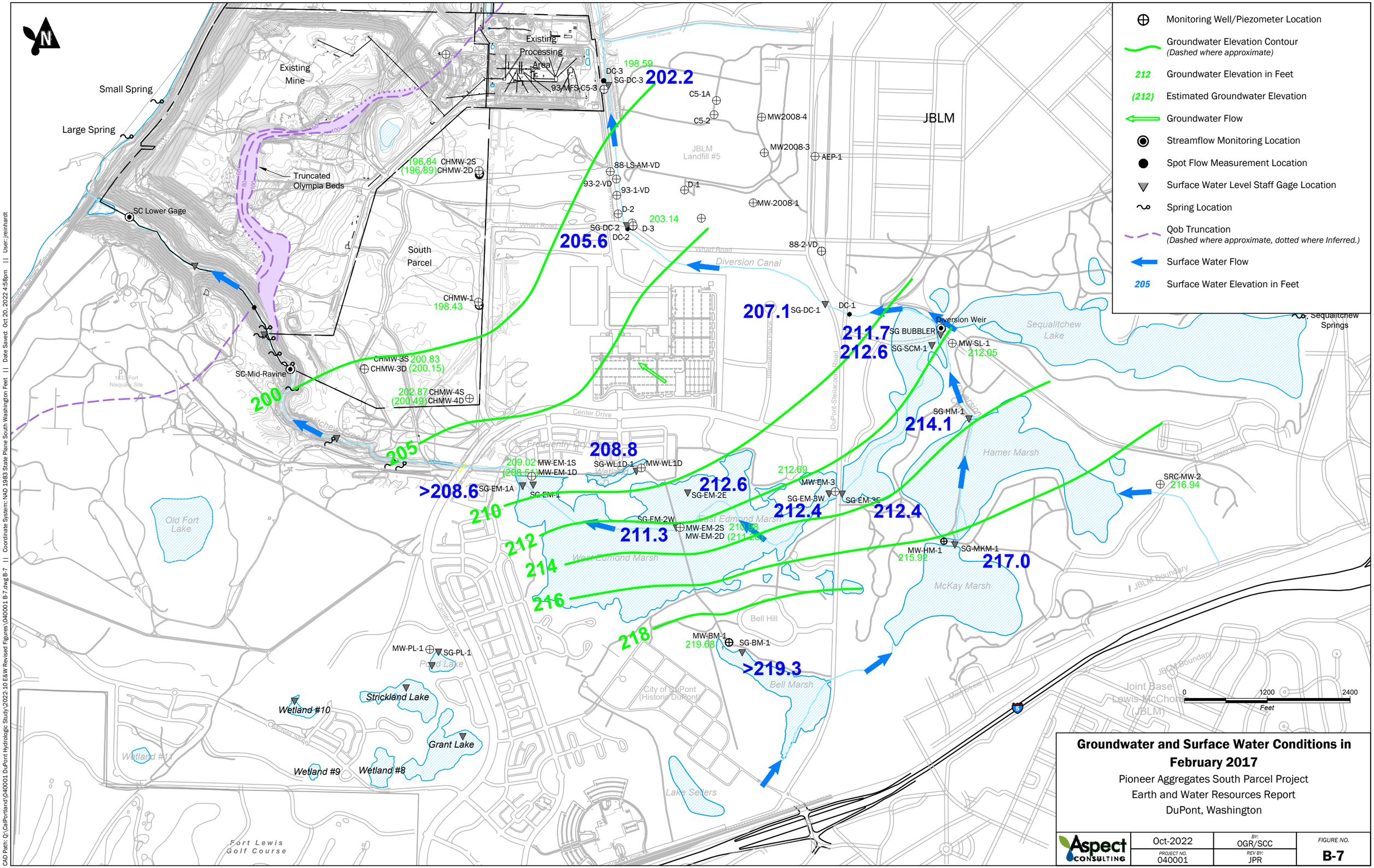

Groundwater and Surface Water Conditions in February 2017

Pioneer Aggregates South Parcel Project
Earth and Water Resources Report
DuPont, Washington

Aspect Consulting	Oct-2022	BY: OGR/SCC	FIGURE NO. B-7
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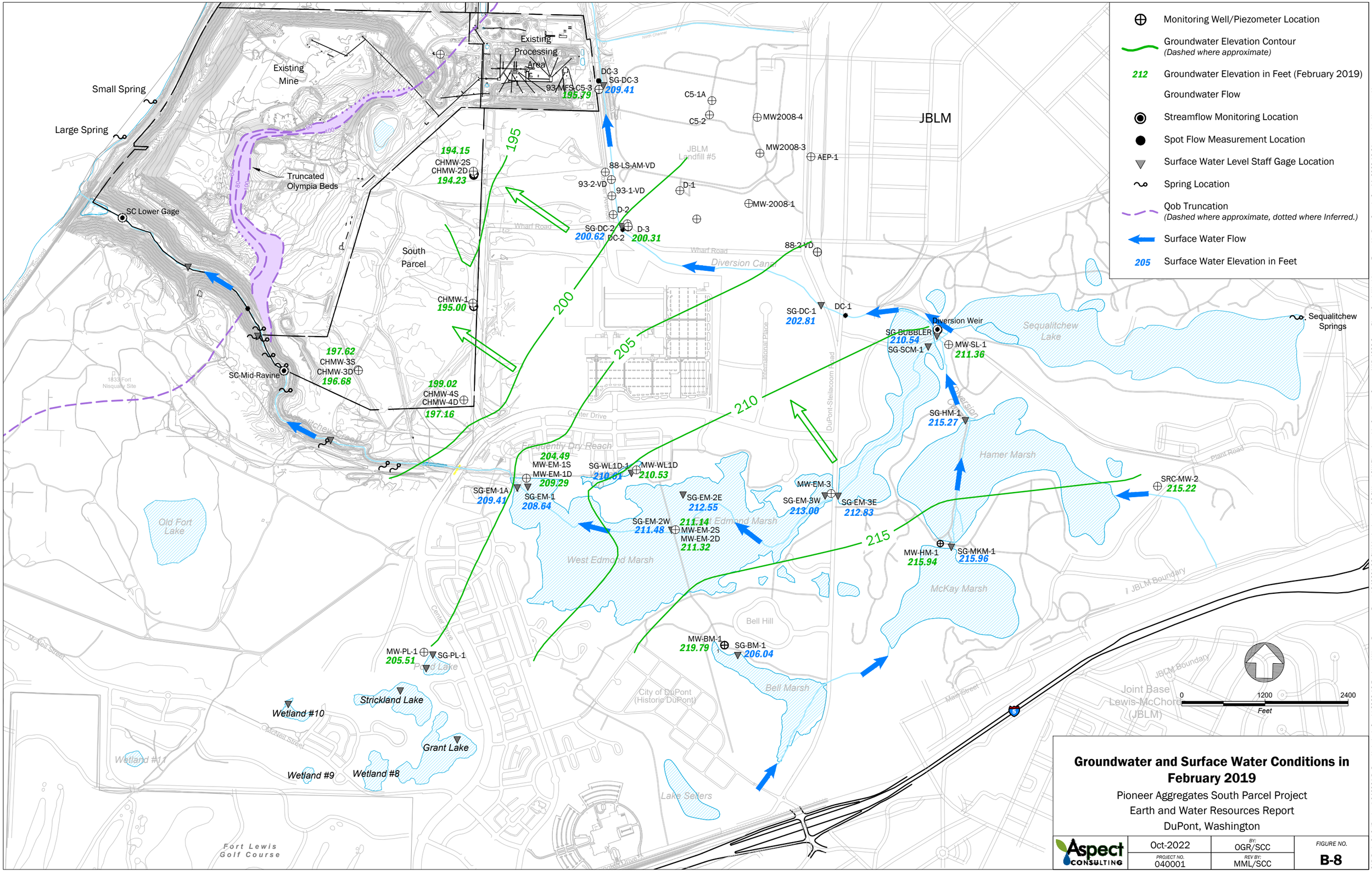

Groundwater and Surface Water Conditions in February 2019

Pioneer Aggregates South Parcel Project
Earth and Water Resources Report
DuPont, Washington

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APPENDIX D

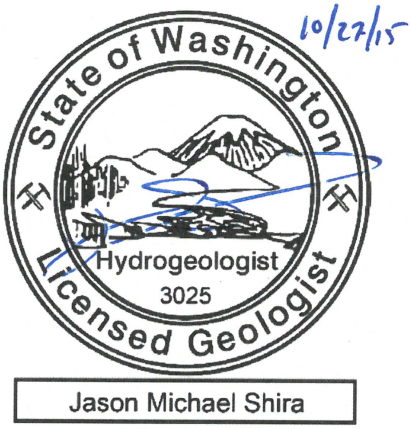
Intertidal Springs Evaluation

MEMORANDUM

Project No.: 040001-014-02

October 27, 2015

To: Pete Stoltz, CalPortland Company



From: Jason Shira, LHG and Owen Reese, P.E.

Re: **Water Sources of the Intertidal Beach Springs—FINAL**

This memorandum presents an evaluation of the water sources to the intertidal beach springs along the Puget Sound shoreline north of Sequalitchew Creek in DuPont, Washington.

An initial analysis was performed in 2004 as a component of the surface water and groundwater evaluations for the proposed mine expansion of CalPortland's DuPont Mine (Aspect, 2004). This update incorporates information about groundwater levels collected since 2004 and the results of a significant update to the three-dimensional groundwater model. This memorandum presents background information about the springs, aquifers, and groundwater conditions, and an analysis of the three contributors of flow in the springs: tidal intrusion, the Vashon Aquifer, and the Sea Level Aquifer.

The relative contribution of these three sources is estimated using standard hydrogeological analytical solutions (as opposed to a numerical model) and site-specific information collected from a variety of studies over the past several decades. This approach provides a rough estimate of the discharge from each of the sources to the intertidal springs collectively. There is insufficient information to evaluate the specific sources at any individual spring; however, much of the information on flow and water quality that informs our approach was collected from the Large Springs.

The 2004 analysis concluded that the Vashon Aquifer contributes 0.5 to 16 percent of flow to the intertidal springs. This updated analysis estimates the Vashon Aquifer contributes 0.2 to 14 percent of the flow to the springs.

Background

Intertidal Beach Springs

Springs are located at multiple points along the shoreline of the Nisqually Reach. Two springs are located along the beach just north of the Sequalitchew Creek estuary and directly west of the area of the proposed South Parcel mine development, Figure 1. The largest of these springs, the Large Spring, was reported to flow between 11 and 18 cubic feet per second (cfs) based on monthly data collected by the U.S. Geological Survey (USGS) in 1942. Spot measurements by CH2M HILL in 1999 and 2000 indicated flows of 9.1 and 14.9 cfs, respectively (CH2M HILL, 2001).

Hydrogeologic Conditions

The Steilacoom Delta was created by a glacial outburst flood that resulted in deposition of glacial outwash sand and gravel, Steilacoom Gravels (Borden and Troost, 2001). The outburst of flood waters eroded away older deposits (Vashon Till and Vashon Outwash) in some areas resulting in a channel of Steilacoom Gravels (Savoca, et al., 2010). In the area of the South Parcel, the Steilacoom Gravels (Qvs) overlie Vashon Till (Qvt) and Vashon Advance Outwash (Qva), which are identified in drilling logs. Beneath these Vashon Drift deposits lies a nonglacial deposit known as the Olympia Beds (Qob).

The Olympia Beds are a low permeable layer that generally consists of lahars, ashes, and fine-grained fluvial sediments. In the vicinity of the South Parcel, the Olympia Beds are best described as mudflows that separate the Vashon Aquifer and Sea Level Aquifer that are of interest in this evaluation. The Olympia Beds are not present in the vicinity of the beach springs. After the Olympia Beds were deposited, advancement of the Puget lobe of the Cordilleran ice sheet, and flow of water beneath the glacier, carved a valley through the Olympia Beds. As the glaciers receded, outburst floods from glacial lakes located northeast of DuPont deposited Steilacoom Gravels over the truncated Vashon Drift deposits and Olympia Beds effectively filling the valley carved by the glacier.

Below the Olympia Beds are glacial drift deposits locally referred to as the Salmon Springs Drift ($Qpog_2$) (Savoca, et al, 2010). These deposits are characterized by intervening nonglacial sediments, the presence of intervening glaciolacustrine sediments, and the presence of a thick, intensely oxidized zone at the top of the recessional outwash (Borden and Troost, 2001). Like the Olympia Beds, the Salmon Springs Drift deposits were truncated by the meltwater and advancement of the Puget lobe of the Cordilleran ice sheet, which was subsequently filled by the outwash of Steilacoom Gravels, Figure 2.

The Steilacoom Gravels host the upper unconfined aquifer. This upper aquifer is separated from a semiconfined aquifer by a 10-foot-thick low permeability unit comprised of Vashon Till. The till layer is not uniformly present. Beneath the till layer is a semiconfined aquifer hosted by the Vashon Advance Outwash. In this memorandum, the unconfined aquifer, upper confining unit, and semiconfined outwash aquifer are referred to collectively as the Vashon Aquifer.

The Salmon Springs Drift hosts the Sea Level Aquifer. The Sea Level Aquifer is regionally considered to be a confined aquifer; however, extending from approximately 6,000 feet upgradient of the truncation of the Olympia Beds, the Sea Level Aquifer is unconfined (Hart Crowser, 1994).

The area between the Olympia Bed truncation and the Puget Sound is comprised of Steilacoom Gravels (Qvs) overlying the Salmon Springs Drift ($Qpog_2$). Locally referred to as the Sequalitchew Delta Aquifer. Due to the thickness and high hydraulic conductivity of the Steilacoom Gravels, the hydraulic gradient of the Sequalitchew Delta Aquifer is fairly shallow. This is one reason springs are not observed higher on the bluffs overlooking Puget Sound.

Downgradient of the truncation of the Olympia Beds, the Vashon Aquifer and the Sea Level Aquifer flow into the Sequalitchew Delta Aquifer, which then discharges to the springs and sea floor of the Puget Sound. Intrusion of salt water into the Sequalitchew Delta Aquifer also occurs near the shoreline and as tidal elevations fluctuate. We evaluated the water sources to the intertidal springs based on the relative contributions to the Sequalitchew Delta Aquifer of saltwater, freshwater from the Vashon Aquifer, and freshwater from the Sea Level Aquifer.

Physical Properties (Hydraulic Conductivity and Gradient)

Hydraulic conductivities (K) within glacial deposits can vary by orders of magnitude because of the heterogenous deposition of gravels, sands, silts, and clay. The unconfined aquifer in the Steilacoom Gravels exhibits a high hydraulic conductivity (1,100 feet per day [ft/d] on average) due to the size of the grains deposited, sand and gravel, and lack of fine-grained material (silts or clay). The two other hydrogeologic units that make up the Vashon Aquifer exhibit hydraulic conductivities that are orders of magnitude lower (0.33 and 77 ft/d on average, respectively). The hydraulic conductivity of the Sea Level Aquifer in the Salmon Springs Drift is also fairly high (690 ft/d on average). The average hydraulic conductivities presented here are derived from parameter estimation techniques used during calibration of the South Parcel Mine Expansion groundwater model (Aspect, 2015), and are generally consistent with prior studies and pumping test results (Woodward Clyde, 1991; CH2M HILL, 2000; Aspect, 2004).

The hydraulic gradient, or slope, of the water table for the Vashon Aquifer is moderate on a regional scale; however, the hydraulic gradient steepens as the Vashon Aquifer approaches and travels over the Olympia Beds truncation. The Sea Level Aquifer also exhibits a change in hydraulic gradient; however, relative to the Vashon Aquifer, it has a comparatively shallow gradient near the Olympia Beds truncation (Figure 2 and Table 1).

Table 1—Hydraulic Gradients

Unit and Location Description	Hydraulic Gradient	Reference
Vashon near landfill	0.0006	Woodward Clyde, 1991,p.3-34
Vashon South Parcel (Dec 2014, high)	0.0009	Unpublished, based on recent monitoring data.
Vashon South Parcel (Oct 2014, low)	0.001	Unpublished, based on recent monitoring data.
Vashon west of landfill	0.005	Woodward Clyde, 1991, p.3-34
Vashon south of Sequalitchew Ck.	0.02	Hart Crowser, 1994, p.3.1-13
Vashon north of Sequalitchew Ck.	0.05	Hart Crowser, 1994, p.3.1-13
Vashon near Qob cutoff	0.33	Woodward Clyde, 1991,p.3-34
Sea Level Aq. near landfill	0.0001	Woodward Clyde, 1991, p.3-35
Sea Level Aq. (Bell Hill No. 1 to MW-18)	0.007	Hart Crowser, 1994, p.3.1-14
Sea Level Aq. west of landfill	0.01	WCC, 1992, p.3-35
Sea Level Aq. (MW-18 to PS)	0.03	Hart Crowser, 1994, p.3.1-14
Sea Level Aq. near Qob cutoff	0.05	Woodward Clyde,1991, p.3-35
Sequalitchew Delta Aquifer	0.002	Woodward Clyde,1991, p.3-35
SLA/Sequalitchew Delta Aquifer (MW-3 to PS)	0.005	Hart Crowser, 1994, p.3.1-14
SLA/ Sequalitchew Delta Aquifer (MW-6 to PS)	0.02	Hart Crowser, 1994, p.3.1-14

Seawater Intrusion

In coastal aquifer systems, the interaction of saltwater with freshwater aquifers is an important component for understanding the physical and chemical behavior of the groundwater system. The Ghyben-Herzberg Relation (Freeze and Cherry, 1979) states that the depth of the freshwater below sea level (Z) is 40 times the height of the water table above sea level (h). It is important to note that the Ghyben-Herzberg Relation is a simplified solution. In reality, the exact position of the saltwater/freshwater interface is governed by hydrostatic pressure, which varies with tide stage, mixing of freshwater and saltwater, combined with geologic heterogeneities, to create a diffuse zone instead of a sharp boundary.

The elevation of the Sequalitchew Delta Aquifer water table is less than 5-feet above mean sea level at the Puget Sound bluffs (Hart Crowser, 1994). This allows for seawater to potentially intrude the Sequalitchew Delta Aquifer. With seawater intrusion, the fresh water floats on top of the denser seawater. The lower the water table elevation (pressure), the more readily seawater displaces the freshwater. Tidal action and diffusion results in a mixing zone between the seawater and freshwater.

Freshwater within the Sequalitchew Delta Aquifer may be up to 100 feet thick in the area below the existing mine, and a few feet thick at the location where the springs discharge to the Puget Sound, Figure 2.

Analysis

Our approach for estimating the relative contribution of the three sources to the intertidal springs was to first estimate the portion of saltwater in the spring discharge using water quality measurements (electrical conductivity) to distinguish saltwater from freshwater. We then used analytical techniques to calculate the flow per unit width in each of the freshwater aquifers based on

their hydrogeologic characteristics. These results were compared with the output from a three-dimensional numerical groundwater model.

Evaluation of Saltwater Discharge from Large Springs

The portion of the discharge in the large springs coming from saltwater that intrudes into the aquifer at high tide, then drains through the springs at lower tidal elevations, was evaluated based on water quality measurements taken from the springs.

Electrical conductivity (EC) is an indicator of the quantity of dissolved solids in a water, and provides a useful measure for identifying salt waters (which have a high EC values) and freshwaters, which have much lower EC values. Monitoring data from the Large Spring (Aspect, 2004) indicate that EC of the spring discharge ranges from 15,400 to 43,200 micromhos per centimeter (μm/cm), and change diurnally with the tidal cycle. Spring discharge measuring EC at this range is indicative of seawater intrusion of the Sequalitchew Delta Aquifer. Groundwater is typically 150 to 200 μm/cm in the Vashon and Sea Level Aquifers (Woodward Clyde, 1991), and marine water in the Nisqually Reach area is 43,236 μm/cm (Thut, et al., 1978). These data indicate that marine water constitutes between 36 and 99 percent of the spring discharge, depending on diurnal tide stage.

Estimate of Vashon and Sea Level Aquifer Contributions

Based on the observed water quality at the Large Spring, the two freshwater aquifers are estimated to contribute from 1 to 64 percent of the flow to the spring. The contributions of each of the aquifers were evaluated using two approaches for calculating groundwater flux: an analytical approach, and the results of a calibrated three-dimensional groundwater model.

An analytical solution, the Dupuit Equation, was used to evaluate the unconfined aquifer conditions, and Darcy's Law for the confined aquifer conditions (Fetter, 2001).

Dupuit Equation

$$q' = K\frac{(h_1^2 - h_2^2)}{2L}$$

Darcy's Law

$$q' = Kb\frac{(h_1 - h_2)}{L}$$

Where,

q' = flow per unit width (square feet per day [ft^2/d]);
K = hydraulic conductivity (feet per day [ft/d]);
h_1 = water level elevation at origin (feet [ft]);
h_2 = water level elevation at L (ft);
L = the distance from origin at point h_2 (ft); and
b = aquifer thickness (ft).

The unconfined portions of the Vashon and Sea Level Aquifers have been characterized in a variety of studies conducted over the past several decades. South of Sequalitchew Creek, the aquifers were characterized as part of remedial efforts for the Former DuPont Works Site. Monitoring wells completed in the Vashon and Sea Level Aquifers indicate the hydraulic gradients vary seasonally and spatially (Hart Crowser, 1994). Similar work was performed for the Army Corp of Engineers on the north side of Sequalitchew Creek. Here, great variations occurred in the Vashon Aquifer and Sequalitchew Delta Aquifer (likely due to tidal influence) with little measurable change in the Sea Level Aquifer (Woodward Clyde, 1991). Recent monitoring data and model simulations of the groundwater response to dewatering confirmed seasonal variations in the Vashon Aquifer system (Aspect, 2015). The range of hydraulic gradients for each hydrogeologic unit are listed in Table 1. In this analysis, the median hydraulic gradient from previous investigations in the area was used for each aquifer and are shown in Table 2. The hydraulic conductivities listed in Table 2 were determined during calibration of the South Parcel Mine Expansion groundwater model (Aspect, 2015).

Table 2—Aquifer Parameters and Flow

Aquifer	Hydrogeologic Unit	Hydraulic Conductivity (K), ft/d	Hydraulic Gradient (dh/dl), ft/ft	Unit Thickness (b), ft	Flow per Unit Width (q'), ft^2/d
Vashon Aquifer	Vashon Steilacoom Gravels (Qvs)	1100	0.005	70	151
	Vashon Advance Outwash (Qva)	77	0.005	40	2
Sea Level Aquifer	Salmon Springs (Qpog2)	690	0.010	150	518
Percentage of Total Flow from Vashon Aquifer					23%

Using the DuPuit equation and the aquifer characteristics shown in Table 2, the total flow per unit width is estimated at 153 ft^2/d for the Vashon Aquifer and 518 ft^2/d for the Sea Level Aquifer. Flow in the Sequalitchew Delta Aquifer is the sum of the flows in these two aquifers, or 671 ft^2/d. As a result, the Vashon Aquifer contributes 23 percent of the freshwater flow to the Sequalitchew Delta Aquifer.

This analysis makes idealized assumptions about the occurrence and movement of groundwater through a complex geological and geographical setting. The analytical solutions presented represent one-dimensional steady-state conditions in an area that is better characterized by transient (tidally and seasonally changing hydraulic gradients and groundwater flow directions) and spatially variable conditions. The location of the intertidal springs and the amount of water discharged is controlled not only by the regional geology, but also by the fine-scale spatial variability of physical conditions that lead to preferential flow paths.

Comparison with Groundwater Model Results

A groundwater model has been previously developed (Aspect, 2004 and 2009) and recently updated (Aspect, 2015) to simulate effects on groundwater behavior in response to CalPortland's proposed dewatering, mining, and cessation of dewatering in the South Parcel. The model is centered between the South Parcel and East Edmonds Marsh, and extends beyond the Olympia Beds truncation to the west and Sequalitchew Lake to the east. The Sea Level Aquifer was treated as underflow in the vicinity of the South Parcel to the Puget Sound. The Vashon Aquifer was simulated as groundwater outflow to the Puget Sound. Although the primary purpose of the model is not predicting the relative discharge amounts from the two aquifers, it is capable of doing so. However, the model does not simulate saltwater intrusion from Puget Sound.

Model results indicate that, on average over the six-year period simulated by the model, the Vashon Aquifer contributes 15 percent of the total freshwater groundwater discharge to Puget Sound. This result is generally consistent with, but slightly lower than, the 23 percent predicted by the simpler analytical approach described above.

Summary of Sources of Water to the Intertidal Springs

By combining the estimates of the marine portion of the springs discharge with the relative flow in the two freshwater aquifers, we arrive at the breakdown of sources shown in Table 3. The makeup of the water (saltwater versus freshwater) discharging from the springs is influenced by tidal stage and season, and the contribution of the Vashon Aquifer from less than 1 percent up to 14 percent. This result is remarkably consistent with the 2004 estimate of 0.5 to 16 percent.

The ratio of sources at a specific intertidal spring may vary depending on its elevation (and thus potential for saltwater intrusion) and preferential flow paths for freshwater from one aquifer or the other.

Table 3—Percentage Contribution to Large Spring

Source	Estimated Percentage of Intertidal Spring Flow
Vashon Aquifer	0.2 - 14
Sea Level Aquifer	0.8 - 49
Puget Sound	36 - 99

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Limitations

Work for this project was performed for the CalPortland Company (Client), and this memorandum was prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. This memorandum does not represent a legal opinion. No other warranty, expressed or implied, is made.

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Attachments

Figure 1—Sequalitchew Creek Basin Map
Figure 2—Aquifer Systems Near DuPont

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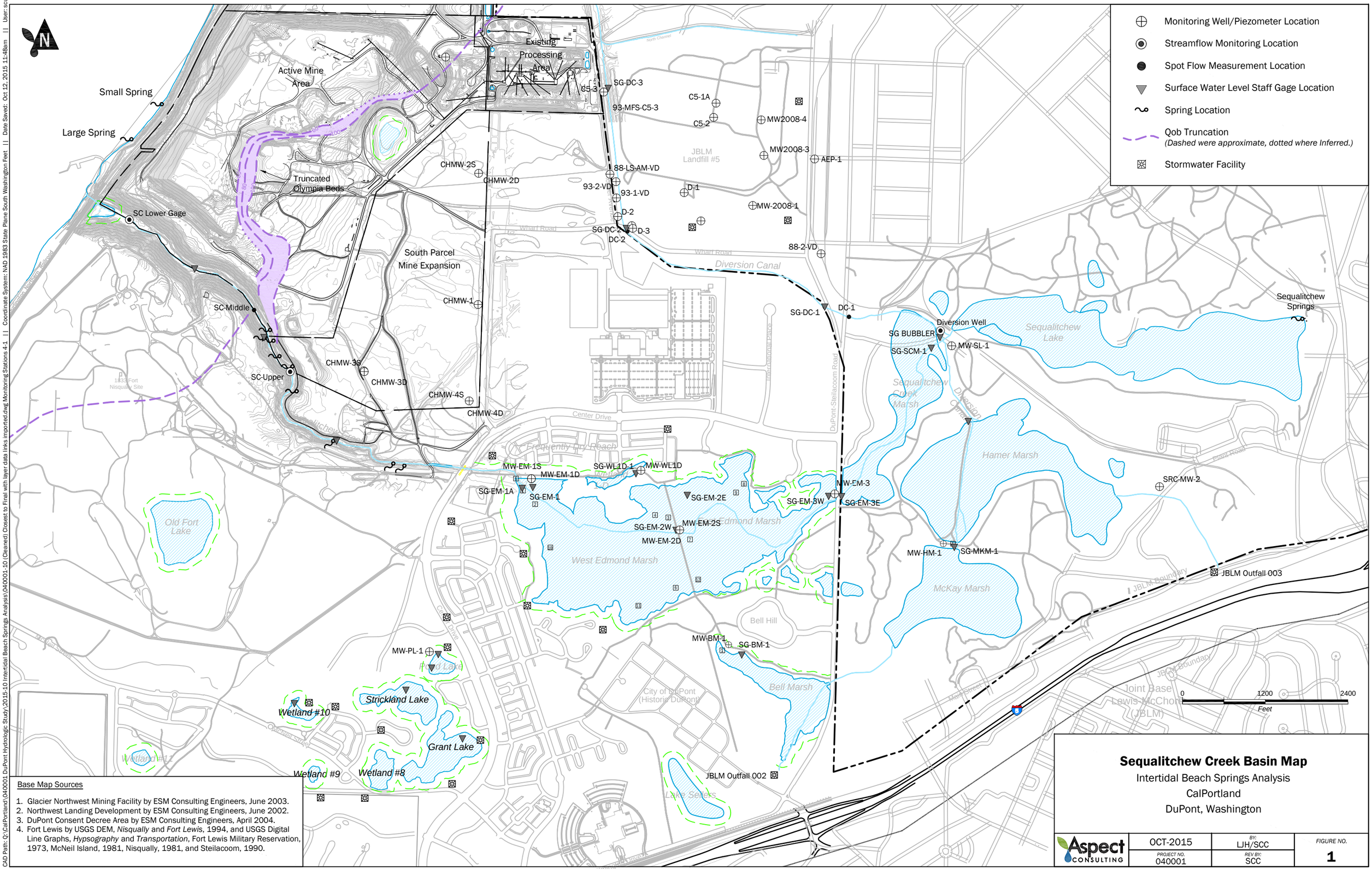
FIGURES



Base Map Sources

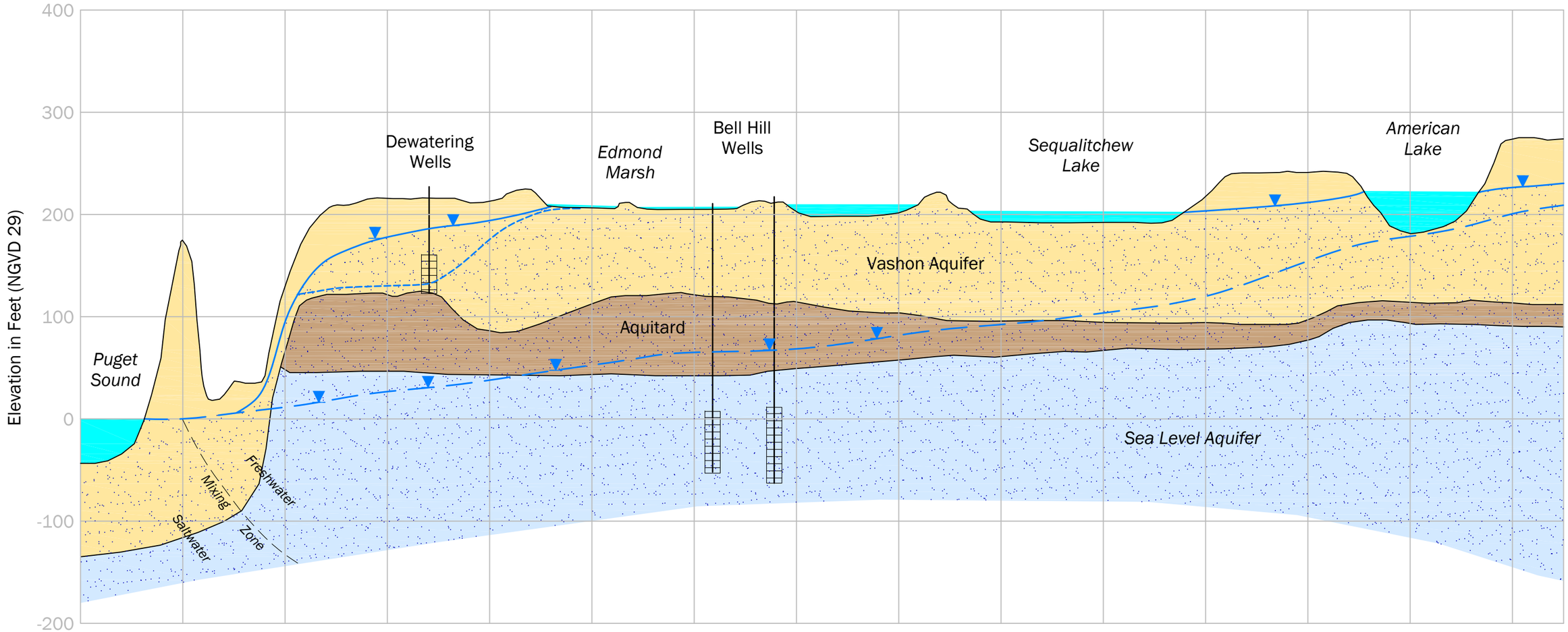
1. Glacier Northwest Mining Facility by ESM Consulting Engineers, June 2003.
2. Northwest Landing Development by ESM Consulting Engineers, June 2002.
3. DuPont Consent Decree Area by ESM Consulting Engineers, April 2004.
4. Fort Lewis by USGS DEM, *Nisqually* and *Fort Lewis*, 1994, and USGS Digital Line Graphs, *Hypsography* and *Transportation*, Fort Lewis Military Reservation, 1973, McNeil Island, 1981, Nisqually, 1981, and Steilacoom, 1990.

Sequalitchew Creek Basin Map

Intertidal Beach Springs Analysis
CalPortland
DuPont, Washington

Aspect Consulting	OCT-2015	BY: LJH/SCC	FIGURE NO. 1
	PROJECT NO. 040001	REV BY: SCC	

C:\CAD Path: Q:\CalPortland\040001 DuPont Hydrologic Study\2015-10 Intertidal Beach Springs Analysis\040001-10 (Cleaned) Closest to Final with layer data links imported.dwg Monitoring Stations 4-1 || Coordinate System: NAD 1983 State Plane South Washington Feet || Date Saved: Oct 12, 2015 11:48am || User: scud



— — — Ghyben-Herzberg Interface

Current Water Level in Vashon Aquifer

Predicted Water Level with Mining

Water Level in the Sea Level Aquifer (City of DuPont Water Supply Aquifer)

Aquifer Systems Near DuPont

Intertidal Beach Springs Analysis

CalPortland

DuPont, Washington

Aspect CONSULTING	OCT-2015	BY: JS/SCC	FIGURE NO. 2
	PROJECT NO. 040001	REV BY: SC	

CAD Path: Q:\CalPortland\040001 DuPont Hydrologic Study\2015-10 Intertidal Beach Springs Analysis\040001-AA-20x.dwg 11x17 Landscape || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Oct 12, 2015 11:48am || User: scudd

APPENDIX E

Site Water Balance Results

Table E-1. Site Water Balance for Existing Conditions

Project No. 040001, DuPont, Washington

	Inflows			Outflows			
Year	Total Precipitation in inches	Total Surface Water Run-On in cfs	Groundwater Inflows in cfs	Evapo-transpiration in inches	Stormwater in cfs	Direct Groundwater Recharge in cfs	Total Groundwater Outflow in cfs
1901	40.83	0	6.9	21.75	0.14	0.92	7.96
1902	38.26	0	6.9	19.55	0.11	0.93	7.94
1903	35.03	0	6.9	16.33	0.11	0.93	7.94
1904	38.42	0	6.9	17.55	0.13	1.03	8.06
1905	25.71	0	6.9	14.10	0.06	0.58	7.54
1906	37.95	0	6.9	21.91	0.12	0.78	7.79
1907	38.20	0	6.9	16.92	0.13	1.05	8.08
1908	38.11	0	6.9	17.89	0.12	1.00	8.02
1909	53.09	0	6.9	25.48	0.18	1.35	8.43
1910	33.20	0	6.9	12.51	0.11	1.04	8.05
1911	48.37	0	6.9	20.55	0.19	1.36	8.44
1912	45.91	0	6.9	16.27	0.18	1.47	8.55
1913	32.51	0	6.9	15.47	0.10	0.85	7.85
1914	36.06	0	6.9	18.48	0.11	0.86	7.88
1915	46.92	0	6.9	21.81	0.16	1.24	8.29
1916	31.16	0	6.9	15.39	0.09	0.79	7.78
1917	50.58	0	6.9	19.90	0.19	1.51	8.60
1918	37.07	0	6.9	16.79	0.12	1.01	8.03
1919	38.67	0	6.9	17.95	0.13	1.02	8.05
1920	45.83	0	6.9	20.26	0.16	1.26	8.32
1921	41.45	0	6.9	18.25	0.14	1.15	8.19
1922	48.12	0	6.9	18.46	0.18	1.47	8.55
1923	34.20	0	6.9	16.99	0.10	0.86	7.86
1924	36.53	0	6.9	18.54	0.11	0.89	7.90
1925	45.82	0	6.9	21.91	0.15	1.18	8.23
1926	37.20	0	6.9	16.90	0.12	1.01	8.03
1927	41.37	0	6.9	19.19	0.14	1.10	8.13
1928	45.78	0	6.9	17.27	0.17	1.41	8.48
1929	51.97	0	6.9	25.28	0.18	1.31	8.38
1930	48.05	0	6.9	18.29	0.17	1.48	8.55
1931	37.66	0	6.9	15.49	0.13	1.10	8.13
1932	48.90	0	6.9	21.31	0.17	1.36	8.43
1933	62.18	0	6.9	22.37	0.26	1.95	9.11
1934	35.86	0	6.9	14.11	0.12	1.09	8.11
1935	52.09	0	6.9	20.01	0.20	1.59	8.68
1936	42.98	0	6.9	19.49	0.15	1.16	8.20
1937	49.63	0	6.9	21.90	0.17	1.37	8.44
1938	26.62	0	6.9	16.09	0.06	0.52	7.48
1939	46.62	0	6.9	23.06	0.15	1.16	8.21
1940	30.97	0	6.9	13.76	0.10	0.86	7.86
1941	43.78	0	6.9	19.73	0.15	1.18	8.24
1942	37.47	0	6.9	17.78	0.12	0.97	7.99
1943	49.82	0	6.9	20.25	0.18	1.46	8.54
1944	50.74	0	6.9	23.68	0.17	1.33	8.40
1945	40.83	0	6.9	16.73	0.14	1.20	8.24
1946	34.17	0	6.9	17.32	0.10	0.84	7.84

Table E-1. Site Water Balance for Existing Conditions

Project No. 040001, DuPont, Washington

	Inflows			Outflows			
Year	Total Precipitation in inches	Total Surface Water Run-On in cfs	Groundwater Inflows in cfs	Evapo-transpiration in inches	Stormwater in cfs	Direct Groundwater Recharge in cfs	Total Groundwater Outflow in cfs
1947	38.87	0	6.9	18.11	0.13	1.02	8.05
1948	43.71	0	6.9	18.59	0.16	1.23	8.29
1949	31.37	0	6.9	16.29	0.09	0.75	7.74
1950	42.12	0	6.9	20.24	0.13	1.08	8.12
1951	46.83	0	6.9	19.36	0.18	1.34	8.43
1952	53.37	0	6.9	20.03	0.22	1.63	8.75
1953	35.77	0	6.9	14.74	0.12	1.05	8.07
1954	39.97	0	6.9	20.58	0.12	0.96	7.98
1955	30.18	0	6.9	15.69	0.08	0.72	7.70
1956	44.18	0	6.9	20.40	0.15	1.17	8.22
1957	58.24	0	6.9	21.68	0.24	1.79	8.93
1958	52.59	0	6.9	19.25	0.21	1.64	8.75
1959	33.13	0	6.9	12.83	0.11	1.01	8.03
1960	55.41	0	6.9	22.14	0.22	1.63	8.75
1961	36.29	0	6.9	15.89	0.13	1.01	8.03
1962	36.22	0	6.9	19.15	0.10	0.85	7.85
1963	33.33	0	6.9	15.82	0.10	0.87	7.87
1964	57.69	0	6.9	23.56	0.24	1.66	8.80
1965	28.52	0	6.9	11.27	0.09	0.87	7.86
1966	38.98	0	6.9	20.63	0.12	0.90	7.92
1967	43.40	0	6.9	18.08	0.15	1.25	8.31
1968	37.92	0	6.9	18.86	0.11	0.94	7.96
1969	45.01	0	6.9	19.71	0.16	1.25	8.30
1970	44.55	0	6.9	17.55	0.17	1.33	8.40
1971	45.61	0	6.9	19.02	0.16	1.31	8.38
1972	51.44	0	6.9	17.60	0.21	1.67	8.78
1973	43.43	0	6.9	17.78	0.15	1.27	8.32
1974	45.51	0	6.9	19.86	0.16	1.26	8.32
1975	46.93	0	6.9	18.39	0.17	1.41	8.49
1976	36.53	0	6.9	16.71	0.11	0.99	8.00
1977	57.46	0	6.9	20.49	0.23	1.82	8.95
1978	35.73	0	6.9	15.88	0.11	0.99	8.00
1979	44.96	0	6.9	19.26	0.16	1.27	8.33
1980	42.56	0	6.9	17.97	0.15	1.22	8.27
1981	38.36	0	6.9	18.84	0.11	0.97	7.98
1982	48.39	0	6.9	19.70	0.18	1.42	8.49
1983	34.00	0	6.9	15.77	0.10	0.91	7.91
1984	38.65	0	6.9	17.77	0.13	1.03	8.06
1985	36.02	0	6.9	16.93	0.11	0.95	7.96
1986	39.21	0	6.9	17.69	0.13	1.06	8.10
1987	35.69	0	6.9	15.79	0.12	0.99	8.01
1988	36.33	0	6.9	17.25	0.12	0.94	7.96
1989	44.58	0	6.9	22.35	0.14	1.09	8.13
1990	47.15	0	6.9	16.93	0.18	1.50	8.58
1991	46.79	0	6.9	17.39	0.18	1.46	8.53
1992	52.29	0	6.9	22.48	0.19	1.47	8.56

Table E-1. Site Water Balance for Existing Conditions

Project No. 040001, DuPont, Washington

	Inflows			Outflows			
Year	Total Precipitation in inches	Total Surface Water Run-On in cfs	Groundwater Inflows in cfs	Evapo-transpiration in inches	Stormwater in cfs	Direct Groundwater Recharge in cfs	Total Groundwater Outflow in cfs
1993	44.54	0	6.9	15.32	0.17	1.46	8.52
1994	33.69	0	6.9	16.27	0.10	0.87	7.87
1995	61.78	0	6.9	20.71	0.26	2.02	9.18
1996	40.75	0	6.9	18.04	0.13	1.13	8.16
1997	43.33	0	6.9	19.88	0.14	1.16	8.20
1998	23.49	0	6.9	13.46	0.05	0.50	7.46
1999	44.25	0	6.9	23.38	0.14	1.02	8.06
2000	31.82	0	6.9	15.14	0.09	0.83	7.83
2001	41.20	0	6.9	18.33	0.14	1.13	8.17
2002	37.41	0	6.9	17.64	0.12	0.98	8.00
2003	46.97	0	6.9	19.04	0.17	1.38	8.45
2004	57.63	0	6.9	24.78	0.21	1.61	8.72
2005	43.60	0	6.9	15.75	0.15	1.39	8.45
2006	35.32	0	6.9	14.01	0.12	1.06	8.08
2007	37.55	0	6.9	17.85	0.12	0.97	7.99
2008	40.60	0	6.9	19.35	0.13	1.05	8.08
2009	35.07	0	6.9	16.35	0.11	0.93	7.94
2010	33.78	0	6.9	16.34	0.10	0.87	7.87
2011	34.09	0	6.9	17.15	0.11	0.83	7.84
2012	38.96	0	6.9	18.93	0.13	0.99	8.01
2013	30.12	0	6.9	14.01	0.09	0.80	7.79
2014	43.52	0	6.9	21.82	0.15	1.06	8.11
2015	25.74	0	6.9	11.70	0.07	0.71	7.68
2016	50.36	0	6.9	23.17	0.18	1.33	8.41
2017	56.54	0	6.9	19.80	0.23	1.81	8.94
2018	58.35	0	6.9	21.81	0.23	1.80	8.93
2019	43.38	0	6.9	17.78	0.15	1.27	8.32
2020	52.71	0	6.9	19.25	0.20	1.65	8.76
2021	37.15	0	6.9	18.10	0.11	0.95	7.96
2022	49.81	0	6.9	19.76	0.19	1.48	8.57
2023	37.80	0	6.9	18.08	0.12	0.97	8.00
2024	39.84	0	6.9	18.68	0.13	1.04	8.08
2025	45.58	0	6.9	20.38	0.15	1.24	8.30
2026	35.92	0	6.9	16.57	0.11	0.96	7.97
2027	31.55	0	6.9	17.24	0.08	0.72	7.69
2028	43.54	0	6.9	18.08	0.16	1.26	8.31
2029	47.68	0	6.9	20.22	0.17	1.35	8.42
2030	34.39	0	6.9	14.94	0.11	0.97	7.98
2031	35.52	0	6.9	18.28	0.10	0.86	7.86
2032	35.66	0	6.9	18.56	0.11	0.84	7.85
2033	43.89	0	6.9	21.58	0.14	1.10	8.14
2034	35.91	0	6.9	15.30	0.12	1.02	8.04
2035	45.85	0	6.9	20.68	0.16	1.24	8.30
2036	27.87	0	6.9	13.20	0.08	0.73	7.71
2037	48.88	0	6.9	20.58	0.19	1.39	8.47
2038	28.10	0	6.9	16.17	0.06	0.60	7.56

Table E-1. Site Water Balance for Existing Conditions

Project No. 040001, DuPont, Washington

	Inflows			Outflows			
Year	Total Precipitation in inches	Total Surface Water Run-On in cfs	Groundwater Inflows in cfs	Evapo-transpiration in inches	Stormwater in cfs	Direct Groundwater Recharge in cfs	Total Groundwater Outflow in cfs
2039	36.26	0	6.9	20.13	0.10	0.79	7.80
2040	33.69	0	6.9	16.62	0.10	0.85	7.85
2041	46.65	0	6.9	23.03	0.16	1.15	8.21
2042	53.77	0	6.9	22.52	0.19	1.54	8.64
2043	51.49	0	6.9	17.48	0.20	1.69	8.79
2044	51.64	0	6.9	21.40	0.19	1.49	8.58
2045	52.33	0	6.9	19.56	0.20	1.62	8.72
2046	36.35	0	6.9	15.18	0.12	1.06	8.08
2047	42.13	0	6.9	20.70	0.13	1.06	8.09
2048	41.81	0	6.9	18.00	0.15	1.18	8.22
2049	36.96	0	6.9	18.50	0.12	0.91	7.93
2050	46.15	0	6.9	19.94	0.16	1.30	8.36
2051	45.24	0	6.9	18.70	0.16	1.31	8.37
2052	48.60	0	6.9	20.18	0.17	1.41	8.48
2053	45.60	0	6.9	18.98	0.17	1.31	8.38
2054	37.71	0	6.9	18.78	0.11	0.94	7.95
2055	33.13	0	6.9	16.22	0.09	0.84	7.84
2056	46.21	0	6.9	21.31	0.16	1.22	8.28
2057	41.86	0	6.9	16.27	0.15	1.27	8.32
2058	67.38	0	6.9	24.61	0.29	2.08	9.27
Average	41.99	0	6.90	18.51	0.14	1.16	8.20
Average in inches	41.99	0	124.26	18.51	2.59	20.89	147.74

Notes:

1) Stormwater is the sum of surface runoff and interflow.

2) Under existing conditions, all stormwater infiltrates within the mine area or on the South Parcel.

3) Total Groundwater outflow is the sum of stormwater + direct groundwater recharge + groundwater inflows.

4) Average flows in cfs are converted to inches by calculating the total volume in cubic feet for the year, then dividing by the project area of 482.4 acres

Table E-2. Site Water Balance for Proposed Action

Project No. 040001, DuPont, Washington

	Inflows			Outflows			
Year	Total Precipitation in inches	Total Surface Water Run-On in cfs	Groundwater Inflows in cfs	Evapo-transpiration in inches	Stormwater in cfs	Direct Groundwater Recharge in cfs	Total Groundwater Outflow in cfs
1901	40.83	0	6.9	19.65	0.62	0.56	8.08
1902	38.26	0	6.9	19.29	0.43	0.62	7.95
1903	35.03	0	6.9	15.81	0.44	0.63	7.97
1904	38.42	0	6.9	16.50	0.56	0.66	8.12
1905	25.71	0	6.9	14.40	0.20	0.42	7.53
1906	37.95	0	6.9	20.60	0.45	0.52	7.86
1907	38.20	0	6.9	16.03	0.53	0.70	8.13
1908	38.11	0	6.9	17.11	0.51	0.65	8.07
1909	53.09	0	6.9	24.23	0.76	0.84	8.50
1910	33.20	0	6.9	11.88	0.49	0.69	8.08
1911	48.37	0	6.9	19.10	0.80	0.83	8.53
1912	45.91	0	6.9	15.18	0.81	0.90	8.61
1913	32.51	0	6.9	15.03	0.39	0.59	7.87
1914	36.06	0	6.9	17.78	0.45	0.57	7.91
1915	46.92	0	6.9	20.70	0.66	0.80	8.36
1916	31.16	0	6.9	15.12	0.32	0.57	7.79
1917	50.58	0	6.9	17.88	0.87	0.94	8.72
1918	37.07	0	6.9	16.10	0.48	0.69	8.06
1919	38.67	0	6.9	16.89	0.53	0.68	8.11
1920	45.83	0	6.9	19.35	0.66	0.81	8.37
1921	41.45	0	6.9	17.43	0.59	0.75	8.23
1922	48.12	0	6.9	17.15	0.81	0.91	8.62
1923	34.20	0	6.9	16.90	0.37	0.59	7.86
1924	36.53	0	6.9	17.69	0.43	0.62	7.95
1925	45.82	0	6.9	20.58	0.63	0.77	8.30
1926	37.20	0	6.9	16.23	0.48	0.68	8.06
1927	41.37	0	6.9	18.21	0.56	0.73	8.19
1928	45.78	0	6.9	15.90	0.78	0.88	8.56
1929	51.97	0	6.9	23.88	0.73	0.83	8.46
1930	48.05	0	6.9	17.46	0.76	0.94	8.60
1931	37.66	0	6.9	15.13	0.54	0.71	8.15
1932	48.90	0	6.9	20.00	0.74	0.87	8.50
1933	62.18	0	6.9	20.65	1.14	1.16	9.21
1934	35.86	0	6.9	13.56	0.52	0.72	8.14
1935	52.09	0	6.9	18.64	0.87	0.98	8.76
1936	42.98	0	6.9	18.66	0.61	0.74	8.25
1937	49.63	0	6.9	21.08	0.71	0.88	8.49
1938	26.62	0	6.9	15.91	0.19	0.41	7.49
1939	46.62	0	6.9	21.51	0.64	0.76	8.29
1940	30.97	0	6.9	13.15	0.40	0.59	7.89
1941	43.78	0	6.9	18.51	0.66	0.74	8.30
1942	37.47	0	6.9	17.09	0.49	0.65	8.03
1943	49.82	0	6.9	18.92	0.82	0.89	8.62
1944	50.74	0	6.9	22.60	0.71	0.85	8.46
1945	40.83	0	6.9	15.79	0.59	0.80	8.29
1946	34.17	0	6.9	17.10	0.36	0.59	7.85

Table E-2. Site Water Balance for Proposed Action

Project No. 040001, DuPont, Washington

	Inflows			Outflows			
Year	Total Precipitation in inches	Total Surface Water Run-On in cfs	Groundwater Inflows in cfs	Evapo-transpiration in inches	Stormwater in cfs	Direct Groundwater Recharge in cfs	Total Groundwater Outflow in cfs
1947	38.87	0	6.9	16.98	0.55	0.67	8.12
1948	43.71	0	6.9	17.19	0.72	0.75	8.37
1949	31.37	0	6.9	16.39	0.32	0.51	7.73
1950	42.12	0	6.9	19.23	0.54	0.73	8.17
1951	46.83	0	6.9	17.77	0.78	0.83	8.51
1952	53.37	0	6.9	18.69	0.96	0.97	8.83
1953	35.77	0	6.9	14.38	0.50	0.69	8.09
1954	39.97	0	6.9	19.95	0.47	0.64	8.01
1955	30.18	0	6.9	15.71	0.28	0.52	7.70
1956	44.18	0	6.9	19.04	0.65	0.75	8.30
1957	58.24	0	6.9	19.94	1.07	1.05	9.03
1958	52.59	0	6.9	17.77	0.97	0.96	8.83
1959	33.13	0	6.9	12.42	0.49	0.66	8.05
1960	55.41	0	6.9	20.71	0.97	0.96	8.83
1961	36.29	0	6.9	15.14	0.53	0.64	8.07
1962	36.22	0	6.9	19.22	0.36	0.58	7.84
1963	33.33	0	6.9	14.98	0.42	0.60	7.92
1964	57.69	0	6.9	21.39	1.06	0.95	8.92
1965	28.52	0	6.9	11.41	0.36	0.59	7.85
1966	38.98	0	6.9	19.52	0.49	0.59	7.98
1967	43.40	0	6.9	17.00	0.65	0.82	8.37
1968	37.92	0	6.9	18.21	0.45	0.65	7.99
1969	45.01	0	6.9	18.12	0.70	0.79	8.39
1970	44.55	0	6.9	16.44	0.74	0.82	8.46
1971	45.61	0	6.9	17.78	0.72	0.83	8.44
1972	51.44	0	6.9	16.26	0.94	1.01	8.85
1973	43.43	0	6.9	17.16	0.65	0.81	8.36
1974	45.51	0	6.9	18.84	0.69	0.79	8.38
1975	46.93	0	6.9	17.37	0.75	0.89	8.54
1976	36.53	0	6.9	16.37	0.43	0.69	8.02
1977	57.46	0	6.9	19.08	1.03	1.10	9.03
1978	35.73	0	6.9	15.40	0.46	0.67	8.03
1979	44.96	0	6.9	18.25	0.66	0.82	8.38
1980	42.56	0	6.9	17.22	0.63	0.78	8.31
1981	38.36	0	6.9	18.37	0.45	0.66	8.01
1982	48.39	0	6.9	18.34	0.79	0.88	8.57
1983	34.00	0	6.9	15.82	0.37	0.64	7.91
1984	38.65	0	6.9	16.62	0.54	0.68	8.12
1985	36.02	0	6.9	16.34	0.45	0.64	7.99
1986	39.21	0	6.9	16.73	0.56	0.69	8.15
1987	35.69	0	6.9	14.90	0.50	0.65	8.05
1988	36.33	0	6.9	16.58	0.46	0.64	8.00
1989	44.58	0	6.9	21.30	0.59	0.71	8.19
1990	47.15	0	6.9	15.40	0.79	0.97	8.66
1991	46.79	0	6.9	16.41	0.78	0.91	8.59
1992	52.29	0	6.9	21.48	0.78	0.93	8.61

Table E-2. Site Water Balance for Proposed Action

Project No. 040001, DuPont, Washington

	Inflows			Outflows			
Year	Total Precipitation in inches	Total Surface Water Run-On in cfs	Groundwater Inflows in cfs	Evapo-transpiration in inches	Stormwater in cfs	Direct Groundwater Recharge in cfs	Total Groundwater Outflow in cfs
1993	44.54	0	6.9	14.26	0.73	0.95	8.58
1994	33.69	0	6.9	16.06	0.38	0.60	7.88
1995	61.78	0	6.9	18.54	1.22	1.18	9.30
1996	40.75	0	6.9	17.66	0.54	0.74	8.18
1997	43.33	0	6.9	18.98	0.59	0.76	8.25
1998	23.49	0	6.9	13.95	0.15	0.38	7.43
1999	44.25	0	6.9	21.64	0.56	0.69	8.16
2000	31.82	0	6.9	14.33	0.37	0.60	7.87
2001	41.20	0	6.9	16.95	0.61	0.74	8.25
2002	37.41	0	6.9	17.01	0.50	0.63	8.03
2003	46.97	0	6.9	17.93	0.76	0.86	8.51
2004	57.63	0	6.9	23.43	0.90	1.00	8.80
2005	43.60	0	6.9	15.06	0.67	0.92	8.48
2006	35.32	0	6.9	13.53	0.50	0.71	8.11
2007	37.55	0	6.9	17.10	0.49	0.64	8.04
2008	40.60	0	6.9	18.40	0.55	0.69	8.13
2009	35.07	0	6.9	16.21	0.44	0.61	7.95
2010	33.78	0	6.9	15.96	0.39	0.60	7.89
2011	34.09	0	6.9	16.25	0.43	0.56	7.89
2012	38.96	0	6.9	17.90	0.52	0.65	8.07
2013	30.12	0	6.9	13.89	0.36	0.54	7.80
2014	43.52	0	6.9	20.23	0.62	0.68	8.19
2015	25.74	0	6.9	12.26	0.24	0.50	7.65
2016	50.36	0	6.9	21.46	0.79	0.81	8.50
2017	56.54	0	6.9	18.34	1.04	1.08	9.02
2018	58.35	0	6.9	20.40	1.05	1.05	9.01
2019	43.38	0	6.9	17.03	0.65	0.82	8.36
2020	52.71	0	6.9	18.40	0.92	0.99	8.81
2021	37.15	0	6.9	17.64	0.44	0.64	7.98
2022	49.81	0	6.9	18.08	0.85	0.91	8.66
2023	37.80	0	6.9	17.69	0.46	0.66	8.02
2024	39.84	0	6.9	17.46	0.55	0.69	8.14
2025	45.58	0	6.9	19.13	0.66	0.81	8.37
2026	35.92	0	6.9	15.90	0.44	0.67	8.01
2027	31.55	0	6.9	17.05	0.27	0.53	7.71
2028	43.54	0	6.9	16.21	0.69	0.83	8.42
2029	47.68	0	6.9	18.88	0.76	0.84	8.50
2030	34.39	0	6.9	14.73	0.41	0.68	7.99
2031	35.52	0	6.9	17.71	0.39	0.60	7.89
2032	35.66	0	6.9	17.56	0.43	0.58	7.91
2033	43.89	0	6.9	19.82	0.61	0.73	8.24
2034	35.91	0	6.9	14.71	0.51	0.67	8.08
2035	45.85	0	6.9	19.52	0.67	0.79	8.36
2036	27.87	0	6.9	13.06	0.32	0.50	7.72
2037	48.88	0	6.9	18.53	0.84	0.85	8.59
2038	28.10	0	6.9	16.42	0.19	0.46	7.55

Table E-2. Site Water Balance for Proposed Action

Project No. 040001, DuPont, Washington

	Inflows			Outflows			
Year	Total Precipitation in inches	Total Surface Water Run-On in cfs	Groundwater Inflows in cfs	Evapo-transpiration in inches	Stormwater in cfs	Direct Groundwater Recharge in cfs	Total Groundwater Outflow in cfs
2039	36.26	0	6.9	19.01	0.40	0.56	7.86
2040	33.69	0	6.9	15.82	0.40	0.59	7.89
2041	46.65	0	6.9	21.34	0.68	0.73	8.31
2042	53.77	0	6.9	21.07	0.87	0.95	8.72
2043	51.49	0	6.9	16.58	0.90	1.04	8.84
2044	51.64	0	6.9	19.94	0.83	0.93	8.66
2045	52.33	0	6.9	18.02	0.91	1.00	8.81
2046	36.35	0	6.9	14.98	0.50	0.69	8.09
2047	42.13	0	6.9	19.91	0.54	0.70	8.13
2048	41.81	0	6.9	17.02	0.62	0.76	8.28
2049	36.96	0	6.9	17.67	0.47	0.60	7.97
2050	46.15	0	6.9	18.99	0.68	0.83	8.41
2051	45.24	0	6.9	16.76	0.74	0.84	8.48
2052	48.60	0	6.9	19.39	0.73	0.89	8.52
2053	45.60	0	6.9	16.45	0.77	0.85	8.52
2054	37.71	0	6.9	18.67	0.41	0.65	7.96
2055	33.13	0	6.9	16.08	0.35	0.60	7.85
2056	46.21	0	6.9	19.74	0.68	0.79	8.37
2057	41.86	0	6.9	15.44	0.65	0.82	8.37
2058	67.38	0	6.9	22.01	1.35	1.17	9.42
Average	41.99	0	6.90	17.57	0.61	0.75	8.26
Average in inches	41.99	0	124.26	17.57	10.95	13.47	148.68

Notes:

1) Stormwater is the sum of surface runoff and interflow.

2) Under existing conditions, all stormwater infiltrates within the mine area or on the South Parcel.

3) Total Groundwater outflow is the sum of stormwater + direct groundwater recharge + groundwater inflows.

4) Average flows in cfs are converted to inches by calculating the total volume in cubic feet for the year, then dividing by the project area of 482.4 acres

Table E-3. Site Water Balance for No Action

Project No. 040001, DuPont, Washington

	Inflows			Outflows			
Year	Total Precipitation in inches	Total Surface Water Run-On in cfs	Groundwater Inflows in cfs	Evapo-transpiration in inches	Stormwater in cfs	Direct Groundwater Recharge in cfs	Total Groundwater Outflow in cfs
1901	40.83	0	6.9	17.80	0.61	0.67	8.18
1902	38.26	0	6.9	15.76	0.53	0.72	8.15
1903	35.03	0	6.9	13.02	0.48	0.74	8.12
1904	38.42	0	6.9	13.94	0.57	0.79	8.26
1905	25.71	0	6.9	11.59	0.32	0.47	7.68
1906	37.95	0	6.9	17.52	0.54	0.60	8.03
1907	38.20	0	6.9	13.57	0.55	0.82	8.27
1908	38.11	0	6.9	14.43	0.54	0.78	8.22
1909	53.09	0	6.9	20.53	0.77	1.04	8.71
1910	33.20	0	6.9	9.95	0.48	0.81	8.19
1911	48.37	0	6.9	16.48	0.74	1.03	8.67
1912	45.91	0	6.9	13.02	0.71	1.12	8.73
1913	32.51	0	6.9	12.67	0.45	0.65	8.00
1914	36.06	0	6.9	15.01	0.50	0.66	8.07
1915	46.92	0	6.9	17.27	0.69	0.95	8.55
1916	31.16	0	6.9	12.31	0.41	0.64	7.95
1917	50.58	0	6.9	15.58	0.79	1.16	8.84
1918	37.07	0	6.9	13.68	0.51	0.79	8.20
1919	38.67	0	6.9	14.68	0.54	0.79	8.23
1920	45.83	0	6.9	16.34	0.67	0.97	8.54
1921	41.45	0	6.9	14.75	0.59	0.89	8.38
1922	48.12	0	6.9	14.65	0.74	1.12	8.76
1923	34.20	0	6.9	13.86	0.46	0.67	8.03
1924	36.53	0	6.9	14.96	0.49	0.71	8.10
1925	45.82	0	6.9	17.56	0.66	0.91	8.47
1926	37.20	0	6.9	13.30	0.53	0.80	8.23
1927	41.37	0	6.9	15.24	0.60	0.85	8.35
1928	45.78	0	6.9	13.70	0.70	1.08	8.68
1929	51.97	0	6.9	20.14	0.77	1.00	8.67
1930	48.05	0	6.9	14.46	0.72	1.14	8.77
1931	37.66	0	6.9	12.52	0.54	0.85	8.30
1932	48.90	0	6.9	17.12	0.72	1.04	8.66
1933	62.18	0	6.9	17.58	0.98	1.49	9.38
1934	35.86	0	6.9	11.17	0.51	0.86	8.27
1935	52.09	0	6.9	16.05	0.80	1.21	8.90
1936	42.98	0	6.9	15.67	0.63	0.88	8.42
1937	49.63	0	6.9	17.60	0.72	1.06	8.68
1938	26.62	0	6.9	12.74	0.33	0.44	7.67
1939	46.62	0	6.9	18.46	0.66	0.91	8.46
1940	30.97	0	6.9	10.99	0.43	0.68	8.01
1941	43.78	0	6.9	15.70	0.65	0.91	8.46
1942	37.47	0	6.9	14.23	0.53	0.76	8.19
1943	49.82	0	6.9	16.31	0.75	1.11	8.76
1944	50.74	0	6.9	18.81	0.74	1.03	8.67
1945	40.83	0	6.9	13.28	0.59	0.94	8.43
1946	34.17	0	6.9	13.91	0.46	0.67	8.02

Table E-3. Site Water Balance for No Action

Project No. 040001, DuPont, Washington

	Inflows			Outflows			
Year	Total Precipitation in inches	Total Surface Water Run-On in cfs	Groundwater Inflows in cfs	Evapo-transpiration in inches	Stormwater in cfs	Direct Groundwater Recharge in cfs	Total Groundwater Outflow in cfs
1947	38.87	0	6.9	14.59	0.55	0.80	8.25
1948	43.71	0	6.9	14.87	0.66	0.94	8.50
1949	31.37	0	6.9	13.16	0.42	0.59	7.91
1950	42.12	0	6.9	16.19	0.60	0.84	8.34
1951	46.83	0	6.9	15.39	0.72	1.03	8.65
1952	53.37	0	6.9	15.86	0.85	1.23	8.98
1953	35.77	0	6.9	11.59	0.53	0.81	8.24
1954	39.97	0	6.9	16.73	0.54	0.75	8.19
1955	30.18	0	6.9	12.57	0.40	0.58	7.88
1956	44.18	0	6.9	16.18	0.66	0.90	8.45
1957	58.24	0	6.9	17.02	0.92	1.37	9.19
1958	52.59	0	6.9	15.27	0.81	1.26	8.97
1959	33.13	0	6.9	10.33	0.48	0.79	8.17
1960	55.41	0	6.9	17.86	0.86	1.23	8.99
1961	36.29	0	6.9	12.51	0.54	0.78	8.22
1962	36.22	0	6.9	15.53	0.49	0.66	8.05
1963	33.33	0	6.9	12.61	0.46	0.69	8.05
1964	57.69	0	6.9	18.56	0.92	1.25	9.07
1965	28.52	0	6.9	9.03	0.40	0.68	7.98
1966	38.98	0	6.9	16.62	0.55	0.69	8.14
1967	43.40	0	6.9	14.50	0.64	0.96	8.51
1968	37.92	0	6.9	15.10	0.53	0.74	8.17
1969	45.01	0	6.9	15.97	0.66	0.95	8.51
1970	44.55	0	6.9	14.03	0.68	1.02	8.59
1971	45.61	0	6.9	15.45	0.68	1.00	8.57
1972	51.44	0	6.9	14.04	0.82	1.26	8.98
1973	43.43	0	6.9	14.57	0.64	0.97	8.50
1974	45.51	0	6.9	15.92	0.69	0.95	8.54
1975	46.93	0	6.9	14.59	0.71	1.09	8.70
1976	36.53	0	6.9	13.24	0.52	0.77	8.19
1977	57.46	0	6.9	16.26	0.91	1.38	9.19
1978	35.73	0	6.9	12.85	0.51	0.76	8.17
1979	44.96	0	6.9	15.51	0.67	0.97	8.54
1980	42.56	0	6.9	14.51	0.63	0.93	8.46
1981	38.36	0	6.9	15.42	0.52	0.75	8.17
1982	48.39	0	6.9	16.01	0.72	1.07	8.70
1983	34.00	0	6.9	12.86	0.46	0.71	8.07
1984	38.65	0	6.9	14.19	0.57	0.79	8.26
1985	36.02	0	6.9	14.00	0.49	0.73	8.12
1986	39.21	0	6.9	14.05	0.58	0.81	8.30
1987	35.69	0	6.9	12.69	0.52	0.75	8.18
1988	36.33	0	6.9	13.88	0.52	0.72	8.15
1989	44.58	0	6.9	18.11	0.64	0.83	8.37
1990	47.15	0	6.9	13.12	0.72	1.17	8.79
1991	46.79	0	6.9	13.71	0.73	1.11	8.74
1992	52.29	0	6.9	17.95	0.79	1.11	8.81

Table E-3. Site Water Balance for No Action

Project No. 040001, DuPont, Washington

	Inflows			Outflows			
Year	Total Precipitation in inches	Total Surface Water Run-On in cfs	Groundwater Inflows in cfs	Evapo-transpiration in inches	Stormwater in cfs	Direct Groundwater Recharge in cfs	Total Groundwater Outflow in cfs
1993	44.54	0	6.9	12.23	0.68	1.12	8.69
1994	33.69	0	6.9	13.11	0.47	0.68	8.04
1995	61.78	0	6.9	16.24	1.01	1.52	9.43
1996	40.75	0	6.9	14.58	0.59	0.86	8.35
1997	43.33	0	6.9	16.08	0.62	0.89	8.41
1998	23.49	0	6.9	10.68	0.29	0.42	7.61
1999	44.25	0	6.9	18.54	0.63	0.80	8.33
2000	31.82	0	6.9	11.87	0.43	0.67	8.01
2001	41.20	0	6.9	14.60	0.60	0.87	8.38
2002	37.41	0	6.9	14.08	0.54	0.76	8.20
2003	46.97	0	6.9	15.14	0.72	1.05	8.67
2004	57.63	0	6.9	19.74	0.88	1.23	9.00
2005	43.60	0	6.9	12.37	0.65	1.08	8.63
2006	35.32	0	6.9	11.04	0.52	0.82	8.25
2007	37.55	0	6.9	14.31	0.54	0.75	8.19
2008	40.60	0	6.9	15.46	0.59	0.81	8.30
2009	35.07	0	6.9	13.14	0.50	0.71	8.12
2010	33.78	0	6.9	13.18	0.48	0.67	8.04
2011	34.09	0	6.9	13.76	0.48	0.65	8.03
2012	38.96	0	6.9	15.06	0.56	0.76	8.23
2013	30.12	0	6.9	11.39	0.42	0.62	7.94
2014	43.52	0	6.9	17.71	0.63	0.81	8.33
2015	25.74	0	6.9	9.40	0.35	0.56	7.81
2016	50.36	0	6.9	18.58	0.76	1.01	8.66
2017	56.54	0	6.9	15.78	0.89	1.38	9.16
2018	58.35	0	6.9	17.23	0.92	1.37	9.18
2019	43.38	0	6.9	14.12	0.64	0.99	8.52
2020	52.71	0	6.9	15.67	0.81	1.24	8.96
2021	37.15	0	6.9	14.75	0.51	0.73	8.14
2022	49.81	0	6.9	15.58	0.77	1.13	8.80
2023	37.80	0	6.9	14.65	0.52	0.76	8.19
2024	39.84	0	6.9	14.75	0.58	0.82	8.29
2025	45.58	0	6.9	16.51	0.65	0.97	8.51
2026	35.92	0	6.9	12.97	0.51	0.76	8.17
2027	31.55	0	6.9	14.07	0.40	0.57	7.87
2028	43.54	0	6.9	14.17	0.65	0.98	8.53
2029	47.68	0	6.9	16.24	0.72	1.03	8.65
2030	34.39	0	6.9	11.78	0.49	0.77	8.16
2031	35.52	0	6.9	14.83	0.48	0.67	8.05
2032	35.66	0	6.9	14.83	0.50	0.66	8.06
2033	43.89	0	6.9	17.36	0.62	0.85	8.37
2034	35.91	0	6.9	11.96	0.53	0.80	8.23
2035	45.85	0	6.9	16.49	0.68	0.95	8.53
2036	27.87	0	6.9	10.47	0.40	0.57	7.87
2037	48.88	0	6.9	16.44	0.75	1.05	8.70
2038	28.10	0	6.9	12.94	0.35	0.49	7.74

Table E-3. Site Water Balance for No Action

Project No. 040001, DuPont, Washington

	Inflows			Outflows			
Year	Total Precipitation in inches	Total Surface Water Run-On in cfs	Groundwater Inflows in cfs	Evapo-transpiration in inches	Stormwater in cfs	Direct Groundwater Recharge in cfs	Total Groundwater Outflow in cfs
2039	36.26	0	6.9	16.09	0.49	0.63	8.02
2040	33.69	0	6.9	13.50	0.45	0.68	8.02
2041	46.65	0	6.9	18.18	0.68	0.90	8.48
2042	53.77	0	6.9	17.80	0.80	1.20	8.90
2043	51.49	0	6.9	13.78	0.80	1.30	8.99
2044	51.64	0	6.9	17.17	0.77	1.14	8.81
2045	52.33	0	6.9	15.36	0.81	1.25	8.95
2046	36.35	0	6.9	12.28	0.52	0.82	8.24
2047	42.13	0	6.9	16.60	0.60	0.82	8.32
2048	41.81	0	6.9	14.25	0.62	0.91	8.43
2049	36.96	0	6.9	14.79	0.52	0.71	8.13
2050	46.15	0	6.9	15.87	0.68	1.00	8.58
2051	45.24	0	6.9	14.87	0.67	1.01	8.59
2052	48.60	0	6.9	16.45	0.71	1.08	8.69
2053	45.60	0	6.9	14.17	0.72	1.03	8.65
2054	37.71	0	6.9	15.06	0.51	0.75	8.16
2055	33.13	0	6.9	12.90	0.45	0.67	8.02
2056	46.21	0	6.9	16.88	0.68	0.95	8.53
2057	41.86	0	6.9	12.85	0.63	0.98	8.51
2058	67.38	0	6.9	19.34	1.10	1.57	9.57
Average	41.99	0	6.90	14.80	0.61	0.90	8.41
Average in inches	41.99	0	124.26	14.80	11.07	16.12	151.44

Notes:

1) Stormwater is the sum of surface runoff and interflow.

2) Under existing conditions, all stormwater infiltrates within the mine area or on the South Parcel.

3) Total Groundwater outflow is the sum of stormwater + direct groundwater recharge + groundwater inflows.

4) Average flows in cfs are converted to inches by calculating the total volume in cubic feet for the year, then dividing by the project area of 482.4 acres

APPENDIX F

Wetland Water Balance Calculations

MARSH WATER BALANCE FIGURES

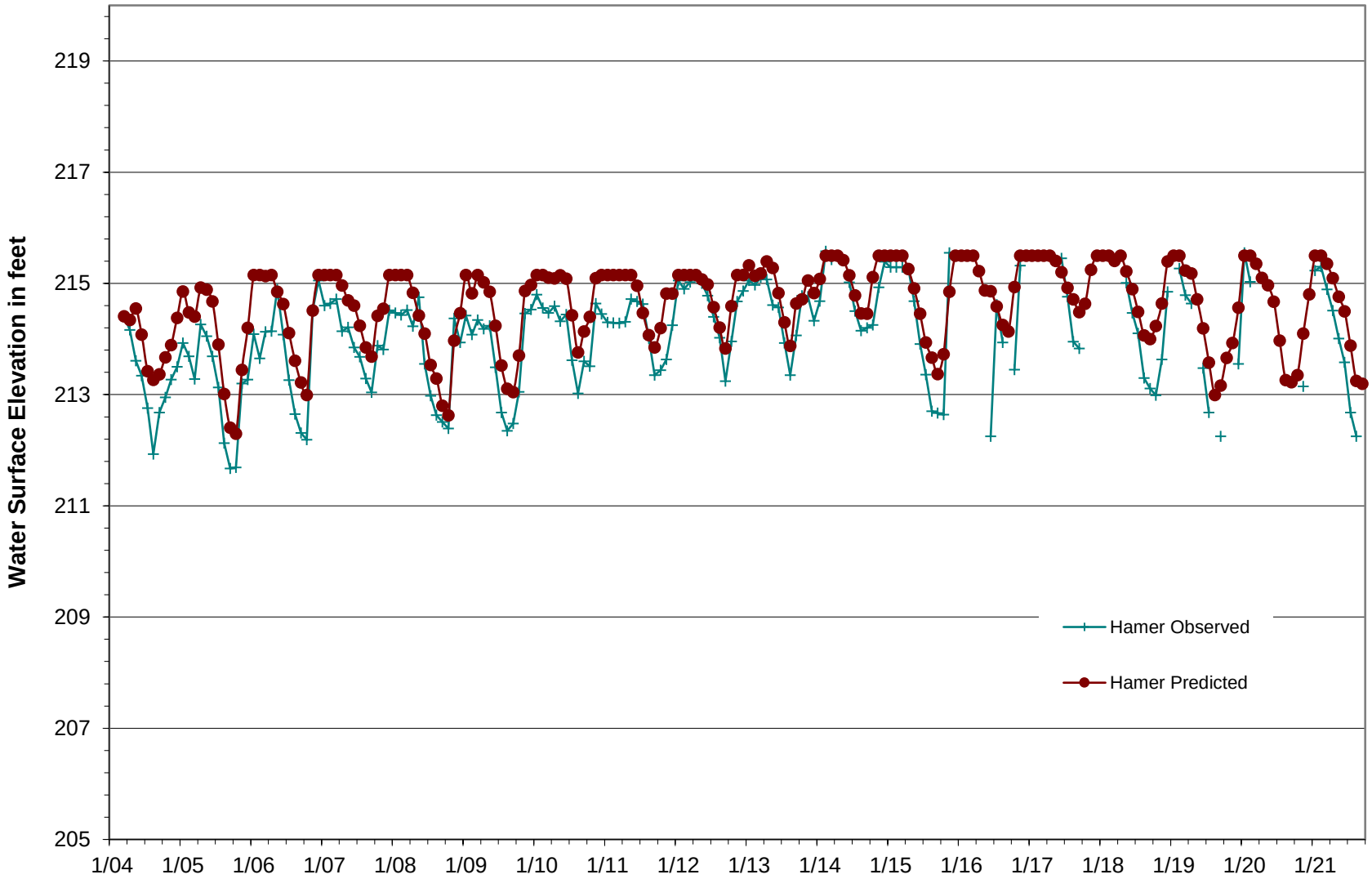


Figure F-1

Predicted Water Levels for Hamer Marsh under Existing Conditions

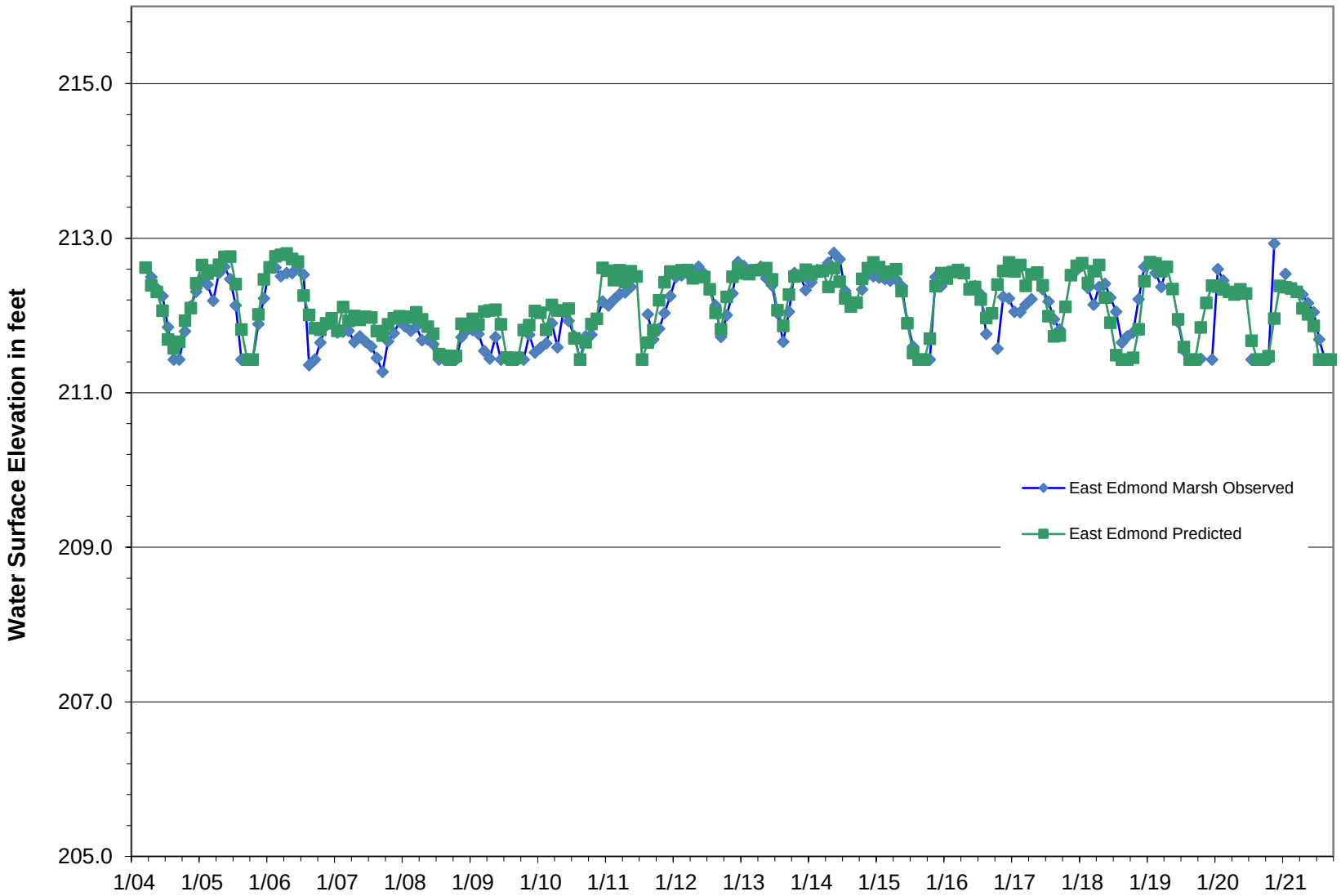


Figure F-2

Predicted Water Levels for East Edmond Marsh under Existing Conditions

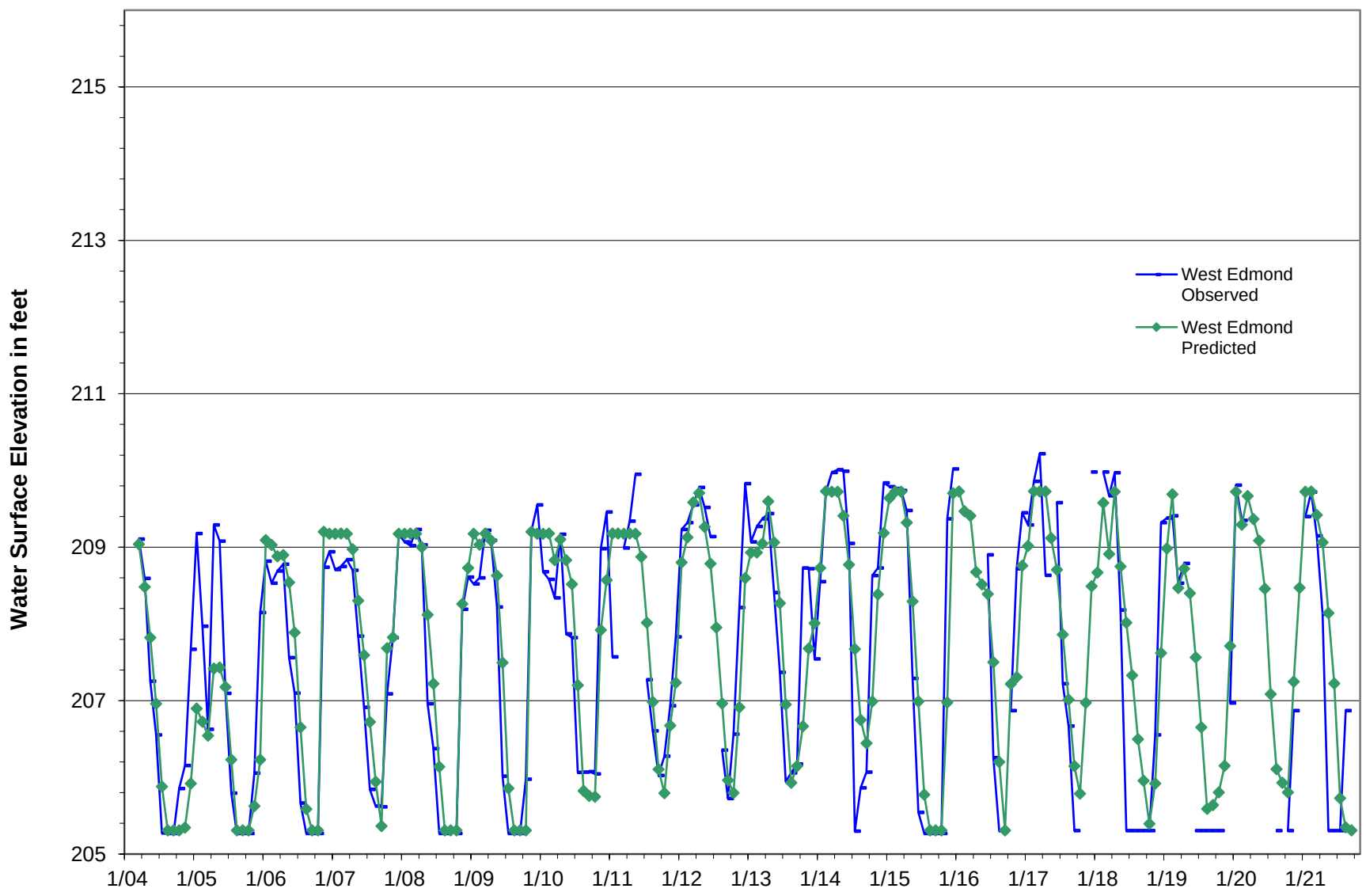


Figure F-3

Predicted Water Levels for West Edmond Marsh under Existing Conditions

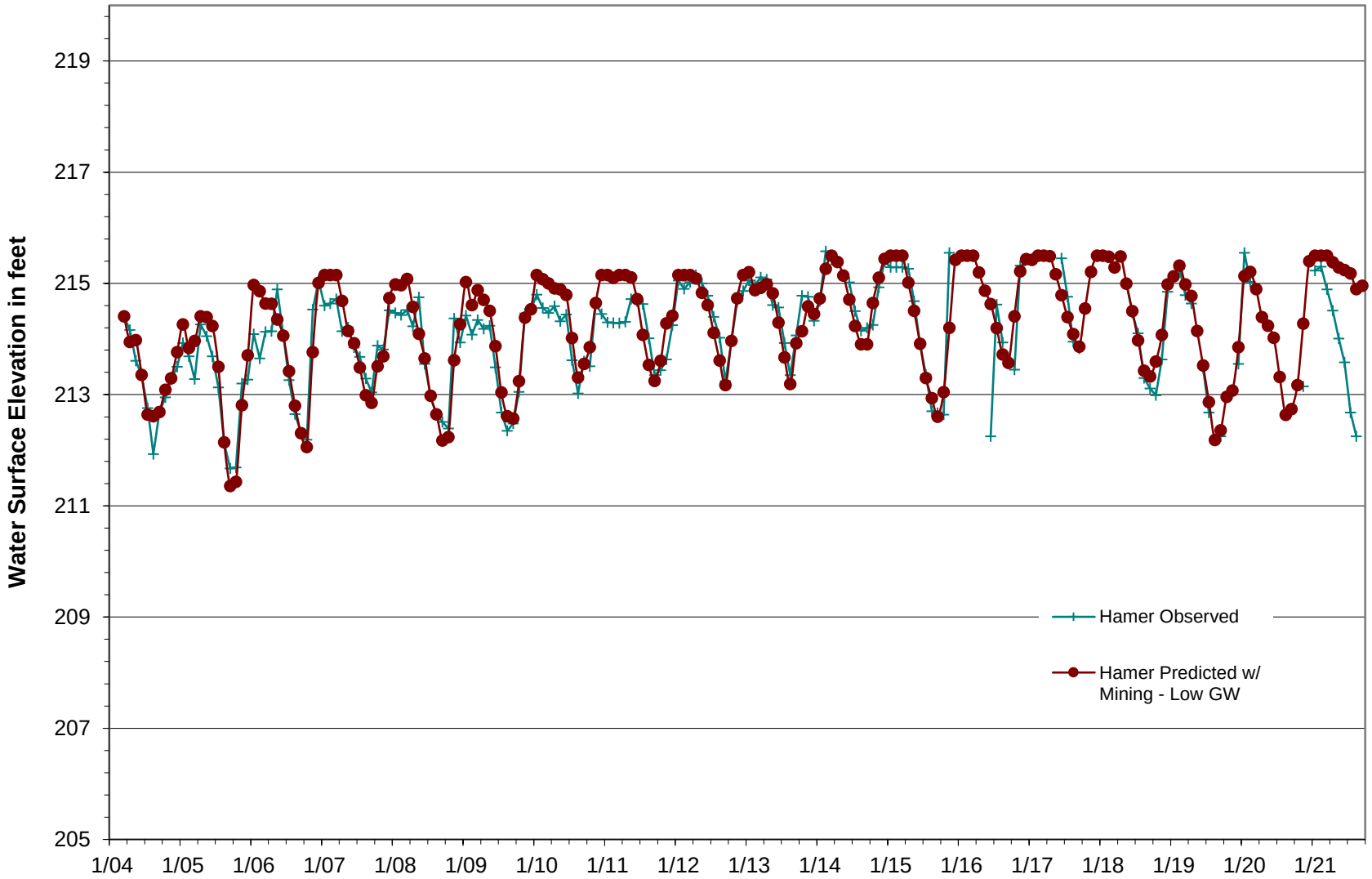


Figure F-4

Predicted Water Levels for Hamer Marsh with Mining - Low Groundwater

Earth and Water Resources Report

DuPont, WA

Aspect Consulting

10/28/2022

S:\CalPortland\DuPont\South Parcel\Water Balance Analyses\Water Balance -2022 - Mining.xlsm

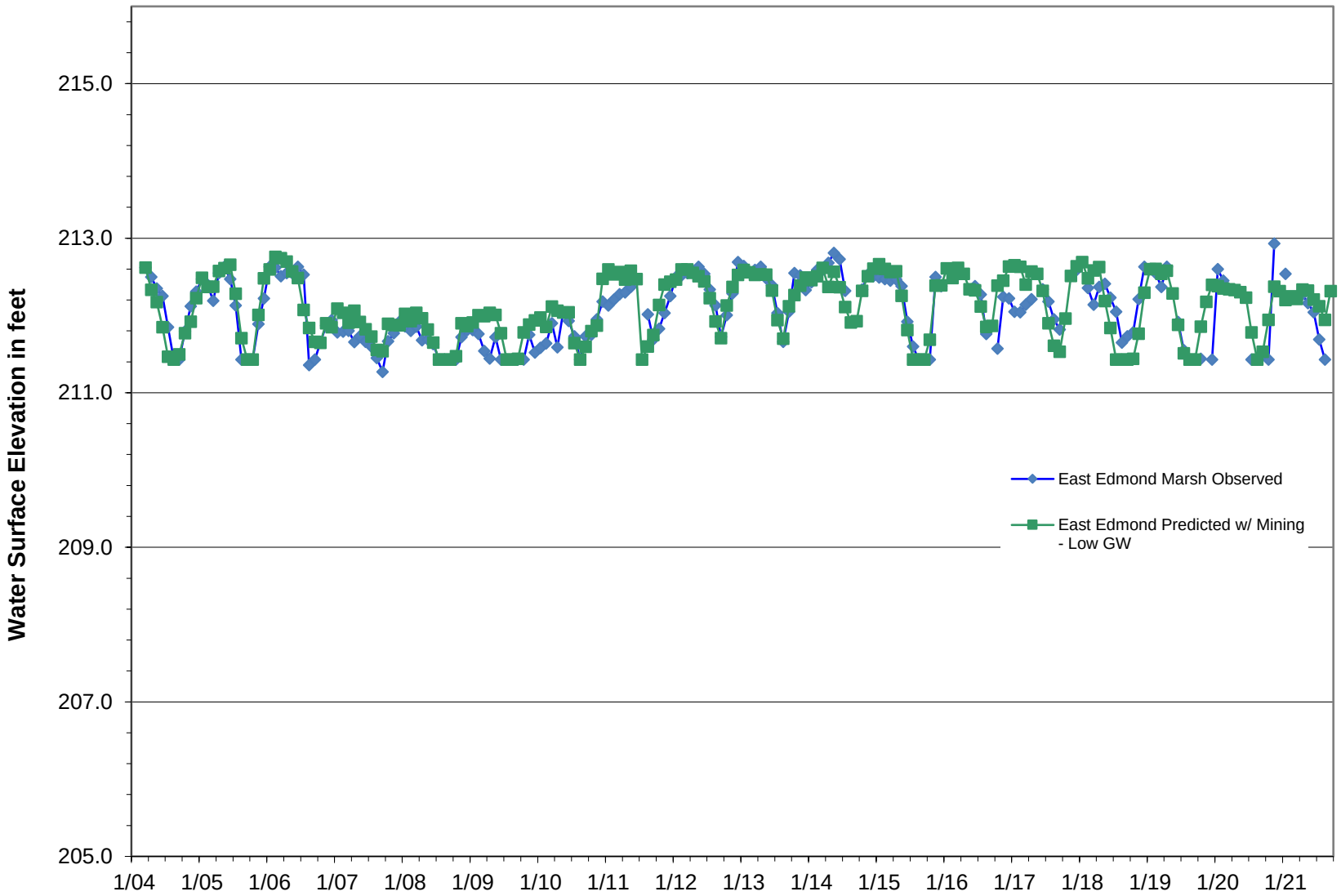


Figure F-5

Predicted Water Levels for East Edmond Marsh with Mining - Low Groundwater

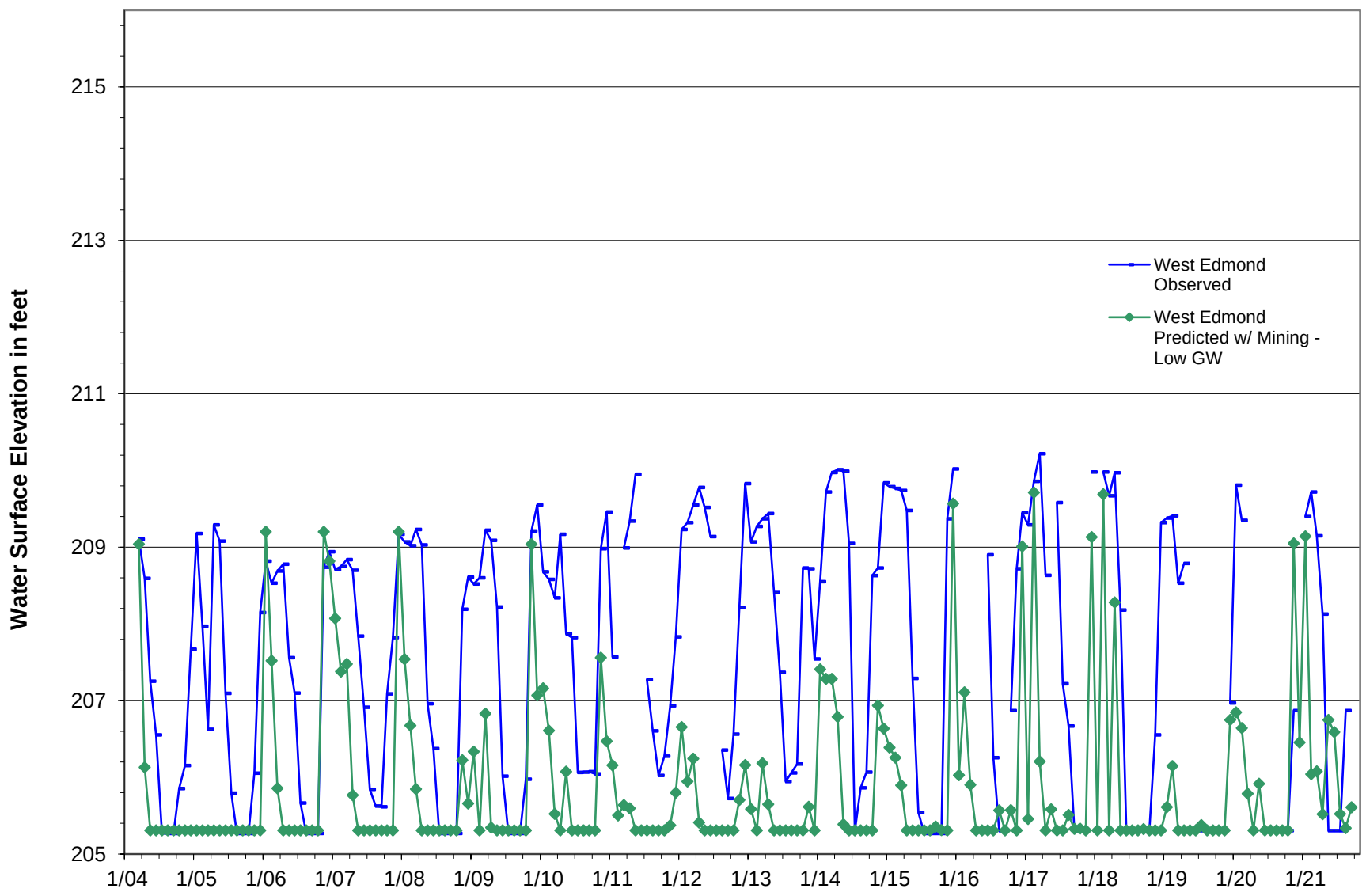


Figure F-6

Predicted Water Levels for West Edmond Marsh with Mining - Low GW

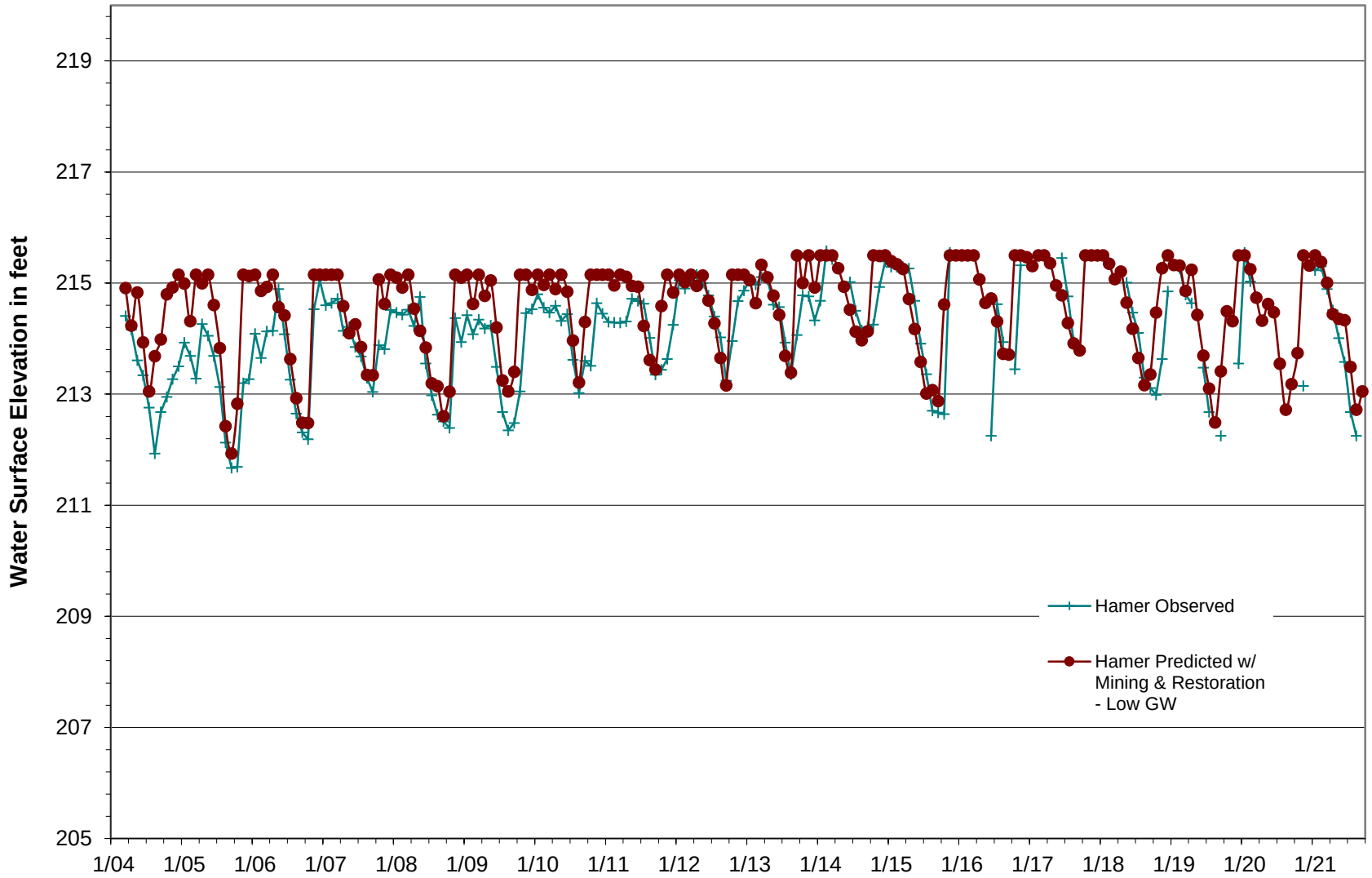


Figure F-7

Predicted Water Levels for Hamer Marsh with Mining + Restoration - Low Groundwater

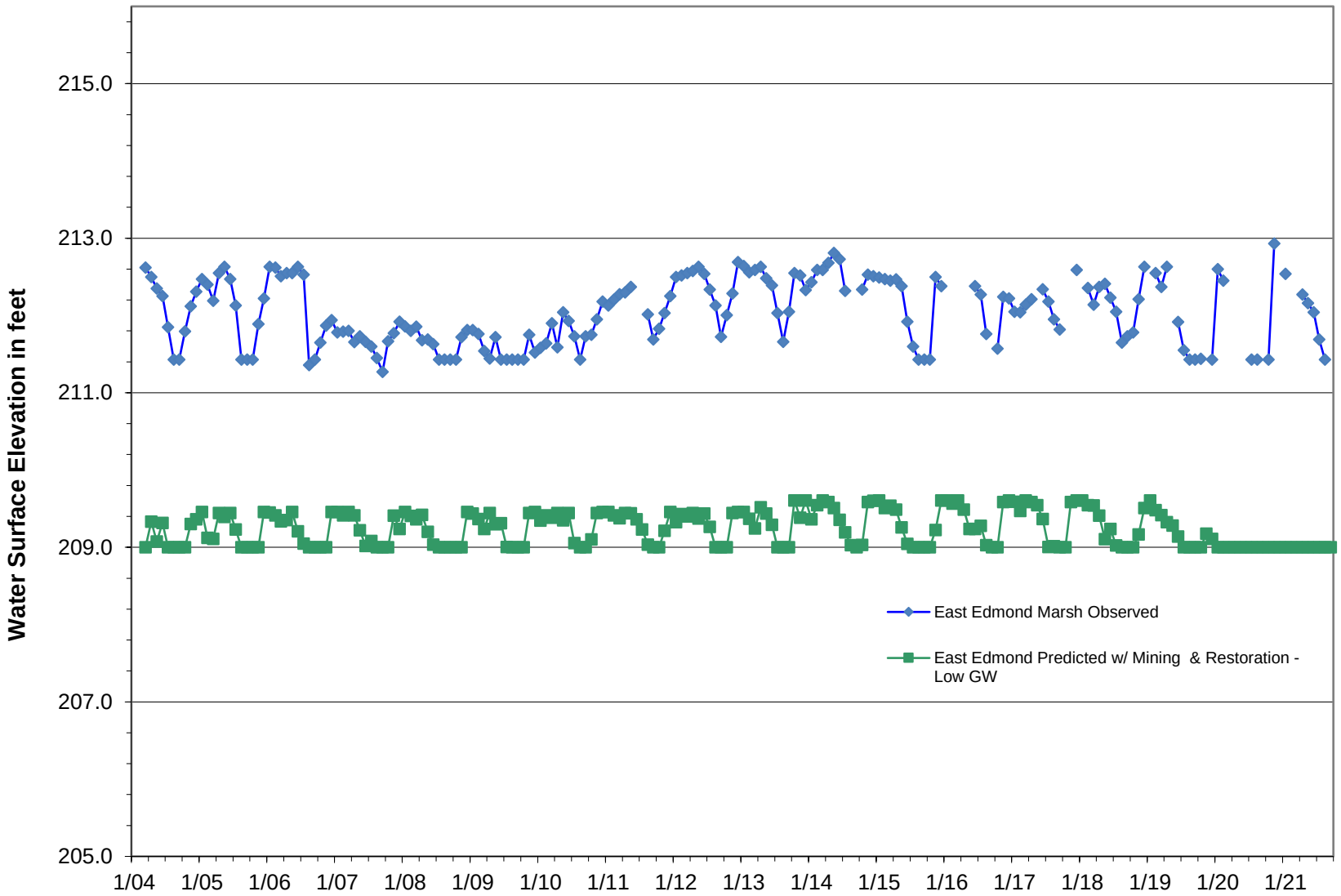


Figure F-8
Predicted Water Levels for East Edmond Marsh with Mining + Restoration - Low Groundwater

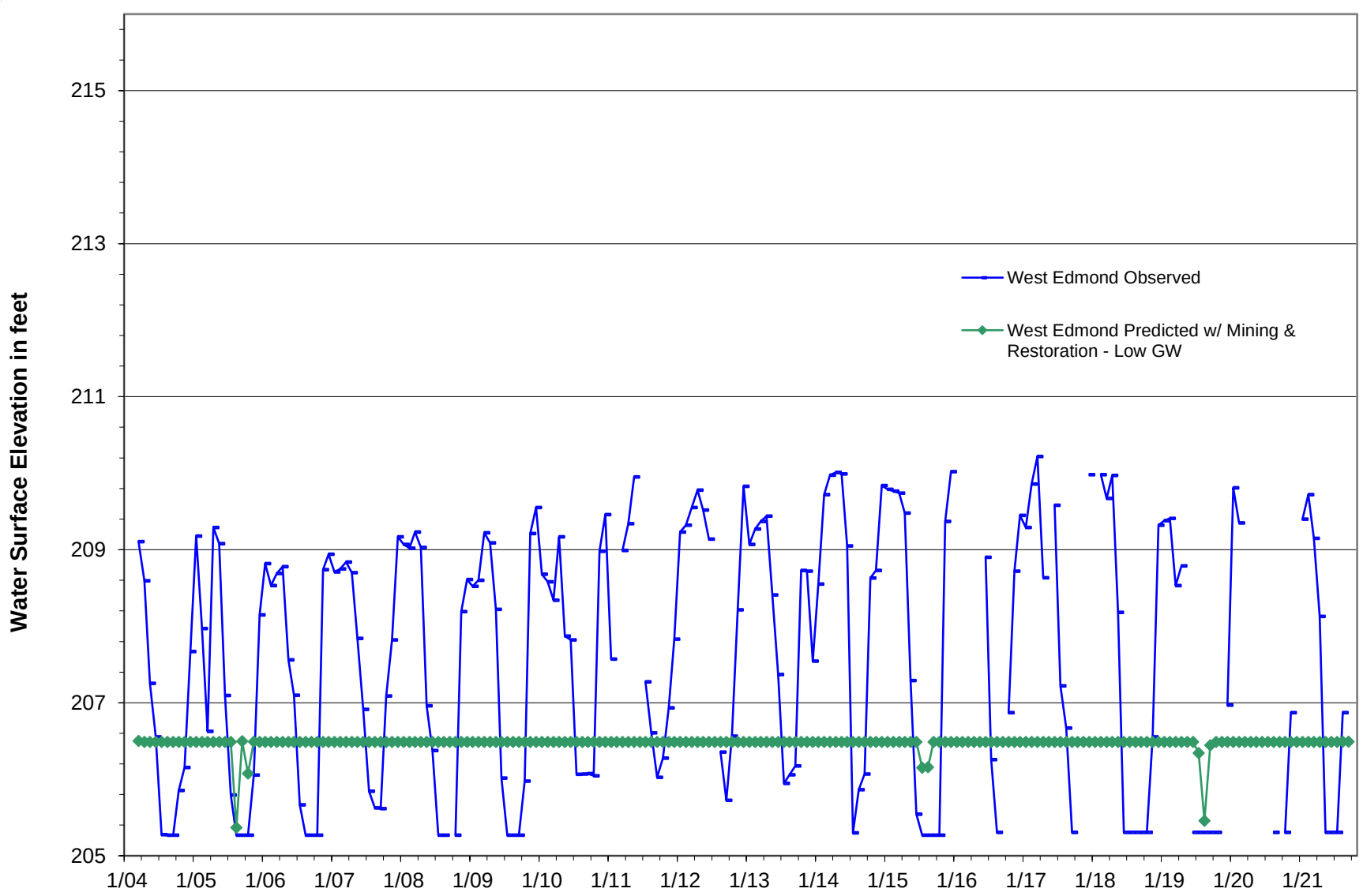


Figure F-9

Predicted Water Levels for West Edmond Marsh with Mining + Restoration - Low GW

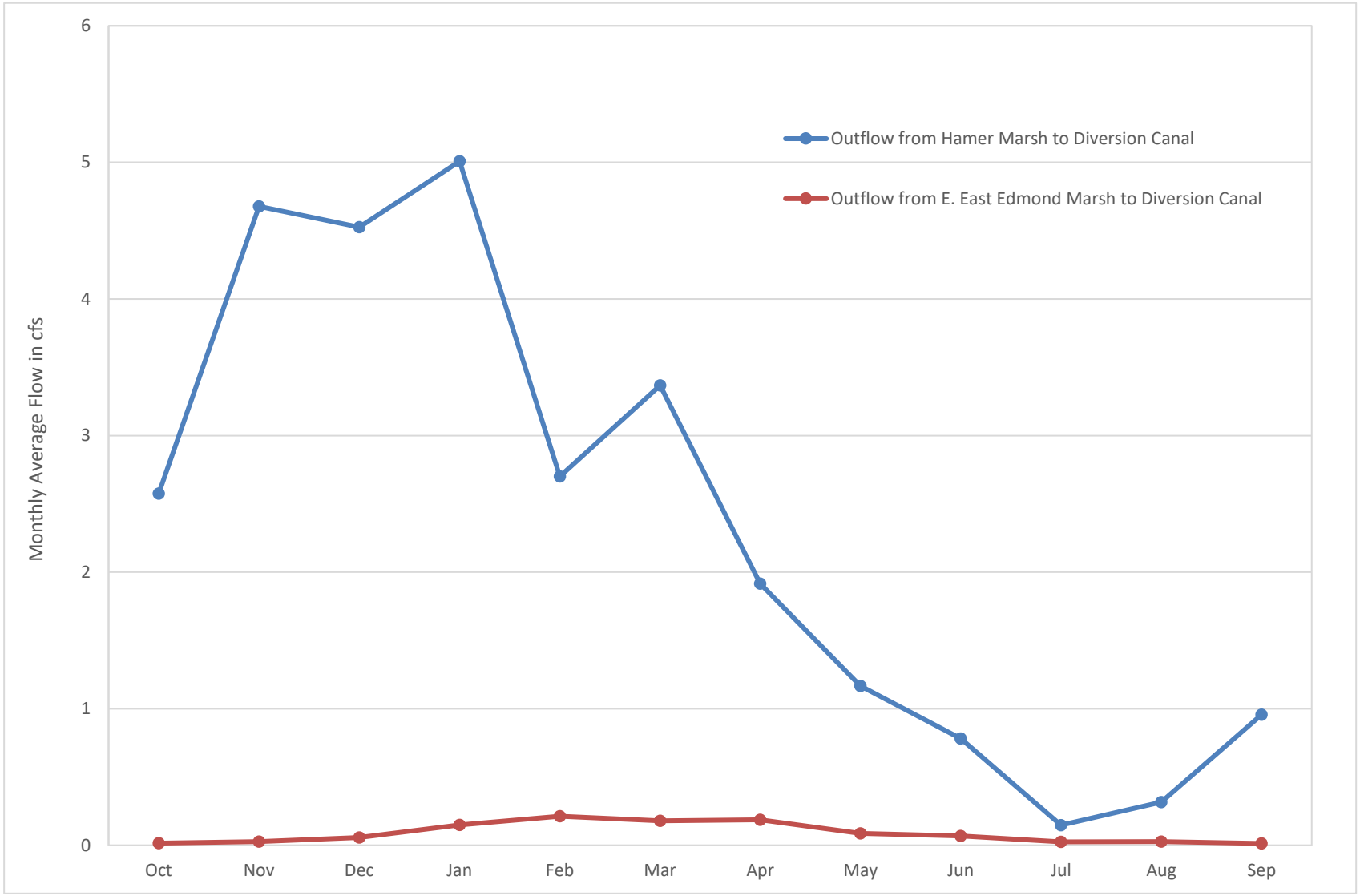


Figure F-10
Marsh Outflow to Diversion Canal under Existing Conditions

MARSH WATER BALANCE MONTHLY AVERAGE TABLES

Table F-1. Annual Average Water Balance for Bell, McKay, and Hamer Marshes - Existing Conditions

CalPortland DuPont - 040001

Flow

	Monthly Average in cfs												
Hydrologic Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average in cfs
Precipitation	0.6	0.9	0.9	1.0	0.7	0.8	0.6	0.4	0.3	0.1	0.1	0.3	0.6
Surface Water Inflows	3.2	5.4	4.8	5.2	2.8	3.5	2.2	1.5	1.0	0.2	0.4	1.2	2.6
Runoff from Ft. Lewis - Outfall 002	1.9	3.3	3.0	3.2	1.7	2.2	1.3	0.9	0.6	0.1	0.2	0.7	1.6
Runoff from Ft. Lewis - Outfall 003	1.2	2.1	1.9	2.0	1.1	1.4	0.9	0.6	0.4	0.1	0.2	0.5	1.0
Evapotranspiration	-0.1	-0.1	0.0	0.0	-0.1	-0.2	-0.3	-0.5	-0.6	-0.7	-0.6	-0.3	-0.3
Recharge (-) Discharge (+)	-0.3	0.1	0.0	0.1	0.1	0.0	0.2	0.1	0.1	0.0	-0.1	-0.1	0.0
Surface Water Outflows	-2.6	-4.8	-4.8	-5.4	-3.2	-3.9	-2.4	-1.6	-1.1	-0.3	-0.4	-1.0	-2.6
To Diversion Canal	-2.6	-4.7	-4.5	-5.0	-2.7	-3.4	-1.9	-1.2	-0.8	-0.1	-0.3	-1.0	-2.3
To E. East Edmond. Marsh (surface)	-0.04	-0.13	-0.30	-0.44	-0.55	-0.53	-0.49	-0.41	-0.35	-0.11	-0.04	-0.03	-0.28
Subsurface Outflows	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.3
Change in Storage	0.5	1.2	0.6	0.5	-0.1	-0.1	-0.1	-0.3	-0.5	-1.0	-0.8	-0.2	0.0

Water Volume

	Average Monthly Volume in AF												
Hydrologic Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Avg. Annual Volume in AF
Precipitation	38	53	55	59	40	46	34	25	20	6	8	18	401
Surface Water Inflows	196	319	297	319	157	218	131	92	62	11	24	71	1898
Runoff from Ft. Lewis - Outfall 002	120	194	181	195	96	133	80	56	37	6	14	43	1156
Runoff from Ft. Lewis - Outfall 003	76	125	116	125	61	85	51	36	24	5	9	28	741
Evapotranspiration	-9	-4	0	0	-6	-12	-19	-31	-35	-42	-35	-20	-214
Recharge (-) Discharge (+)	-16	6	1	8	4	0	10	8	7	0	-6	-6	15
Surface Water Outflows	-161	-286	-297	-335	-181	-239	-143	-97	-67	-16	-22	-59	-1903
To Diversion Canal	-158	-278	-278	-308	-150	-207	-114	-72	-47	-9	-19	-57	-1698
To E. East Edmond. Marsh (surface)	-3	-8	-19	-27	-31	-32	-29	-25	-21	-7	-2	-2	-205
Subsurface Outflows	-15	-18	-18	-20	-18	-19	-19	-19	-18	-17	-15	-14	-210
Change in Storage	33	69	37	31	-3	-6	-7	-21	-32	-59	-47	-10	-13

Table F-2. Annual Average Water Balance for East Edmond Marsh - Existing Conditions

CalPortland DuPont - 040001

Flow

	Monthly Average in cfs												
Hydrologic Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average in cfs
Precipitation	0.6	0.9	0.9	1.0	0.7	0.7	0.6	0.4	0.3	0.1	0.1	0.3	0.5
Surface Water Inflows	0.1	0.2	0.3	0.5	0.6	0.5	0.5	0.4	0.4	0.1	0.0	0.0	0.3
From Sequalitchew Lake	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
From Center Drive	0.03	0.04	0.04	0.04	0.02	0.03	0.02	0.01	0.01	0.00	0.00	0.01	0.02
From Hamer (surface)	0.04	0.13	0.30	0.44	0.55	0.53	0.49	0.41	0.35	0.11	0.04	0.03	0.28
Subsurface Inflows	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.3
Evapotranspiration	-0.1	-0.1	0.0	0.0	-0.1	-0.2	-0.3	-0.5	-0.6	-0.7	-0.6	-0.3	-0.3
Recharge (-) Discharge (+)	-0.3	-0.3	-0.4	-0.5	-0.6	-0.6	-0.6	-0.6	-0.5	-0.6	-0.3	-0.3	-0.5
Surface Water Outflows	-0.1	-0.6	-0.7	-1.2	-1.0	-0.9	-0.7	-0.2	-0.2	-0.1	-0.1	0.0	-0.5
To Diversion Canal	-0.1	-0.3	-0.4	-0.8	-0.7	-0.6	-0.5	-0.2	-0.1	0.0	0.0	0.0	-0.3
To West Edmond Marsh	-0.03	-0.24	-0.28	-0.48	-0.36	-0.31	-0.22	-0.06	-0.05	-0.01	-0.01	-0.01	-0.17
Change in Storage	0.4	0.5	0.4	0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.8	-0.5	-0.1	-0.1

Water Volume

	Average Monthly Volume in AF												
Hydrologic Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Avg. Annual Volume
Precipitation	37	53	54	59	39	46	33	25	20	6	8	18	398
Surface Water Inflows	4	10	21	29	32	34	30	26	21	7	3	2	220
From Sequalitchew Lake	0	0	0	0	0	0	0	0	0	0	0	0	0
From Center Drive	2	2	2	2	1	2	1	1	1	0	0	1	16
From Hamer (surface)	3	8	19	27	31	32	29	25	21	7	2	2	205
Subsurface Inflows	15	18	18	20	18	19	19	19	18	17	15	14	210
Evapotranspiration	-8	-4	0	0	-6	-12	-19	-31	-35	-41	-34	-19	-210
Recharge (-) Discharge (+)	-20	-17	-27	-33	-33	-39	-34	-37	-31	-37	-16	-17	-341
Surface Water Outflows	-6	-33	-42	-76	-58	-53	-42	-13	-10	-3	-4	-2	-342
To Diversion Canal	-4	-19	-25	-46	-38	-34	-28	-10	-8	-3	-3	-1	-218
To West Edmond Marsh	-2	-14	-17	-29	-20	-19	-13	-3	-3	-1	-1	0	-124
Change in Storage	21.9	28.1	24.4	-0.9	-8.1	-6.0	-11.7	-10.5	-18.3	-51.5	-28.0	-3.1	-64.0

Table F-3. Annual Average Water Balance for West Edmond Marsh - Existing Conditions

CalPortland DuPont - 040001

Flow

	Monthly Average in cfs												
Hydrologic Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average in cfs
Precipitation	0.07	0.10	0.19	0.27	0.23	0.25	0.18	0.14	0.10	0.03	0.02	0.04	0.14
Surface Water Inflows	0.03	0.24	0.28	0.48	0.36	0.31	0.22	0.06	0.05	0.01	0.01	0.01	0.17
From East Edmond	0.03	0.24	0.28	0.48	0.36	0.31	0.22	0.06	0.05	0.01	0.01	0.01	0.17
Evapotranspiration	-0.02	-0.01	0.00	0.00	-0.03	-0.07	-0.11	-0.16	-0.19	-0.18	-0.12	-0.05	-0.08
Recharge (-) Discharge (+)	-0.08	-0.04	-0.11	-0.23	-0.28	-0.30	-0.26	-0.36	-0.42	-0.43	-0.27	-0.12	-0.24
Surface Water Outflows	0.00	-0.06	-0.13	-0.17	-0.12	-0.19	-0.07	-0.03	-0.01	-0.01	-0.01	0.00	-0.07
To Center Drive	0.00	-0.06	-0.13	-0.17	-0.12	-0.19	-0.07	-0.03	-0.01	-0.01	-0.01	0.00	-0.07
Change in Storage	0.00	0.23	0.23	0.35	0.16	0.00	-0.03	-0.36	-0.48	-0.58	-0.36	-0.12	-0.1

Water Volume

	Average Monthly Volume in AF												
Hydrologic Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Avg. Annual Volume
Precipitation	4	6	12	17	13	15	11	8	6	2	1	2	98
Surface Water Inflows	2	14	17	29	20	19	13	3	3	1	1	0	124
From East Edmond	2	14	17	29	20	19	13	3	3	1	1	0	124
Evapotranspiration	-1	-1	0	0	-2	-4	-6	-10	-11	-11	-7	-3	-56
Recharge (-) Discharge (+)	-5	-2	-7	-14	-16	-18	-15	-22	-25	-27	-17	-7	-175
Surface Water Outflows	0	-3	-8	-11	-7	-12	-4	-2	-1	-1	0	0	-49
To Center Drive	0	-3	-8	-11	-7	-12	-4	-2	-1	-1	0	0	-49
Change in Storage	0.1	13.8	14.4	21.8	9.2	0.0	-1.9	-22.0	-28.3	-35.9	-22.3	-7.3	-58.6

Table F-4. Annual Average Water Balance for Bell, McKay, and Hamer Marshes with Mining - Low Groundwater

Flow

	Monthly Average in cfs												
Hydrologic Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average in cfs
Precipitation	0.6	0.8	0.9	1.0	0.7	0.8	0.6	0.4	0.3	0.1	0.1	0.3	0.5
Surface Water Inflows	3.2	5.4	4.8	5.2	2.8	3.5	2.2	1.5	1.0	0.2	0.4	1.2	2.6
Runoff from Ft. Lewis - Outfall 002	1.9	3.3	3.0	3.2	1.7	2.2	1.3	0.9	0.6	0.1	0.2	0.7	1.6
Runoff from Ft. Lewis - Outfall 003	1.2	2.1	1.9	2.0	1.1	1.4	0.9	0.6	0.4	0.1	0.2	0.5	1.0
Evapotranspiration	-0.1	-0.1	0.0	0.0	-0.1	-0.2	-0.3	-0.5	-0.6	-0.7	-0.6	-0.3	-0.3
Recharge (-) Discharge (+)	-0.2	0.0	0.0	-0.1	-0.3	-0.2	-0.3	-0.2	-0.2	-0.2	-0.3	-0.2	-0.2
Surface Water Outflows	-2.6	-4.7	-4.4	-5.2	-3.0	-3.7	-2.2	-1.5	-1.0	-0.2	-0.3	-1.0	-2.5
To Diversion Canal	-2.6	-4.6	-4.2	-4.8	-2.5	-3.2	-1.7	-1.2	-0.8	-0.2	-0.3	-1.0	-2.3
To Seq. Ck. Marsh (surface)	0.0	0.0	-0.2	-0.4	-0.5	-0.5	-0.4	-0.3	-0.2	-0.1	0.0	0.0	-0.2
Subsurface Outflows	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
Change in Storage	0.7	1.3	1.0	0.6	-0.1	-0.1	-0.3	-0.5	-0.7	-1.0	-0.9	-0.2	0.0

Water Volume

	Average Monthly Volume in AF												
Hydrologic Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Avg. Annual Volume
Precipitation	35	51	53	59	41	47	34	25	20	6	8	17	395
Surface Water Inflows	196	319	297	319	157	218	131	92	62	11	24	71	1897
Runoff from Ft. Lewis - Outfall 002	120	194	181	195	96	133	80	56	37	6	14	43	1156
Runoff from Ft. Lewis - Outfall 003	76	125	116	125	61	85	51	36	24	5	9	28	741
Evapotranspiration	-8	-4	0	0	-6	-13	-20	-31	-36	-41	-34	-19	-210
Recharge (-) Discharge (+)	-12	3	-2	-4	-15	-11	-19	-12	-12	-12	-19	-11	-126
Surface Water Outflows	-158	-279	-268	-317	-165	-228	-130	-91	-62	-14	-20	-58	-1791
To Diversion Canal	-158	-276	-258	-295	-137	-199	-104	-71	-48	-10	-20	-57	-1633
To Seq. Ck. Marsh (surface)	0	-2	-10	-22	-28	-29	-26	-20	-14	-4	-1	-1	-158
Subsurface Outflows	-11	-15	-17	-18	-15	-17	-15	-15	-13	-13	-11	-10	-170
Change in Storage	41	75	64	40	-4	-4	-19	-31	-42	-63	-53	-10	-6

Table F-5. Annual Average Water Balance for East Edmond Marsh with Mining - Low Groundwater

Flow

	Monthly Average in cfs												
Hydrologic Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average in cfs
Precipitation	0.6	0.9	0.9	0.9	0.7	0.7	0.6	0.4	0.3	0.1	0.1	0.3	0.5
Surface Water Inflows	0.0	0.1	0.2	0.4	0.5	0.5	0.5	0.3	0.3	0.1	0.0	0.0	0.2
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Hamer (surface)	0.0	0.0	0.2	0.4	0.5	0.5	0.4	0.3	0.2	0.1	0.0	0.0	0.2
Subsurface Inflows	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Evapotranspiration	-0.1	-0.1	0.0	0.0	-0.1	-0.2	-0.3	-0.5	-0.6	-0.7	-0.6	-0.3	-0.3
Recharge (-) Discharge (+)	-0.2	-0.1	-0.3	-0.4	-0.5	-0.6	-0.5	-0.5	-0.4	-0.4	-0.2	-0.2	-0.4
Surface Water Outflows	0.0	-0.2	-0.4	-0.5	-0.6	-0.5	-0.3	-0.1	-0.1	0.0	0.0	0.0	-0.2
To Diversion Canal	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.2	-0.1	-0.1	0.0	0.0	0.0	-0.1
To West Edmond Marsh	-0.01	-0.22	-0.32	-0.41	-0.37	-0.28	-0.18	-0.07	-0.06	-0.01	-0.01	-0.01	-0.16
Change in Storage	0.4	0.8	0.7	0.7	0.3	0.3	0.1	-0.1	-0.3	-0.8	-0.4	0.0	0.1

Water Volume

	Average Monthly Volume in AF												
Hydrologic Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Avg. Annual Volume
Precipitation	36	53	53	58	39	46	33	25	20	6	8	18	395
Surface Water Inflows	2	5	13	24	29	30	27	21	15	4	1	2	173
From Sequalitchew Lake	0	0	0	0	0	0	0	0	0	0	0	0	0
From Center Drive	2	2	2	2	1	2	1	1	1	0	0	1	16
From Hamer (surface)	0.0	2.5	10.2	22.1	27.9	29.0	26.1	20.2	14.4	3.7	0.5	1.3	158
Subsurface Inflows	11	15	17	18	15	17	15	15	13	13	11	10	170
Evapotranspiration	-8	-4	0	0	-6	-12	-19	-31	-35	-41	-34	-19	-209
Recharge (-) Discharge (+)	-13	-8	-16	-27	-29	-35	-30	-31	-23	-27	-9	-10	-259
Surface Water Outflows	-1	-15	-23	-33	-32	-29	-20	-9	-8	-3	-2	-1	-175
To Diversion Canal	-1	-1	-3	-8	-11	-11	-10	-5	-4	-2	-1	-1	-59
To West Edmond Marsh	-1	-13	-20	-25	-20	-17	-11	-4	-3	-1	-1	0	-116
Change in Storage	26.4	45.2	43.8	40.3	17.7	17.2	5.6	-9.1	-18.2	-48.4	-26.0	0.2	94.9

Table F-6. Annual Average Water Balance for West Edmond Marsh with Mining - Low Groundwater

Flow

	Monthly Average in cfs												
Hydrologic Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average in cfs
Precipitation	0.03	0.05	0.12	0.18	0.13	0.13	0.08	0.04	0.03	0.00	0.01	0.02	0.07
Surface Water Inflows	0.01	0.22	0.32	0.41	0.37	0.28	0.18	0.07	0.06	0.01	0.01	0.01	0.16
From East Edmond	0.01	0.22	0.32	0.41	0.37	0.28	0.18	0.07	0.06	0.01	0.01	0.01	0.16
Evapotranspiration	-0.01	0.00	0.00	0.00	-0.02	-0.04	-0.05	-0.05	-0.04	-0.04	-0.03	-0.02	-0.02
Recharge (-) Discharge (+)	-0.03	-0.20	-0.51	-0.65	-0.64	-0.64	-0.51	-0.13	-0.06	0.02	0.01	0.00	-0.28
Surface Water Outflows	0.00	-0.02	-0.05	-0.02	-0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01
To Center Drive	0.00	-0.02	-0.05	-0.02	-0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01
Change in Storage	0.00	0.05	-0.11	-0.08	-0.19	-0.26	-0.31	-0.07	-0.01	0.00	0.00	0.00	-0.1

Water Volume

	Average Monthly Volume in AF												
Hydrologic Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Avg. Annual Volume
Precipitation	2	3	7	11	7	8	4	2	2	0	0	1	49
Surface Water Inflows	1	13	20	25	20	17	11	4	3	1	1	0	116
From East Edmond	1	13	20	25	20	17	11	4	3	1	1	0	116
Evapotranspiration	0	0	0	0	-1	-2	-3	-3	-2	-2	-2	-1	-17
Recharge (-) Discharge (+)	-2	-12	-31	-40	-36	-39	-30	-8	-3	1	1	0	-201
Surface Water Outflows	0	-1	-3	-1	-2	0	0	0	0	0	0	0	-8
To Center Drive	0	-1	-3	-1	-2	0	0	0	0	0	0	0	-8
Change in Storage	-0.1	2.9	-6.7	-5.0	-10.5	-16.3	-18.6	-4.6	-0.8	-0.1	-0.1	-0.1	-60.0

Table F-7. Annual Average Water Balance for Bell, McKay, and Hamer Marshes with Mining + Restoration - Low Groundwater

Flow

	Monthly Average in cfs												
Hydrologic Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average in cfs
Precipitation	0.6	0.9	0.9	1.0	0.7	0.7	0.6	0.4	0.3	0.1	0.1	0.3	0.6
Surface Water Inflows	3.2	5.4	4.8	5.2	2.8	3.5	2.2	1.5	1.0	0.2	0.4	1.2	2.6
Runoff from Ft. Lewis - Outfall 002	1.9	3.3	3.0	3.2	1.7	2.2	1.3	0.9	0.6	0.1	0.2	0.7	1.6
Runoff from Ft. Lewis - Outfall 003	1.2	2.1	1.9	2.0	1.1	1.4	0.9	0.6	0.4	0.1	0.2	0.5	1.0
Evapotranspiration	-0.1	-0.1	0.0	0.0	-0.1	-0.2	-0.3	-0.5	-0.6	-0.7	-0.5	-0.3	-0.3
Recharge (-) Discharge (+)	-0.5	-0.3	-0.1	0.0	-0.1	0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2
Surface Water Outflows	-0.7	-4.0	-4.7	-5.3	-2.9	-3.1	-2.0	-0.9	-0.6	-0.1	0.0	-0.1	-2.0
To Diversion Canal	-0.6	-3.7	-4.2	-4.7	-2.3	-2.7	-1.5	-0.6	-0.3	0.0	0.0	-0.1	-1.7
To E. East Edmond. Marsh (surface)	-0.05	-0.33	-0.53	-0.55	-0.54	-0.47	-0.49	-0.34	-0.29	-0.09	-0.01	0.00	-0.3
Subsurface Outflows	-0.8	-0.9	-0.9	-0.9	-0.9	-0.9	-0.8	-0.8	-0.7	-0.6	-0.5	-0.5	-0.8
Change in Storage	1.7	1.0	0.1	0.1	-0.4	0.0	-0.5	-0.4	-0.6	-1.2	-0.8	0.3	0.0

Water Volume

	Average Monthly Volume in AF												
Hydrologic Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Avg. Annual Volume
Precipitation	36	56	57	60	40	45	33	25	19	6	8	17	401
Surface Water Inflows	196	319	297	319	157	218	131	92	62	11	24	71	1898
Runoff from Ft. Lewis - Outfall 002	120	194	181	195	96	133	80	56	37	6	14	43	1156
Runoff from Ft. Lewis - Outfall 003	76	125	116	125	61	85	51	36	24	5	9	28	741
Evapotranspiration	-8	-4	0	0	-6	-12	-19	-30	-34	-40	-33	-18	-206
Recharge (-) Discharge (+)	-33	-16	-6	3	-4	-2	-8	-3	-6	-5	-13	-15	-109
Surface Water Outflows	-41	-241	-291	-323	-160	-193	-121	-58	-37	-5	0	-4	-1473
To Diversion Canal	-38	-221	-259	-289	-130	-164	-91	-37	-19	0	0	-4	-1252
To E. East Edmond. Marsh (surface)	-3	-20	-32	-34	-30	-29	-29	-21	-17	-5	0	0	-221
Subsurface Outflows	-46	-52	-54	-56	-48	-55	-47	-48	-42	-37	-31	-32	-548
Change in Storage	104	62	4	4	-20	2	-30	-22	-38	-71	-47	18	-36

Table F-8. Annual Average Water Balance for East Edmond Marsh with Mining + Restoration - Low Groundwater

Flow

	Monthly Average in cfs												
Hydrologic Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average in cfs
Precipitation	0.4	0.6	0.5	0.6	0.4	0.4	0.3	0.2	0.2	0.1	0.1	0.2	0.3
Surface Water Inflows	3.8	7.5	11.6	16.4	20.4	22.1	20.9	13.7	8.0	3.5	2.5	2.2	10.98
From Sequalitchew Lake	3.7	7.1	11.0	15.8	19.8	21.6	20.4	13.4	7.7	3.4	2.5	2.2	10.66
From Center Drive	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02
From Hamer (surface)	0.0	0.3	0.5	0.5	0.5	0.5	0.5	0.3	0.3	0.1	0.0	0.0	0.31
Subsurface Inflows	0.8	0.9	0.9	0.9	0.9	0.9	0.8	0.8	0.7	0.6	0.5	0.5	0.8
Evapotranspiration	-0.1	0.0	0.0	0.0	-0.1	-0.1	-0.2	-0.3	-0.4	-0.4	-0.4	-0.2	-0.2
Recharge (-) Discharge (+)	1.1	1.3	1.3	1.4	1.3	1.4	1.3	1.3	1.2	1.0	1.1	1.0	1.2
Surface Water Outflows	-5.6	-9.5	-13.7	-18.9	-22.6	-24.2	-22.7	-15.4	-9.4	-4.6	-3.5	-3.4	-12.7
To Diversion Canal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
To West Edmond Marsh	-5.6	-9.5	-13.7	-18.9	-22.6	-24.2	-22.7	-15.4	-9.4	-4.6	-3.5	-3.4	-12.7
Change in Storage	0.4	0.7	0.6	0.4	0.4	0.5	0.5	0.3	0.4	0.2	0.2	0.3	0.4

Water Volume

	Average Monthly Volume in AF												
Hydrologic Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Avg. Annual Volume
Precipitation	25	35	34	35	23	27	19	15	12	4	5	12	246
Surface Water Inflows	232	444	710	1008	1142	1356	1243	845	477	216	152	129	7956
From Sequalitchew Lake	227	422	676	972	1111	1326	1212	823	459	211	151	129	7719
From Center Drive	2	2	2	2	1	2	1	1	1	0	0	1	16
From Hamer (surface)	3.0	19.9	32.3	33.5	30.5	28.9	29.1	20.7	17.4	5.5	0.4	0.0	221
Subsurface Inflows	46	52	54	56	48	55	47	48	42	37	31	32	548
Evapotranspiration	-6	-3	0	0	-3	-7	-11	-18	-21	-26	-23	-13	-131
Recharge (-) Discharge (+)	70	76	80	84	75	85	78	78	73	62	66	62	889
Surface Water Outflows	-342	-565	-843	-1161	-1265	-1487	-1348	-950	-561	-283	-217	-202	-9224
To Diversion Canal	0	0	0	0	0	0	0	0	0	0	0	0	0
To West Edmond Marsh	-342	-565	-843	-1161	-1265	-1487	-1348	-950	-561	-283	-217	-202	-9224
Change in Storage	26.0	40.2	34.3	22.4	20.7	28.1	27.6	17.8	21.5	9.7	15.1	20.5	283.8

Table F-9. Annual Average Water Balance for West Edmond Marsh with Mining + Restoration - Low Groundwater

Flow

	Monthly Average in cfs												
Hydrologic Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average in cfs
Precipitation	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.1
Surface Water Inflows	5.6	9.5	13.7	18.9	22.6	24.2	22.7	15.4	9.4	4.6	3.5	3.4	12.7
From East Edmond	5.6	9.5	13.7	18.9	22.6	24.2	22.7	15.4	9.4	4.6	3.5	3.4	12.7
Evapotranspiration	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
Recharge (-) Discharge (+)	-1.0	-0.8	-0.7	-0.6	-0.7	-0.7	-0.8	-0.8	-0.9	-1.0	-1.1	-1.0	-0.8
Surface Water Outflows	-4.7	-8.8	-13.2	-18.5	-22.0	-23.6	-21.9	-14.6	-8.5	-3.5	-2.4	-2.4	-11.9
To Center Drive	-4.7	-8.8	-13.2	-18.5	-22.0	-23.6	-21.9	-14.6	-8.5	-3.5	-2.4	-2.4	-11.9
Change in Storage	-0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.03	0.01	0.0

Water Volume

	Average Monthly Volume in AF												
Hydrologic Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Avg. Annual Volume
Precipitation	8	11	10	11	7	8	6	5	4	1	2	3	75
Surface Water Inflows	342	565	843	1161	1265	1487	1348	950	561	283	217	202	9224
From East Edmond	342	565	843	1161	1265	1487	1348	950	561	283	217	202	9224
Evapotranspiration	-2	-1	0	0	-1	-2	-3	-6	-6	-8	-7	-4	-40
Recharge (-) Discharge (+)	-63	-49	-44	-36	-37	-44	-46	-51	-54	-64	-67	-60	-614
Surface Water Outflows	-286	-525	-809	-1136	-1234	-1450	-1305	-898	-504	-213	-147	-142	-8648
To Center Drive	-286	-525	-809	-1136	-1234	-1450	-1305	-898	-504	-213	-147	-142	-8648
Change in Storage	-0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.6	-2.1	0.7	-2.0

MARSH WATER BALANCE MONTHLY RESULTS

Table F-10. Water Balance for Bell, McKay, and Hamer Marshes - Existing Conditions

Monthly Average in Inches of Water	WY2004					WY2005							
Hydrologic Process	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Precipitation	2.0	1.0	3.8	0.9	0.1	3.6	2.9	4.0	3.2	4.3	4.3	0.6	4.5
Surface Water Inflows	6.3	1.5	16.1	1.4	0.0	16.4	11.7	18.7	13.0	21.1	19.1	0.3	20.3
Runoff from Ft. Lewis - Outfall 002	3.8	0.8	9.9	0.7	0.0	10.0	7.2	11.5	8.0	12.9	11.7	0.0	12.5
Runoff from Ft. Lewis - Outfall 003	2.5	0.7	6.2	0.7	0.0	6.3	4.5	7.2	5.0	8.1	7.3	0.3	7.8
Evapotranspiration	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3
Recharge (-) Discharge (+)	-6.0	2.8	0.8	-0.3	-2.1	-4.1	-0.9	-2.1	-1.6	-1.3	0.1	-2.7	-6.0
Surface Water Outflows	-5.9	-2.4	-13.2	-2.4	-0.1	-12.5	-8.8	-14.4	-9.8	-16.4	-15.8	-0.9	-17.1
To Diversion Canal	-4.8	-1.5	-12.3	-1.3	0.0	-12.5	-8.8	-14.4	-9.8	-16.4	-14.8	-0.3	-15.9
To Seq. Ck. Marsh (surface)	-1.1	-0.9	-0.9	-1.1	0.0	0.0	0.0	0.0	0.0	0.0	-1.0	-0.6	-1.3
Subsurface Outflows	-1.3	-1.6	-1.9	-1.6	-1.4	-1.3	-1.5	-1.5	-1.5	-1.8	-2.0	-1.3	-1.3
Change in Storage	-6.2	-0.8	2.5	-5.6	-7.9	-1.8	1.1	3.7	2.7	5.8	5.7	-4.5	-0.9
Predicted WSE in feet													
Bell	218.34	218.27	218.48	218.01	217.35	217.20	217.29	217.60	217.82	218.31	218.79	218.41	218.33
McKay	216.19	216.12	216.33	215.86	215.20	215.05	215.14	215.45	215.67	216.16	216.64	216.26	216.18
Hamer	214.41	214.34	214.55	214.08	213.42	213.27	213.36	213.67	213.89	214.38	214.86	214.48	214.40
Observed WSE ('04) in feet													
Bell						216.36	217.40	217.36	217.72	218.30	219.11	217.92	216.95
McKay	216.19	215.81	214.71	214.26				213.70	213.84	214.35	215.15	214.68	213.74
Hamer	214.41	214.17	213.61	213.34	212.76	211.93	212.68	212.95	213.27	213.50	213.93	213.69	213.28

Table F-10. Water Balance for Bell, McKay, and Hamer Marshes - Existing Conditions

Monthly Average in Inches of Water — WY2006

Hydrologic Process	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Precipitation	5.4	3.9	3.8	1.4	0.2	1.6	3.3	6.7	6.5	12.2	3.2	2.6	3.9
Surface Water Inflows	25.8	16.4	15.5	3.2	0.0	5.1	17.0	46.3	38.2	94.8	10.6	8.7	15.6
Runoff from Ft. Lewis - Outfall 002	15.8	10.1	9.5	1.9	0.0	3.0	10.4	28.3	23.4	57.1	6.5	5.3	9.6
Runoff from Ft. Lewis - Outfall 003	10.0	6.3	6.0	1.4	0.0	2.1	6.6	18.0	14.8	37.6	4.1	3.4	6.0
Evapotranspiration	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0
Recharge (-) Discharge (+)	0.8	-0.4	-2.3	-3.6	-5.7	-6.8	-6.7	2.2	-2.0	2.0	1.1	1.6	1.4
Surface Water Outflows	-21.9	-15.2	-14.3	-4.6	-0.2	-4.1	-12.9	-38.8	-31.8	-95.3	-12.5	-9.8	-16.7
To Diversion Canal	-20.8	-12.6	-11.9	-2.8	-0.2	-4.1	-12.9	-38.8	-31.8	-94.9	-9.6	-6.6	-13.6
To Seq. Ck. Marsh (surface)	-1.0	-2.7	-2.5	-1.8	0.0	0.0	0.0	0.0	0.0	-0.5	-2.9	-3.2	-3.1
Subsurface Outflows	-2.0	-1.9	-1.5	-1.2	-1.0	-0.8	-0.9	-2.1	-1.8	-2.2	-1.8	-2.1	-2.0
Change in Storage	6.3	-0.4	-2.6	-9.3	-10.7	-7.3	-1.3	13.8	9.1	11.4	0.0	-0.2	0.2
Predicted WSE in feet													
Bell	218.86	218.82	218.60	217.83	216.94	216.33	216.23	217.37	218.13	219.08	219.08	219.06	219.08
McKay	216.71	216.67	216.45	215.68	214.79	214.18	214.08	215.22	215.98	216.93	216.93	216.91	216.93
Hamer	214.93	214.89	214.67	213.90	213.01	212.40	212.30	213.44	214.20	215.15	215.15	215.13	215.15
Observed WSE ('04) in feet													
Bell			218.33	217.05	215.63			218.25	217.95				
McKay	216.07	215.43	214.48	213.57				214.39	214.34	216.95	216.28	216.60	216.49
Hamer	214.26	214.05	213.69	213.13	212.13	211.67	211.69	213.20	213.27	214.09	213.65	214.13	214.14

Table F-10. Water Balance for Bell, McKay, and Hamer Marshes - Existing Conditions

Monthly Average in Inches of Water	WY2007												
Hydrologic Process	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Precipitation	2.1	2.2	0.4	0.0	0.8	1.6	14.4	8.6	6.5	4.5	5.7	1.7	1.1
Surface Water Inflows	6.5	6.8	0.0	0.0	1.0	5.2	152.0	52.5	33.2	17.8	27.6	4.5	2.2
Runoff from Ft. Lewis - Outfall 002	3.9	4.1	0.0	0.0	0.4	3.1	91.2	31.9	20.3	10.9	16.9	2.7	1.2
Runoff from Ft. Lewis - Outfall 003	2.5	2.7	0.0	0.0	0.5	2.1	60.8	20.6	12.9	6.9	10.7	1.8	1.0
Evapotranspiration	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2
Recharge (-) Discharge (+)	1.1	1.4	-0.1	-0.5	-1.2	-3.2	4.0	2.2	1.6	1.1	1.1	1.9	2.2
Surface Water Outflows	-8.2	-7.5	-0.4	0.0	-1.5	-4.2	-149.1	-53.4	-39.0	-21.0	-31.1	-6.2	-3.3
To Diversion Canal	-4.9	-5.2	-0.1	0.0	-1.5	-4.2	-149.1	-52.0	-35.8	-18.0	-27.8	-3.3	-1.4
To Seq. Ck. Marsh (surface)	-3.2	-2.4	-0.3	0.0	0.0	0.0	0.0	-1.4	-3.2	-2.9	-3.2	-2.9	-1.8
Subsurface Outflows	-1.9	-1.8	-1.7	-1.5	-1.3	-1.1	-2.6	-2.2	-2.3	-1.9	-2.1	-2.2	-2.3
Change in Storage	-3.6	-2.7	-6.3	-6.0	-4.7	-2.7	18.2	7.7	0.0	0.0	0.0	-2.3	-3.2
Predicted WSE in feet													
Bell	218.78	218.56	218.03	217.54	217.15	216.92	218.44	219.08	219.08	219.08	219.08	218.89	218.63
McKay	216.63	216.41	215.88	215.39	215.00	214.77	216.29	216.93	216.93	216.93	216.93	216.74	216.48
Hamer	214.85	214.63	214.10	213.61	213.22	212.99	214.51	215.15	215.15	215.15	215.15	214.96	214.70
Observed WSE ('04) in feet													
Bell			218.46	217.75	217.19	216.57							
McKay	216.06	216.27	214.34	213.60			216.87	217.29	217.02	216.97	216.90	217.35	216.64
Hamer	214.89	214.08	213.26	212.65	212.31	212.19	214.53	215.05	214.60	214.64	214.72	214.14	214.21

Table F-10. Water Balance for Bell, McKay, and Hamer Marshes - Existing Conditions

Monthly Average in Inches of Water						WY2008							
Hydrologic Process	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Precipitation	2.7	1.5	1.0	1.7	5.0	2.8	7.7	4.2	3.6	4.9	1.8	1.3	1.7
Surface Water Inflows	9.1	4.0	1.9	5.2	26.2	9.9	44.6	17.9	13.5	22.1	4.7	2.8	4.4
Runoff from Ft. Lewis - Outfall 002	5.6	2.4	1.0	3.1	16.1	6.1	27.2	11.0	8.3	13.6	2.8	1.6	2.6
Runoff from Ft. Lewis - Outfall 003	3.5	1.7	0.9	2.1	10.1	3.9	17.4	6.9	5.2	8.5	1.9	1.2	1.8
Evapotranspiration	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7
Recharge (-) Discharge (+)	1.6	1.5	0.6	-0.9	1.8	-0.3	0.4	0.4	0.4	1.0	0.0	0.1	0.1
Surface Water Outflows	-8.7	-5.0	-2.6	-4.1	-20.8	-8.5	-43.3	-20.5	-15.0	-24.6	-6.5	-4.0	-4.6
To Diversion Canal	-6.9	-3.3	-2.0	-4.1	-20.8	-7.5	-41.8	-17.3	-11.9	-21.4	-3.5	-2.1	-3.5
To Seq. Ck. Marsh (surface)	-1.9	-1.7	-0.6	0.0	0.0	-1.1	-1.5	-3.2	-3.0	-3.2	-3.0	-1.9	-1.1
Subsurface Outflows	-2.1	-1.9	-1.7	-1.6	-2.3	-1.9	-2.1	-2.1	-2.0	-2.1	-1.9	-1.9	-1.7
Change in Storage	-1.2	-4.3	-4.7	-2.0	8.8	1.6	7.3	0.0	0.0	0.0	-3.8	-4.9	-3.9
Predicted WSE in feet													
Bell	218.53	218.17	217.78	217.61	218.35	218.48	219.08	219.08	219.08	219.08	218.76	218.35	218.03
McKay	216.38	216.02	215.63	215.46	216.20	216.33	216.93	216.93	216.93	216.93	216.61	216.20	215.88
Hamer	214.60	214.24	213.85	213.68	214.42	214.55	215.15	215.15	215.15	215.15	214.83	214.42	214.10
Observed WSE ('04) in feet													
Bell				218.18									
McKay	216.01	214.98	214.26	213.68	215.97	214.67	216.83	216.83	216.91	216.98	215.93	215.06	214.63
Hamer	213.85	213.68	213.29	213.04	213.88	213.81	214.52	214.47	214.43	214.52	214.23	214.75	213.55

Table F-10. Water Balance for Bell, McKay, and Hamer Marshes - Existing Conditions

Monthly Average in Inches of Water WY2009

Hydrologic Process	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Precipitation	0.9	2.1	0.5	2.6	8.3	5.2	7.3	1.6	5.3	3.5	3.4	1.3	0.0
Surface Water Inflows	1.4	7.4	0.2	11.8	64.3	27.5	41.4	3.6	25.4	13.0	13.2	3.0	0.0
Runoff from Ft. Lewis - Outfall 002	0.7	4.5	0.0	7.2	39.1	16.9	25.3	2.2	15.6	8.0	8.1	1.7	0.0
Runoff from Ft. Lewis - Outfall 003	0.7	2.9	0.2	4.6	25.2	10.6	16.1	1.5	9.8	5.0	5.1	1.3	0.0
Evapotranspiration	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5
Recharge (-) Discharge (+)	-1.3	-1.4	-2.6	-5.7	2.4	-3.1	-0.7	-1.7	0.5	-1.2	-0.6	-2.1	-2.9
Surface Water Outflows	-1.9	-5.6	-0.7	-8.9	-56.3	-22.0	-37.8	-5.2	-23.6	-13.0	-13.0	-4.3	0.0
To Diversion Canal	-1.8	-5.6	-0.7	-8.9	-56.3	-22.0	-36.6	-2.6	-21.3	-9.9	-10.0	-2.3	0.0
To Seq. Ck. Marsh (surface)	-0.1	0.0	0.0	0.0	0.0	0.0	-1.2	-2.6	-2.3	-3.1	-3.0	-2.0	0.0
Subsurface Outflows	-1.5	-1.4	-0.9	-0.8	-2.1	-1.7	-2.0	-1.7	-2.2	-1.8	-1.9	-1.4	-1.2
Change in Storage	-6.8	-2.9	-5.9	-2.1	16.1	5.9	8.2	-4.0	4.0	-1.5	-2.1	-7.3	-8.6
Predicted WSE in feet													
Bell	217.46	217.22	216.73	216.56	217.90	218.39	219.08	218.75	219.08	218.95	218.78	218.17	217.45
McKay	215.31	215.07	214.58	214.41	215.75	216.24	216.93	216.60	216.93	216.80	216.63	216.02	215.30
Hamer	213.53	213.29	212.80	212.63	213.97	214.46	215.15	214.82	215.15	215.02	214.85	214.24	213.52
Observed WSE ('04) in feet													
Bell													
McKay					216.11	214.61	216.38	215.34	216.31	215.69	215.73	214.44	
Hamer	212.98	212.63	212.51	212.39	214.37	213.94	214.42	214.08	214.34	214.18	214.24	213.49	212.68

Table F-10. Water Balance for Bell, McKay, and Hamer Marshes - Existing Conditions

Monthly Average in Inches of Water			WY2010										
Hydrologic Process	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Precipitation	1.9	2.8	5.6	8.9	3.0	8.0	3.3	3.3	3.3	4.6	4.3	0.4	0.2
Surface Water Inflows	6.3	11.4	32.9	60.0	11.0	47.2	11.4	12.5	12.3	20.2	17.6	0.0	0.0
Runoff from Ft. Lewis - Outfall 002	3.8	7.0	20.2	36.5	6.7	28.8	7.0	7.7	7.5	12.4	10.8	0.0	0.0
Runoff from Ft. Lewis - Outfall 003	2.5	4.4	12.7	23.6	4.3	18.5	4.4	4.8	4.8	7.8	6.8	0.0	0.0
Evapotranspiration	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0
Recharge (-) Discharge (+)	-3.2	-2.8	-1.4	1.2	0.1	1.0	-0.2	-0.5	0.5	0.1	-0.1	-1.7	-2.6
Surface Water Outflows	-4.9	-8.6	-26.7	-53.4	-10.8	-52.0	-11.9	-12.7	-12.3	-18.9	-16.8	-0.4	-0.2
To Diversion Canal	-4.9	-8.6	-26.7	-53.4	-8.3	-49.2	-9.0	-9.5	-9.3	-15.8	-13.7	-0.1	0.0
To Seq. Ck. Marsh (surface)	0.0	0.0	0.0	0.0	-2.5	-2.8	-2.9	-3.2	-3.0	-3.1	-3.1	-0.3	-0.1
Subsurface Outflows	-1.1	-1.1	-1.6	-2.3	-2.0	-2.1	-2.1	-2.0	-2.0	-2.1	-2.0	-1.7	-1.4
Change in Storage	-5.0	-0.7	7.9	14.0	1.3	2.1	0.0	-0.6	-0.1	0.7	-0.7	-7.9	-8.0
Predicted WSE in feet													
Bell	217.03	216.98	217.63	218.79	218.90	219.08	219.08	219.03	219.02	219.08	219.02	218.36	217.69
McKay	214.88	214.83	215.48	216.64	216.75	216.93	216.93	216.88	216.87	216.93	216.87	216.21	215.54
Hamer	213.10	213.05	213.70	214.86	214.97	215.15	215.15	215.10	215.09	215.15	215.09	214.43	213.76
Observed WSE ('04) in feet													
Bell													
McKay				216.08	215.95	216.60	216.40	216.04	216.36	216.01	215.95	214.27	214.28
Hamer	212.35	212.48	213.05	214.46	214.53	214.80	214.56	214.47	214.59	214.32	214.44	213.62	213.02

Table F-10. Water Balance for Bell, McKay, and Hamer Marshes - Existing Conditions

Monthly Average in Inches of Water	WY2011												
Hydrologic Process	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Precipitation	4.0	4.2	6.6	7.2	6.1	3.1	7.2	5.7	4.8	2.8	0.8	0.3	1.3
Surface Water Inflows	18.2	18.9	34.4	38.5	30.5	10.3	39.3	26.9	21.2	9.3	0.9	0.0	3.0
Runoff from Ft. Lewis - Outfall 002	11.2	11.6	21.0	23.5	18.7	6.3	24.0	16.5	13.0	5.7	0.4	0.0	1.7
Runoff from Ft. Lewis - Outfall 003	7.0	7.3	13.4	15.0	11.8	4.0	15.3	10.4	8.2	3.6	0.5	0.0	1.3
Evapotranspiration	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3
Recharge (-) Discharge (+)	0.7	-2.2	-0.3	1.3	1.2	1.1	1.3	1.6	1.7	1.2	1.9	1.7	0.2
Surface Water Outflows	-14.0	-14.9	-29.8	-44.5	-36.2	-12.3	-44.8	-30.4	-22.6	-10.1	-1.7	-0.3	-2.7
To Diversion Canal	-14.0	-14.6	-28.8	-41.4	-32.9	-9.4	-41.6	-27.3	-19.4	-7.0	-0.6	-0.1	-2.7
To Seq. Ck. Marsh (surface)	0.0	-0.2	-1.0	-3.1	-3.2	-2.9	-3.2	-3.1	-3.2	-3.1	-1.1	-0.2	0.0
Subsurface Outflows	-2.0	-1.8	-2.1	-1.8	-1.7	-1.7	-1.7	-1.8	-1.9	-1.7	-3.3	-2.6	-2.1
Change in Storage	4.5	3.2	8.3	0.7	0.0	0.0	0.0	0.0	0.0	-2.3	-5.9	-4.8	-2.6
Predicted WSE in feet													
Bell	218.06	218.33	219.02	219.08	219.08	219.08	219.08	219.08	219.08	218.89	218.40	218.00	217.78
McKay	215.91	216.18	216.87	216.93	216.93	216.93	216.93	216.93	216.93	216.74	216.25	215.85	215.63
Hamer	214.13	214.40	215.09	215.15	215.15	215.15	215.15	215.15	215.15	214.96	214.47	214.07	213.85
Observed WSE ('04) in feet													
Bell													
McKay	214.29	215.23	216.18	216.90	217.01	217.07	217.13						
Hamer	213.60	213.51	214.64	214.45	214.30	214.29	214.28	214.31	214.72	214.68	214.63	214.01	213.35

Table F-10. Water Balance for Bell, McKay, and Hamer Marshes - Existing Conditions

Monthly Average in Inches of Water	WY2012												WY2013
Hydrologic Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Precipitation	4.1	6.1	3.2	7.2	3.9	6.8	4.3	3.1	3.3	1.6	0.0	0.1	6.5
Surface Water Inflows	19.3	32.1	12.6	40.0	14.7	35.5	17.5	11.1	11.9	4.3	0.0	0.0	38.6
Runoff from Ft. Lewis - Outfall 002	11.9	19.7	7.7	24.4	9.0	21.7	10.7	6.8	7.3	2.5	0.0	0.0	23.6
Runoff from Ft. Lewis - Outfall 003	7.4	12.5	4.9	15.6	5.7	13.8	6.7	4.3	4.6	1.7	0.0	0.0	15.0
Evapotranspiration	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0
Recharge (-) Discharge (+)	-1.2	-1.3	-2.2	1.2	0.6	1.1	1.5	1.5	1.1	1.4	1.4	-0.6	-0.7
Surface Water Outflows	-14.9	-26.9	-11.9	-42.4	-17.0	-40.5	-19.5	-11.6	-11.9	-5.9	0.0	-0.1	-32.2
To Diversion Canal	-14.9	-26.5	-9.5	-40.0	-14.0	-37.2	-16.4	-8.4	-9.0	-3.2	0.0	0.0	-32.2
To Seq. Ck. Marsh (surface)	0.0	-0.4	-2.3	-2.3	-3.0	-3.2	-3.1	-3.2	-2.9	-2.6	0.0	-0.1	0.0
Subsurface Outflows	-2.1	-2.1	-1.8	-2.0	-1.7	-1.7	-1.8	-1.9	-1.8	-1.8	-1.8	-1.5	-2.1
Change in Storage	4.2	7.4	0.0	4.0	0.0	0.0	0.0	-1.0	-1.1	-4.9	-4.4	-4.5	9.2
Predicted WSE in feet													
Bell	218.13	218.75	218.75	219.08	219.08	219.08	219.08	219.00	218.91	218.50	218.13	217.76	218.52
McKay	215.98	216.60	216.60	216.93	216.93	216.93	216.93	216.85	216.76	216.35	215.98	215.61	216.37
Hamer	214.20	214.82	214.82	215.15	215.15	215.15	215.15	215.07	214.98	214.57	214.20	213.83	214.59
Observed WSE ('04) in feet													
Bell					219.68	219.77	219.87	219.91	219.77	219.42	219.07	218.23	218.84
McKay	214.03	214.15	214.78	215.42	215.25	215.08	214.91	214.89	215.43	215.18	214.93	213.70	214.59
Hamer	213.44	213.63	214.25	215.05	214.90	215.03	215.15	215.00	214.78	214.40	214.02	213.24	213.96

Table F-10. Water Balance for Bell, McKay, and Hamer Marshes - Existing Conditions

Monthly Average in Inches of Water — WY2014

Hydrologic Process	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Precipitation	6.5	7.6	3.5	1.7	3.7	5.5	4.4	1.9	0.0	1.6	6.9	2.6	4.1
Surface Water Inflows	33.5	42.4	13.5	4.0	14.6	25.0	17.7	5.0	0.0	4.3	40.5	8.9	17.3
Runoff from Ft. Lewis - Outfall 002	20.5	25.8	8.3	2.4	9.0	15.3	10.9	3.0	0.0	2.6	24.7	5.5	10.6
Runoff from Ft. Lewis - Outfall 003	13.0	16.5	5.2	1.6	5.6	9.7	6.8	2.0	0.0	1.8	15.8	3.5	6.7
Evapotranspiration	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5
Recharge (-) Discharge (+)	0.0	2.2	0.4	-0.2	-0.5	-0.8	-1.1	-0.2	-0.2	-1.3	0.3	0.8	0.3
Surface Water Outflows	-30.8	-50.4	-13.5	-5.7	-14.4	-23.4	-17.6	-6.9	0.0	-4.2	-34.1	-8.5	-15.3
To Diversion Canal	-29.2	-47.1	-10.2	-2.8	-11.2	-20.1	-13.8	-3.7	0.0	-3.5	-34.1	-6.7	-13.4
To Seq. Ck. Marsh (surface)	-1.6	-3.2	-3.2	-2.9	-3.2	-3.2	-3.8	-3.2	0.0	-0.7	0.0	-1.8	-1.9
Subsurface Outflows	-2.0	-1.8	-1.8	-1.5	-1.7	-1.7	-1.7	-1.5	-1.6	-1.4	-2.0	-1.9	-1.9
Change in Storage	6.7	0.0	2.1	-2.3	0.5	2.6	-1.4	-5.4	-6.3	-5.1	9.2	0.9	4.1
Predicted WSE in feet													
Bell	219.08	219.08	219.25	219.07	219.11	219.32	219.21	218.76	218.23	217.81	218.57	218.64	218.98
McKay	216.93	216.93	217.10	216.92	216.96	217.17	217.06	216.61	216.08	215.66	216.42	216.49	216.83
Hamer	215.15	215.15	215.32	215.14	215.18	215.39	215.28	214.83	214.30	213.88	214.64	214.71	215.05
Observed WSE ('04) in feet													
Bell	219.44	219.62	219.81	219.57	219.35	219.49	219.46	219.25	218.80	218.09	219.27	219.36	219.48
McKay	215.49	215.65	215.47	215.46	215.49	215.57	215.97	216.22	214.67	213.77	214.98	216.08	216.03
Hamer	214.68	214.86	215.05	214.97	215.11	215.07	214.61	214.57	213.93	213.35	214.07	214.78	214.76

Table F-10. Water Balance for Bell, McKay, and Hamer Marshes - Existing Conditions

Monthly Average in Inches of Water — WY2015

Hydrologic Process	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation	2.4	4.2	6.9	9.8	4.5	3.3	1.3	1.2	1.6	1.8	5.9	6.1	4.8
Surface Water Inflows	7.7	18.1	33.2	59.2	18.2	12.0	2.5	2.4	4.2	5.2	30.0	29.3	20.6
Runoff from Ft. Lewis - Outfall 002	4.7	11.1	20.3	35.9	11.2	7.3	1.4	1.3	2.5	3.1	18.4	17.9	12.7
Runoff from Ft. Lewis - Outfall 003	3.0	7.0	12.9	23.3	7.0	4.6	1.1	1.0	1.7	2.1	11.6	11.4	8.0
Evapotranspiration	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0
Recharge (-) Discharge (+)	-2.5	-1.0	0.3	0.8	1.6	2.0	2.5	2.2	2.0	2.6	1.1	-1.0	1.1
Surface Water Outflows	-8.7	-16.4	-33.1	-66.8	-20.3	-13.1	-3.8	-3.6	-5.7	-5.3	-25.8	-27.2	-24.6
To Diversion Canal	-5.8	-14.0	-30.4	-62.7	-16.3	-9.1	-1.4	-1.5	-3.4	-4.1	-24.5	-24.2	-20.6
To Seq. Ck. Marsh (surface)	-2.9	-2.4	-2.7	-4.1	-3.9	-4.1	-2.3	-2.1	-2.2	-1.2	-1.2	-3.0	-4.1
Subsurface Outflows	-1.5	-1.8	-1.7	-1.7	-2.1	-2.0	-2.0	-2.1	-2.0	-2.0	-2.3	-2.0	-1.9
Change in Storage	-2.7	3.1	5.0	0.0	0.0	-1.0	-3.2	-4.4	-3.9	0.0	7.9	4.6	0.0
Predicted WSE in feet													
Bell	218.76	219.01	219.43	219.43	219.43	219.35	219.08	218.71	218.39	218.39	219.04	219.43	219.43
McKay	216.61	216.86	217.28	217.28	217.28	217.20	216.93	216.56	216.24	216.24	216.89	217.28	217.28
Hamer	214.83	215.08	215.50	215.50	215.50	215.42	215.15	214.78	214.46	214.46	215.11	215.50	215.50
Observed WSE ('04) in feet													
Bell	218.67	219.27	219.76										
McKay	215.03	215.78	216.09	215.95	216.19	215.94	215.82	215.62	215.27	215.36	215.45	215.97	216.17
Hamer	214.33	214.68	215.58	215.43			215.02	214.50	214.15	214.20	214.25	214.93	215.39

Table F-10. Water Balance for Bell, McKay, and Hamer Marshes - Existing Conditions

Monthly Average in Inches of Water — WY2016

Hydrologic Process	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Precipitation	4.1	4.7	4.4	2.1	0.8	0.4	0.2	2.2	1.3	5.0	7.1	12.0	6.9
Surface Water Inflows	16.3	17.9	17.9	5.9	1.0	0.0	0.0	7.7	3.2	26.3	42.8	88.5	34.5
Runoff from Ft. Lewis - Outfall 002	10.0	11.0	11.0	3.6	0.4	0.0	0.0	4.7	1.8	16.2	26.1	53.4	21.1
Runoff from Ft. Lewis - Outfall 003	6.3	6.9	6.9	2.3	0.5	0.0	0.0	3.0	1.3	10.2	16.7	35.1	13.4
Evapotranspiration	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0
Recharge (-) Discharge (+)	0.7	0.6	0.6	0.9	0.7	0.0	0.0	-1.6	-1.4	-3.6	2.7	1.6	-0.5
Surface Water Outflows	-19.4	-21.0	-19.7	-8.0	-1.8	-0.4	-0.2	-5.9	-2.8	-21.0	-36.3	-92.3	-39.1
To Diversion Canal	-15.3	-17.3	-15.6	-4.3	-0.5	-0.1	-0.1	-5.9	-2.8	-21.0	-36.3	-89.8	-35.1
To Seq. Ck. Marsh (surface)	-4.1	-3.7	-4.1	-3.7	-1.3	-0.3	-0.2	0.0	0.0	0.0	0.0	-2.4	-4.1
Subsurface Outflows	-1.8	-1.7	-1.9	-1.8	-1.8	-1.8	-1.7	-1.7	-1.4	-1.4	-2.3	-2.1	-1.8
Change in Storage	0.0	0.0	0.0	-2.9	-4.2	-5.5	-6.2	-3.3	-3.6	4.3	13.5	7.8	0.0
Predicted WSE in feet													
Bell	219.43	219.43	219.43	219.19	218.84	218.38	217.87	217.59	217.30	217.66	218.78	219.43	219.43
McKay	217.28	217.28	217.28	217.04	216.69	216.23	215.72	215.44	215.15	215.51	216.63	217.28	217.28
Hamer	215.50	215.50	215.50	215.26	214.91	214.45	213.94	213.66	213.37	213.73	214.85	215.50	215.50
Observed WSE ('04) in feet													
Bell					219.23	219.09	218.69	217.87	217.69	217.50	219.85		
McKay	216.10	215.99	215.89	215.65	215.44	214.58	213.88				215.69	216.17	
Hamer	215.29	215.29	215.29	215.26	214.68	213.91	213.36	212.70	212.67	212.64	215.55		

Table F-10. Water Balance for Bell, McKay, and Hamer Marshes - Existing Conditions

Monthly Average in Inches of Water — WY2017

Hydrologic Process	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Precipitation	5.8	5.9	1.8	1.0	2.3	1.3	0.2	1.5	9.3	6.9	3.9	3.4	8.6
Surface Water Inflows	25.0	27.6	4.5	1.6	7.3	2.9	0.0	3.7	62.0	36.3	15.4	12.6	43.5
Runoff from Ft. Lewis - Outfall 002	15.3	16.9	2.7	0.9	4.4	1.7	0.0	2.2	37.6	22.2	9.4	7.8	26.5
Runoff from Ft. Lewis - Outfall 003	9.7	10.7	1.8	0.8	2.9	1.2	0.0	1.5	24.4	14.1	5.9	4.9	17.1
Evapotranspiration	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6
Recharge (-) Discharge (+)	-1.1	-1.8	0.4	0.8	4.2	3.5	2.1	1.2	-2.9	2.1	1.8	1.0	1.9
Surface Water Outflows	-27.5	-28.7	-6.2	-2.6	-7.9	-4.2	-0.2	-3.7	-55.8	-35.5	-19.0	-14.9	-51.6
To Diversion Canal	-23.7	-24.7	-3.0	-0.9	-5.5	-2.2	0.0	-3.1	-55.5	-32.9	-15.0	-10.8	-48.0
To Seq. Ck. Marsh (surface)	-3.8	-4.1	-3.3	-1.7	-2.4	-2.0	-0.2	-0.6	-0.2	-2.6	-4.1	-4.1	-3.7
Subsurface Outflows	-1.6	-1.7	-1.8	-1.8	-2.3	-2.3	-2.1	-1.8	-2.0	-2.4	-2.1	-2.2	-1.8
Change in Storage	0.0	0.0	-3.3	-4.2	-0.2	-3.3	-4.0	-1.5	9.6	6.8	0.0	0.0	0.0
Predicted WSE in feet													
Bell	219.43	219.43	219.15	218.80	218.79	218.51	218.18	218.06	218.87	219.43	219.43	219.43	219.43
McKay	217.28	217.28	217.00	216.65	216.64	216.36	216.03	215.91	216.72	217.28	217.28	217.28	217.28
Hamer	215.50	215.50	215.22	214.87	214.86	214.58	214.25	214.13	214.94	215.50	215.50	215.50	215.50
Observed WSE ('04) in feet													
Bell							219.47		218.88				
McKay					215.60	215.55	214.85		214.09	215.95	216.30	216.16	216.16
Hamer					212.25	214.62	213.94		213.45	215.32			

Table F-10. Water Balance for Bell, McKay, and Hamer Marshes - Existing Conditions

Monthly Average in Inches of Water — WY2018

Hydrologic Process	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Precipitation	8.7	4.6	2.8	1.8	0.0	0.1	1.0	5.2	7.2	5.8	7.2	3.3	2.3
Surface Water Inflows	49.3	18.7	9.4	4.6	0.0	0.0	1.8	25.2	38.8	27.0	37.3	10.8	7.1
Runoff from Ft. Lewis - Outfall 002	30.0	11.5	5.8	2.8	0.0	0.0	0.9	15.5	23.7	16.6	22.8	6.6	4.3
Runoff from Ft. Lewis - Outfall 003	19.3	7.2	3.7	1.8	0.0	0.0	0.8	9.7	15.1	10.5	14.6	4.2	2.8
Evapotranspiration	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3
Recharge (-) Discharge (+)	3.4	3.2	3.4	3.6	3.9	4.6	2.1	-4.4	-1.4	2.0	2.5	2.7	2.3
Surface Water Outflows	-57.8	-22.3	-11.2	-6.4	0.0	-0.1	-2.8	-21.5	-34.6	-29.5	-45.1	-14.0	-9.4
To Diversion Canal	-53.7	-18.4	-7.1	-3.2	0.0	0.0	-1.4	-20.2	-32.9	-26.2	-41.0	-10.3	-5.4
To Seq. Ck. Marsh (surface)	-4.1	-3.9	-4.1	-3.2	0.0	-0.1	-1.4	-1.3	-1.7	-3.4	-4.1	-3.7	-4.1
Subsurface Outflows	-2.3	-2.3	-2.4	-2.4	-2.8	-3.1	-2.5	-1.8	-2.1	-2.2	-2.0	-2.2	-2.2
Change in Storage	0.0	0.0	-1.1	-2.5	-3.4	-2.4	-2.8	1.8	7.3	3.1	0.0	0.0	-1.1
Predicted WSE in feet													
Bell	219.43	219.43	219.34	219.13	218.85	218.65	218.41	218.56	219.17	219.43	219.43	219.43	219.34
McKay	217.28	217.28	217.19	216.98	216.70	216.50	216.26	216.41	217.02	217.28	217.28	217.28	217.19
Hamer	215.50	215.50	215.41	215.20	214.92	214.72	214.48	214.63	215.24	215.50	215.50	215.50	215.41
Observed WSE ('04) in feet													
Bell							219.80						
McKay	216.28	216.12		215.96	216.02	215.96	216.12			216.35		216.30	216.35
Hamer				215.45	214.76	213.95	213.83						

Table F-10. Water Balance for Bell, McKay, and Hamer Marshes - Existing Conditions

Monthly Average in Inches of Water — WY2019

Hydrologic Process	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Precipitation	6.1	0.7	0.9	0.2	0.3	1.8	4.0	3.8	6.4	3.4	4.8	1.6	3.6
Surface Water Inflows	27.7	0.3	1.3	0.0	0.0	5.2	18.6	15.2	33.7	12.3	18.5	3.8	12.9
Runoff from Ft. Lewis - Outfall 002	17.0	0.0	0.6	0.0	0.0	3.1	11.4	9.3	20.6	7.5	11.4	2.2	7.9
Runoff from Ft. Lewis - Outfall 003	10.8	0.3	0.6	0.0	0.0	2.1	7.2	5.9	13.1	4.7	7.2	1.5	5.0
Evapotranspiration	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0
Recharge (-) Discharge (+)	2.6	2.0	2.1	2.1	1.1	0.9	-2.1	0.9	1.4	1.1	0.9	0.0	-0.1
Surface Water Outflows	-31.2	-1.0	-2.2	-0.2	-0.3	-4.1	-14.3	-12.2	-29.7	-13.2	-21.8	-5.3	-13.1
To Diversion Canal	-27.5	-0.2	-0.7	0.0	-0.1	-4.1	-14.3	-11.6	-27.9	-9.4	-18.1	-2.3	-9.8
To Seq. Ck. Marsh (surface)	-3.7	-0.8	-1.5	-0.2	-0.2	0.0	0.0	-0.5	-1.8	-3.8	-3.7	-3.0	-3.2
Subsurface Outflows	-2.1	-2.2	-2.3	-2.5	-2.2	-2.2	-2.3	-2.3	-2.7	-2.3	-1.9	-2.0	-1.9
Change in Storage	1.1	-3.4	-3.9	-4.9	-5.1	-0.8	2.8	4.8	9.1	1.3	0.0	-3.3	-0.6
Predicted WSE in feet													
Bell	219.43	219.15	218.83	218.42	218.00	217.93	218.16	218.57	219.33	219.43	219.43	219.16	219.11
McKay	217.28	217.00	216.68	216.27	215.85	215.78	216.01	216.42	217.18	217.28	217.28	217.01	216.96
Hamer	215.50	215.22	214.90	214.49	214.07	214.00	214.23	214.64	215.40	215.50	215.50	215.23	215.18
Observed WSE ('04) in feet													
Bell				219.79	219.20	219.09	218.29					219.89	219.77
McKay	216.38	214.68	214.31	214.30	213.97	213.79		214.25	214.52	214.67	215.96	214.44	214.37
Hamer		215.01	214.47	214.10	213.30	213.11	212.99	213.63	214.85		215.27	214.79	214.64

Table F-10. Water Balance for Bell, McKay, and Hamer Marshes - Existing Conditions

Monthly Average in Inches of Water	WY2020												
Hydrologic Process	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Precipitation	1.1	0.7	1.0	0.8	3.5	3.9	1.7	6.5	9.6	4.2	3.5	1.5	3.1
Surface Water Inflows	2.1	0.4	1.9	1.2	18.1	19.3	5.1	38.7	62.1	15.8	13.1	3.6	11.6
Runoff from Ft. Lewis - Outfall 002	1.1	0.1	1.0	0.6	11.1	11.9	3.0	23.7	37.7	9.7	8.0	2.1	7.1
Runoff from Ft. Lewis - Outfall 003	0.9	0.3	0.9	0.6	7.0	7.4	2.0	15.0	24.4	6.1	5.0	1.5	4.5
Evapotranspiration	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2
Recharge (-) Discharge (+)	-0.6	-0.8	-1.8	-2.0	-1.6	0.6	3.0	-3.5	2.2	-0.1	-1.3	0.8	0.6
Surface Water Outflows	-3.2	-1.0	-2.5	-1.7	-13.7	-14.8	-4.0	-32.3	-60.1	-17.4	-14.0	-5.1	-11.8
To Diversion Canal	-1.2	-0.4	-2.0	-1.7	-13.7	-14.8	-4.0	-32.3	-58.5	-13.6	-9.9	-2.3	-8.8
To Seq. Ck. Marsh (surface)	-1.9	-0.7	-0.4	0.0	0.0	0.0	0.0	0.0	-1.5	-3.8	-4.1	-2.8	-3.1
Subsurface Outflows	-1.9	-1.7	-1.6	-1.4	-1.9	-2.0	-2.0	-1.9	-2.6	-2.0	-1.8	-1.9	-1.9
Change in Storage	-5.6	-6.2	-7.4	-7.0	2.0	6.0	3.2	7.6	11.3	0.0	-1.8	-3.1	-1.6
Predicted WSE in feet													
Bell	218.64	218.12	217.51	216.92	217.09	217.59	217.86	218.49	219.43	219.43	219.28	219.03	218.90
McKay	216.49	215.97	215.36	214.77	214.94	215.44	215.71	216.34	217.28	217.28	217.13	216.88	216.75
Hamer	214.71	214.19	213.58	212.99	213.16	213.66	213.93	214.56	215.50	215.50	215.35	215.10	214.97
Observed WSE ('04) in feet													
Bell		218.58	217.47	216.86		218.20				219.71			
McKay		213.99			214.92			213.72	215.28	214.65			
Hamer		213.47	212.68		212.25			213.55	215.55	215.03			

Table F-10. Water Balance for Bell, McKay, and Hamer Marshes - Existing Conditions

Monthly Average in Inches of Water					WY2021								
Hydrologic Process	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Precipitation	2.5	0.3	0.4	2.8	3.0	5.6	5.2	7.3	4.7	2.5	1.2	2.0	2.4
Surface Water Inflows	8.1	0.0	0.0	10.8	12.3	29.6	26.5	41.2	18.1	8.0	2.2	6.1	8.1
Runoff from Ft. Lewis - Outfall 002	4.9	0.0	0.0	6.6	7.6	18.1	16.2	25.2	11.1	4.9	1.2	3.7	4.9
Runoff from Ft. Lewis - Outfall 003	3.2	0.0	0.0	4.2	4.8	11.5	10.2	16.1	7.0	3.1	0.9	2.4	3.1
Evapotranspiration	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7
Recharge (-) Discharge (+)	0.2	-2.4	-3.1	-2.1	-1.9	0.3	0.3	0.3	1.1	1.3	0.9	0.8	0.2
Surface Water Outflows	-8.8	-0.3	-0.4	-8.1	-9.3	-23.9	-21.3	-38.0	-21.3	-10.1	-3.3	-7.8	-8.2
To Diversion Canal	-6.1	0.0	-0.4	-8.1	-9.3	-23.9	-21.2	-35.7	-17.7	-6.0	-1.2	-4.7	-6.1
To Seq. Ck. Marsh (surface)	-2.7	-0.2	0.0	0.0	0.0	0.0	-0.1	-2.3	-3.7	-4.1	-2.1	-3.1	-2.1
Subsurface Outflows	-1.8	-1.5	-1.4	-1.5	-1.6	-2.0	-2.3	-2.5	-2.0	-2.2	-2.1	-2.1	-2.0
Change in Storage	-3.5	-8.4	-8.5	-0.5	1.5	9.0	8.4	8.4	0.0	-1.8	-3.1	-4.0	-3.2
Predicted WSE in feet													
Bell	218.60	217.90	217.19	217.15	217.28	218.03	218.73	219.43	219.43	219.28	219.02	218.69	218.43
McKay	216.45	215.75	215.04	215.00	215.13	215.88	216.58	217.28	217.28	217.13	216.87	216.54	216.28
Hamer	214.67	213.97	213.26	213.22	213.35	214.10	214.80	215.50	215.50	215.35	215.09	214.76	214.50
Observed WSE ('04) in feet													
Bell					217.23			219.68			219.71	219.41	218.99
McKay						213.87		214.86	214.88	215.59	214.57	214.46	214.38
Hamer						213.15		215.23	215.30	214.89	214.51	214.01	213.58

Table F-10. Water Balance for Bell, McKay, and Hamer Marshes - Existing Conditions

Monthly Average in Inches of Water	WY2021		
Hydrologic Process	Jul	Aug	Sep
Precipitation	0.0	0.3	2.6
Surface Water Inflows	0.0	0.0	9.7
Runoff from Ft. Lewis - Outfall 002	0.0	0.0	5.9
Runoff from Ft. Lewis - Outfall 003	0.0	0.0	3.8
Evapotranspiration	-4.5	-4.0	-2.3
Recharge (-) Discharge (+)	-1.1	-2.0	-1.5
Surface Water Outflows	0.0	-0.3	-7.3
To Diversion Canal	0.0	-0.3	-7.3
To Seq. Ck. Marsh (surface)	0.0	0.0	0.0
Subsurface Outflows	-1.8	-1.7	-1.7
Change in Storage	-7.4	-7.7	-0.6
Predicted WSE in feet			
Bell	217.81	217.17	217.13
McKay	215.66	215.02	214.98
Hamer	213.88	213.24	213.20
Observed WSE ('04) in feet			
Bell	218.05		
McKay		213.27	
Hamer	212.68	212.25	

Table F-11. Water Balance for East Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water	WY2004						WY2005						
Hydrologic Process	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Precipitation	2.0	1.0	3.8	0.9	0.1	3.6	2.9	4.0	3.2	4.3	4.3	0.6	4.5
Surface Water Inflows	0.3	0.9	1.0	1.1	0.0	0.2	0.1	0.2	0.1	0.2	1.2	0.6	1.4
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.1	0.0	0.1	0.0	0.0	0.2	0.1	0.2	0.1	0.2	0.2	0.0	0.2
From Hamer (surface)	1.0	0.9	0.9	1.1	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.6	1.3
Subsurface Inflows	1.2	1.6	1.8	1.6	1.3	1.3	1.5	1.5	1.5	1.7	2.0	1.3	1.2
Evapotranspiration	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3
Recharge (-) Discharge (+)	*-5.2*	*-4.2*	*-4.0*	*-2.4*	*-1.1*	*-2.4*	*-1.2*	*-1.3*	*-2.2*	*-2.1*	*-2.9*	*-3.3*	*-5.0*
Surface Water Outflows	-1.8	0.0	-0.4	-0.3	-0.2	0.0	0.0	0.0	-0.1	-0.1	-0.9	0.0	-0.3
To Diversion Canal	-1.5	0.0	-0.7	-0.6	-0.4	-0.1	0.0	0.0	-0.2	-0.3	-1.1	0.0	-0.5
To West Edmond Marsh	-2.0	0.0	-0.3	-0.2	-0.1	0.0	0.0	0.0	-0.1	-0.1	-0.9	0.0	-0.2
Change in Storage	-4.8	-2.8	-0.8	-2.8	-4.4	-1.4	1.0	3.3	2.0	3.9	3.7	-1.4	0.6
Predicted WSE in ft													
EM-2S	212.62	212.32	212.19	211.87	211.51	211.39	211.48	211.75	211.92	212.25	212.48	212.31	212.26
East Edmond	212.62	212.39	212.31	212.06	211.69	211.57	211.66	211.93	212.10	212.42	212.65	212.54	212.58
Eastern East Edmond Marsh	212.36	212.13	211.89	211.53	211.07	210.94	211.03	211.29	211.41	211.66	211.90	211.79	211.71
Observed WSE in ft													
EM-2S	210.72	210.74	210.76	210.70	210.40	209.82	209.92	210.33	210.61	210.76	210.86	210.79	210.64
East Edmond (EM-2E)	212.62	212.50	212.35	212.25	211.85	211.43	211.43	211.80	212.12	212.31	212.47	212.40	212.19
East Edmond (EM-2W)	211.15	211.15	211.22	211.20	210.91	210.32	210.41	210.80	211.08	211.20	211.26	211.24	211.09
East Edmond (EM-3E)	212.42	212.29	212.14	212.04	211.69	211.07	211.43	211.70	211.93	212.09	212.15	212.17	211.97
East Edmond (EM-3W)	212.42	212.29	212.15	212.04	211.70	211.10	211.57	211.70	211.94	212.04	212.26	212.20	211.98
Eastern East Edmond (SCM-1)	212.39	212.26	212.09	211.98	211.58	210.96	211.20	211.63	211.84	212.08	212.27	212.17	211.95

Table F-11. Water Balance for East Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water — WY2006

Hydrologic Process	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Precipitation	5.4	3.9	3.8	1.4	0.2	1.6	3.3	6.7	6.5	12.2	3.2	2.6	3.9
Surface Water Inflows	1.2	2.8	2.5	1.8	0.0	0.1	0.2	0.3	0.3	1.0	3.0	3.2	3.2
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.2	0.1	0.1	0.0	0.0	0.1	0.2	0.3	0.3	0.6	0.1	0.1	0.1
From Hamer (surface)	1.0	2.6	2.4	1.8	0.0	0.0	0.0	0.0	0.0	0.5	2.9	3.1	3.0
Subsurface Inflows	2.0	1.9	1.5	1.2	0.9	0.8	0.9	2.0	1.8	2.2	1.7	2.0	1.9
Evapotranspiration	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0
Recharge (-) Discharge (+)	*-2.8*	*-3.7*	*-2.4*	*-3.7*	*-4.2*	*-5.3*	*-4.6*	*-1.5*	*-3.1*	*-2.0*	*-4.1*	*-4.6*	*-4.3*
Surface Water Outflows	-1.6	-0.3	-0.9	-0.3	0.0	0.0	0.0	0.0	0.0	-5.8	-0.9	-1.0	-1.4
To Diversion Canal	-1.8	-0.6	-1.2	-0.6	0.0	0.0	0.0	0.0	0.0	-5.9	-1.4	-1.5	-1.7
To West Edmond Marsh	-1.5	-0.2	-0.9	-0.2	0.0	0.0	0.0	0.0	0.0	-5.8	-0.7	-0.8	-1.3
Change in Storage	2.4	1.4	0.8	-4.1	-7.1	-5.2	-1.3	7.0	5.4	7.6	2.3	0.9	1.4
Predicted WSE in ft													
EM-2S	212.38	212.29	212.16	211.68	211.09	210.66	210.55	211.14	211.59	212.19	212.15	211.98	211.85
East Edmond	212.66	212.76	212.76	212.41	211.82	211.43	211.43	212.01	212.47	212.62	212.77	212.78	212.80
Eastern East Edmond Marsh	211.90	211.87	211.86	211.38	210.79	210.36	210.25	210.84	211.29	212.35	212.34	212.20	212.23
Observed WSE in ft													
EM-2S	210.94	210.90	210.69	210.42	209.82	209.15	209.21	210.48	210.71	210.98	210.88	210.58	210.57
East Edmond (EM-2E)	212.55	212.63	212.47	212.13	211.43	211.43	211.43	211.89	212.22	212.63	212.62	212.51	212.55
East Edmond (EM-2W)	211.28	211.32	211.14	210.88	210.28	209.64	209.67	210.87	211.12	211.31	211.25	210.92	210.89
East Edmond (EM-3E)	212.32	212.40	212.26	211.92	211.13			211.78	212.02	212.42	212.37	212.27	212.30
East Edmond (EM-3W)	212.50	212.41	212.25	211.92	211.15	210.44	210.58	211.75	212.02	212.42	212.38	212.26	212.29
Eastern East Edmond (SCM-1)	212.25	212.43	212.29	211.88	211.08	210.95	210.57	211.69	211.99	212.58	212.47	212.20	212.32

Table F-11. Water Balance for East Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water — WY2007

Hydrologic Process	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Precipitation	2.1	2.2	0.4	0.0	0.8	1.6	14.4	8.6	6.5	4.5	5.7	1.7	1.1
Surface Water Inflows	3.2	2.4	0.3	0.0	0.0	0.1	0.7	1.8	3.6	3.2	3.5	3.1	1.9
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.1	0.1	0.0	0.0	0.0	0.1	0.7	0.4	0.3	0.2	0.2	0.1	0.0
From Hamer (surface)	3.2	2.3	0.3	0.0	0.0	0.0	0.0	1.4	3.3	3.1	3.3	3.0	1.9
Subsurface Inflows	1.8	1.8	1.7	1.5	1.3	1.1	2.2	2.3	2.3	2.0	2.2	2.3	2.4
Evapotranspiration	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2
Recharge (-) Discharge (+)	*-4.3*	*-2.5*	*-3.1*	*-0.4*	*-1.8*	*-2.0*	*-0.4*	*0.8*	*-0.9*	*-1.2*	*-0.1*	*-1.3*	*-2.2*
Surface Water Outflows	-0.4	-0.3	0.0	-0.1	0.0	0.0	-7.7	-6.5	-7.5	-2.5	-6.6	-2.1	-0.4
To Diversion Canal	-0.8	-0.6	0.0	-0.3	0.0	0.0	-7.7	-6.9	-10.1	-3.8	-8.3	-3.9	-0.8
To West Edmond Marsh	-0.3	-0.2	0.0	-0.1	0.0	0.0	-7.7	-6.4	-6.7	-2.1	-6.1	-1.6	-0.3
Change in Storage	-0.7	-0.2	-5.3	-2.9	-2.1	-0.2	8.8	7.0	3.9	5.4	3.4	1.8	-0.4
Predicted WSE in ft													
EM-2S	211.54	211.34	210.88	210.63	210.46	210.44	211.17	211.65	211.77	212.00	212.05	211.99	211.81
East Edmond	212.73	212.70	212.26	212.01	211.83	211.82	211.90	211.96	211.80	212.11	211.93	211.99	211.94
Eastern East Edmond Marsh	211.99	211.82	211.38	211.06	210.88	210.86	212.23	212.75	212.54	212.60	212.63	212.10	211.91
Observed WSE in ft													
EM-2S	210.71	210.85	210.62	210.36	210.21	210.06	211.03	211.01	210.90	210.87	210.83	210.79	210.82
East Edmond (EM-2E)	212.55	212.63	212.53	211.36	211.43	211.65	211.87	211.94	211.78	211.79	211.80	211.65	211.73
East Edmond (EM-2W)	211.08	211.28	211.06	210.74	210.64	210.49	211.37	211.37	211.26	211.26	211.22	211.15	211.24
East Edmond (EM-3E)	212.28	212.39	212.04	211.75	211.51	211.32	212.52	212.61	212.44	212.46	212.43	212.30	212.37
East Edmond (EM-3W)	212.27	212.40	212.03	211.75	211.50	211.31	212.51	212.60	212.42	212.42	212.42	212.29	212.36
Eastern East Edmond (SCM-1)	212.26	212.46	211.97	211.70	211.38	211.33	212.58	212.67	212.49	212.48	212.49	212.29	212.44

Table F-11. Water Balance for East Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water — WY2008

Hydrologic Process	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Precipitation	2.7	1.5	1.0	1.7	5.0	2.8	7.7	4.2	3.6	4.9	1.8	1.3	1.7
Surface Water Inflows	2.1	1.8	0.6	0.1	0.2	1.2	1.9	3.6	3.3	3.6	3.1	2.1	1.2
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.1	0.0	0.0	0.1	0.2	0.1	0.3	0.2	0.1	0.2	0.1	0.0	0.1
From Hamer (surface)	2.0	1.8	0.6	0.0	0.0	1.1	1.6	3.4	3.2	3.4	3.0	2.0	1.1
Subsurface Inflows	2.2	2.0	1.8	1.6	2.3	2.0	2.3	2.2	2.1	2.2	2.0	1.9	1.7
Evapotranspiration	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7
Recharge (-) Discharge (+)	*-2.3*	*-0.5*	*-1.2*	*-1.4*	*-1.1*	*-2.0*	*-1.7*	*-2.1*	*-2.0*	*-2.3*	*-2.0*	*-2.6*	*-1.5*
Surface Water Outflows	-0.3	-0.3	-0.3	-0.1	-1.9	-1.4	-5.0	-4.4	-3.7	-3.5	-2.4	-0.4	-0.3
To Diversion Canal	-0.6	-0.6	-0.5	-0.3	-2.0	-1.6	-5.3	-5.8	-5.0	-4.5	-3.8	-0.8	-0.6
To West Edmond Marsh	-0.2	-0.2	-0.2	-0.1	-1.9	-1.3	-4.9	-4.0	-3.2	-3.2	-2.0	-0.3	-0.2
Change in Storage	0.6	0.0	-2.0	-0.6	3.6	2.2	5.2	3.5	2.7	3.7	0.5	-0.9	-1.0
Predicted WSE in ft													
EM-2S	211.70	211.56	211.35	211.31	211.61	211.70	212.01	212.05	212.05	212.10	211.92	211.68	211.51
East Edmond	211.98	211.97	211.80	211.74	211.89	211.96	211.99	211.98	211.98	212.04	211.95	211.86	211.76
Eastern East Edmond Marsh	211.82	211.70	211.41	211.29	211.68	211.84	212.54	212.54	212.45	212.55	212.12	211.88	211.67
Observed WSE in ft													
EM-2S	210.87	210.86	210.68	210.52	210.85	210.93	211.00	210.98	210.95	210.94	210.83	210.79	210.70
East Edmond (EM-2E)	211.66	211.60	211.45	211.27	211.66	211.77	211.92	211.86	211.80	211.86	211.68	211.69	211.63
East Edmond (EM-2W)	211.30	211.28	211.11	210.95	211.29	211.32	211.37	211.35	211.34	211.32	211.28	211.21	211.15
East Edmond (EM-3E)	212.31	212.23	212.09	211.93	212.32	212.40	212.56	212.50	212.44	212.50	212.37	212.33	212.27
East Edmond (EM-3W)	212.29	212.24	212.09	211.91	212.31	212.40	212.54	212.49	212.43	212.49	212.35	212.33	212.25
Eastern East Edmond (SCM-1)	212.35	212.29	212.13	212.06	212.38	212.48	212.63	212.58	212.52	212.55	212.43	212.39	212.32

Table F-11. Water Balance for East Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water WY2009

Hydrologic Process	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Precipitation	0.9	2.1	0.5	2.6	8.3	5.2	7.3	1.6	5.3	3.5	3.4	1.3	0.0
Surface Water Inflows	0.2	0.1	0.0	0.1	0.4	0.2	1.6	2.7	2.7	3.4	3.1	2.1	0.0
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.0	0.1	0.0	0.1	0.4	0.2	0.3	0.0	0.2	0.1	0.1	0.0	0.0
From Hamer (surface)	0.1	0.0	0.0	0.0	0.0	0.0	1.3	2.7	2.4	3.2	3.0	2.1	0.0
Subsurface Inflows	1.5	1.4	1.0	0.7	1.8	1.6	2.1	1.7	2.3	1.9	1.9	1.5	1.3
Evapotranspiration	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5
Recharge (-) Discharge (+)	*-0.8*	*0.3*	*-0.3*	*-1.8*	*-1.0*	*-2.0*	*-2.4*	*-2.3*	*-3.1*	*-3.3*	*-3.3*	*-2.8*	*-2.0*
Surface Water Outflows	-0.2	-0.1	-0.1	0.0	-2.0	-2.8	-3.8	-2.5	-2.0	-1.9	-1.0	-0.4	0.0
To Diversion Canal	-0.5	-0.2	-0.2	-0.1	-2.1	-3.1	-4.2	-4.2	-2.4	-2.6	-1.5	-0.8	0.0
To West Edmond Marsh	-0.2	-0.1	-0.1	0.0	-2.0	-2.7	-3.7	-2.0	-1.9	-1.7	-0.9	-0.3	0.0
Change in Storage	-3.0	-0.2	-1.2	0.6	7.0	2.2	4.8	0.6	3.8	1.6	0.8	-2.1	-5.2
Predicted WSE in ft													
EM-2S	211.26	211.24	211.15	211.19	211.78	211.97	212.27	212.14	212.27	212.15	211.98	211.65	211.22
East Edmond	211.50	211.48	211.43	211.48	211.89	211.86	211.96	211.88	212.05	212.06	212.08	211.89	211.46
Eastern East Edmond Marsh	211.30	211.23	211.08	211.11	211.84	212.10	212.62	212.09	212.39	212.31	212.21	211.87	211.44
Observed WSE in ft													
EM-2S	210.43	210.28	210.14	210.00	210.90	210.97	210.95	210.92	210.89	210.87	210.93	210.61	210.18
East Edmond (EM-2E)	211.43	211.43	211.43	211.43	211.72	211.81	211.81	211.76	211.54	211.44	211.72	211.43	211.43
East Edmond (EM-2W)	210.88	210.70	210.56	210.41	211.31	211.34	211.33	211.30	211.36	211.36	211.37	211.04	210.58
East Edmond (EM-3E)	211.92	211.63	211.47	211.30	212.41	212.42	212.44	212.39	212.25	212.31	212.38	211.93	211.59
East Edmond (EM-3W)	211.92	211.67	211.50	211.33	212.32	212.40	212.43	212.37	212.25	212.29	212.36	211.94	211.67
Eastern East Edmond (SCM-1)	211.96	211.71	211.54	211.38	212.39	212.48	212.53	212.47	212.33	212.37	212.44	211.94	211.51

Table F-11. Water Balance for East Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water WY2010

Hydrologic Process	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Precipitation	1.9	2.8	5.6	8.9	3.0	8.0	3.3	3.3	3.3	4.6	4.3	0.4	0.2
Surface Water Inflows	0.1	0.1	0.3	0.4	2.7	3.1	3.1	3.6	3.2	3.4	3.4	0.3	0.1
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.1	0.1	0.3	0.4	0.1	0.3	0.1	0.1	0.1	0.2	0.2	0.0	0.0
From Hamer (surface)	0.0	0.0	0.0	0.0	2.6	2.8	2.9	3.5	3.1	3.2	3.2	0.3	0.1
Subsurface Inflows	1.2	1.1	1.6	2.3	2.1	2.1	2.1	2.1	2.1	2.2	2.1	1.7	1.5
Evapotranspiration	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0
Recharge (-) Discharge (+)	*-1.5*	*-1.3*	*-2.0*	*-1.3*	*-3.1*	*-2.8*	*-1.8*	*-3.4*	*-2.6*	*-3.1*	*-3.0*	*-2.6*	*-1.3*
Surface Water Outflows	-0.1	-0.1	-0.1	-4.6	-1.3	-5.5	-5.1	-0.4	-2.7	-2.2	-1.5	0.0	-0.3
To Diversion Canal	-0.3	-0.1	-0.1	-4.7	-1.7	-6.2	-7.4	-0.8	-3.3	-2.9	-2.1	0.0	-0.6
To West Edmond Marsh	-0.1	0.0	0.0	-4.5	-1.2	-5.3	-4.4	-0.3	-2.5	-2.0	-1.3	0.0	-0.2
Change in Storage	-2.5	0.3	4.3	5.3	3.3	4.9	1.0	4.0	1.4	1.7	1.5	-4.6	-3.8
Predicted WSE in ft													
EM-2S	211.01	211.04	211.40	211.84	211.91	212.10	212.00	212.05	211.93	211.83	211.70	211.28	210.96
East Edmond	211.43	211.45	211.81	211.88	212.06	212.04	211.82	212.14	212.07	212.06	212.09	211.70	211.43
Eastern East Edmond Marsh	211.14	211.14	211.47	212.19	212.37	212.75	212.20	212.36	212.38	212.34	212.30	211.92	211.46
Observed WSE in ft													
EM-2S	210.12	210.11	210.47	211.06	211.04	211.03	211.03	210.86	211.15	211.13	211.10	210.88	210.61
East Edmond (EM-2E)	211.43	211.43	211.43	211.75	211.52	211.58	211.64	211.90	211.59	212.04	211.93	211.73	211.43
East Edmond (EM-2W)	210.51	210.52	210.90	211.41	211.41	211.39	211.40	211.24	211.58	211.54	211.52	211.36	211.03
East Edmond (EM-3E)	211.49	211.46	211.74	212.41	212.33	212.49	212.38	212.42	212.43	212.55	212.48	212.25	211.93
East Edmond (EM-3W)	211.48	211.46	211.72	212.31	212.25	212.27	212.22	212.39	212.25	212.54	212.44	212.25	211.96
Eastern East Edmond (SCM-1)	211.45	211.46	211.78	212.48	212.40	212.57	212.45	212.49	212.52	212.62	212.55	212.24	211.87

Table F-11. Water Balance for East Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water WY2011

Hydrologic Process	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Precipitation	4.0	4.2	6.6	7.2	6.1	3.1	7.2	5.7	4.8	2.8	0.8	0.3	1.3
Surface Water Inflows	0.2	0.4	1.4	3.6	3.3	2.9	3.5	3.2	3.4	3.1	1.1	0.2	0.1
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.2	0.2	0.3	0.3	0.2	0.1	0.3	0.2	0.2	0.1	0.0	0.0	0.0
From Hamer (surface)	0.0	0.3	1.1	3.3	3.1	2.8	3.2	3.0	3.2	3.0	1.1	0.2	0.0
Subsurface Inflows	2.1	1.9	2.3	1.9	1.6	1.6	1.6	1.7	1.8	1.7	3.2	3.1	2.3
Evapotranspiration	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3
Recharge (-) Discharge (+)	*-1.0*	*-2.2*	*-2.0*	*-4.1*	*-4.8*	*-3.1*	*-4.6*	*-3.4*	*-3.9*	*-3.8*	*-26.1*	*3.0*	*0.6*
Surface Water Outflows	-0.1	-0.2	-3.6	-0.5	-3.5	-3.1	-2.7	-4.0	-0.8	-0.6	0.0	0.0	0.0
To Diversion Canal	-0.3	-0.5	-3.8	-0.9	-4.1	-4.3	-3.2	-5.4	-1.5	-1.1	0.0	0.0	0.0
To West Edmond Marsh	-0.1	-0.2	-3.5	-0.4	-3.4	-2.7	-2.5	-3.5	-0.6	-0.4	0.0	0.0	0.0
Change in Storage	2.7	3.0	4.2	8.2	2.7	0.8	3.9	1.2	2.1	-0.5	-25.6	2.6	1.9
Predicted WSE in ft													
EM-2S	211.19	211.43	211.69	212.11	212.09	211.96	212.03	211.93	211.85	211.57	209.35	209.55	209.70
East Edmond	211.65	211.89	211.96	212.62	212.58	212.46	212.58	212.43	212.57	212.50	211.43	211.65	211.81
Eastern East Edmond Marsh	211.60	211.74	212.25	212.75	213.02	212.78	213.06	212.82	212.75	212.49	210.36	210.58	210.74
Observed WSE in ft													
EM-2S	211.01	211.05	211.33	211.43	211.30	211.27	211.25	211.27	211.30	211.22	206.59	211.06	210.85
East Edmond (EM-2E)	211.73	211.75	211.95	212.18	212.13	212.20	212.27	212.30	212.37			212.01	211.69
East Edmond (EM-2W)	211.46	211.48	211.73	211.78	211.68	211.65	211.61	211.58	211.68			211.48	211.33
East Edmond (EM-3E)	212.23	212.37	212.59	212.73	212.73	212.73	212.73	212.76	212.88			212.49	212.06
East Edmond (EM-3W)	212.23	212.25	212.43	212.70	212.63	212.69	212.75	212.77	212.85			212.50	212.18
Eastern East Edmond (SCM-1)	212.28	212.32	212.67	212.81	212.78	212.79	212.80	212.83	212.95			212.58	212.26

Table F-11. Water Balance for East Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water	WY2012												WY2013
Hydrologic Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Precipitation	4.1	6.1	3.2	7.2	3.9	6.8	4.3	3.1	3.3	1.6	0.0	0.1	6.5
Surface Water Inflows	0.2	0.7	2.5	2.6	3.1	3.4	3.2	3.3	2.9	2.6	0.0	0.1	0.3
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.2	0.3	0.1	0.3	0.1	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.3
From Hamer (surface)	0.0	0.4	2.4	2.3	2.9	3.1	3.0	3.2	2.8	2.6	0.0	0.1	0.0
Subsurface Inflows	2.1	2.2	1.8	2.0	1.6	1.6	1.7	1.8	1.7	1.7	1.8	1.5	2.0
Evapotranspiration	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0
Recharge (-) Discharge (+)	*-0.7*	*-2.2*	*-3.0*	*-2.0*	*-3.3*	*-3.9*	*-2.2*	*-3.6*	*-3.5*	*-2.6*	*-0.9*	*-1.9*	*-2.5*
Surface Water Outflows	0.0	-1.8	-1.5	-5.0	-2.3	-3.4	-3.5	-0.8	-0.5	-0.5	-0.4	0.0	-0.2
To Diversion Canal	0.0	-1.8	-1.7	-5.3	-2.7	-4.0	-4.7	-1.4	-1.0	-1.0	-0.8	0.0	-0.3
To West Edmond Marsh	0.0	-1.7	-1.4	-5.0	-2.2	-3.3	-3.1	-0.6	-0.4	-0.4	-0.3	0.0	-0.1
Change in Storage	4.6	4.6	3.1	4.7	2.4	3.2	1.4	0.7	0.2	-1.7	-3.5	-2.6	5.1
Predicted WSE in ft													
EM-2S	210.09	210.43	210.49	210.70	210.67	210.68	210.58	210.39	210.18	209.84	209.56	209.34	209.77
East Edmond	212.20	212.43	212.57	212.55	212.59	212.59	212.48	212.51	212.50	212.34	212.03	211.82	212.24
Eastern East Edmond Marsh	211.13	211.63	211.88	212.52	212.70	212.99	212.83	212.63	212.45	212.12	211.66	211.45	211.79
Observed WSE in ft													
EM-2S	210.97	211.29	211.31	211.37	211.36	211.38	211.40	211.41	211.36	211.25	211.14	210.84	211.08
East Edmond (EM-2E)	211.83	212.03	212.25	212.50	212.52	212.55	212.57	212.63	212.54	212.34	212.13	211.72	212.01
East Edmond (EM-2W)	211.40	211.67	211.71	211.72	211.75	211.76	211.77	211.78	211.75	211.65	211.55	211.31	211.50
East Edmond (EM-3E)	212.19	212.38	212.61	212.85	212.88	212.92	212.95	213.00	212.91	212.70	212.50	212.09	212.37
East Edmond (EM-3W)	212.29	212.50	212.73	212.98	212.99	213.02	213.05	213.11	213.03	212.82	212.61	212.20	212.48
Eastern East Edmond (SCM-1)	212.40	212.59	212.85	213.10	213.12	213.15	213.18	213.35	213.17	212.95	212.74	212.21	212.55

Table F-11. Water Balance for East Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water | WY2014

Hydrologic Process	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Precipitation	6.5	7.6	3.5	1.7	3.7	5.5	4.4	1.9	0.0	1.6	6.9	2.6	4.1
Surface Water Inflows	1.9	3.5	3.2	2.9	3.2	3.3	4.0	3.3	0.0	0.8	0.3	1.9	2.0
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.3	0.3	0.1	0.0	0.1	0.2	0.2	0.1	0.0	0.0	0.3	0.1	0.2
From Hamer (surface)	1.6	3.2	3.1	2.9	3.1	3.1	3.8	3.2	0.0	0.8	0.0	1.8	1.9
Subsurface Inflows	2.1	1.8	1.8	1.5	1.6	1.7	1.7	1.6	1.6	1.4	2.0	1.9	1.8
Evapotranspiration	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5
Recharge (-) Discharge (+)	*-3.0*	*-2.7*	*-3.8*	*-3.4*	*-3.6*	*-4.1*	*-5.0*	*-4.0*	*-1.9*	*-1.8*	*-1.6*	*-2.0*	*-2.7*
Surface Water Outflows	-2.0	-4.6	-3.0	-1.3	-1.7	-2.3	-1.0	-0.5	0.0	-0.3	-0.2	-0.3	-2.4
To Diversion Canal	-2.3	-5.0	-3.8	-2.1	-2.2	-2.9	-1.8	-1.0	0.0	-0.6	-0.4	-0.6	-2.7
To West Edmond Marsh	-1.9	-4.5	-2.8	-1.1	-1.5	-2.2	-0.8	-0.4	0.0	-0.2	-0.2	-0.3	-2.3
Change in Storage	5.0	5.7	1.7	0.8	2.0	2.1	0.8	-1.5	-4.8	-2.3	5.0	3.0	2.4
Predicted WSE in ft													
EM-2S	210.06	210.28	210.18	210.02	209.94	209.86	209.63	209.25	209.00	209.00	209.42	209.52	209.57
East Edmond	212.50	212.61	212.54	212.54	212.59	212.59	212.61	212.47	212.07	211.87	212.27	212.50	212.51
Eastern East Edmond Marsh	212.23	212.88	212.88	212.70	212.75	212.86	212.66	212.34	211.93	211.60	211.91	212.02	212.24
Observed WSE in ft													
EM-2S	211.31	211.47	211.40	211.40	211.39	211.44	211.43	211.37	211.19	210.88	211.31	211.51	211.47
East Edmond (EM-2E)	212.29	212.69	212.64	212.56	212.59	212.63	212.48	212.39	212.03	211.66	212.05	212.55	212.52
East Edmond (EM-2W)	211.69	211.83	211.78	211.75	211.76	211.81	211.82	211.80	211.64	211.36	211.76	211.89	211.86
East Edmond (EM-3E)	212.65	213.05	212.99	212.91	213.01	212.99	212.86	212.77	212.41	212.03	212.41	212.93	212.88
East Edmond (EM-3W)	212.76	213.17	213.11	213.04	213.06	213.10	212.96	212.88	212.51	212.15	212.53	213.03	212.99
Eastern East Edmond (SCM-1)	212.90	213.32	213.27	213.18	213.21	213.26	213.10	213.03	212.65	212.26	212.66	213.16	213.14

Table F-11. Water Balance for East Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water — WY2015

Hydrologic Process	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation	2.4	4.2	6.9	9.8	4.5	3.3	1.3	1.2	1.6	1.8	5.9	6.1	4.8
Surface Water Inflows	3.0	2.4	3.0	4.5	4.0	4.4	2.4	2.1	2.3	1.3	1.5	3.3	4.4
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.1	0.2	0.3	0.4	0.2	0.1	0.0	0.0	0.0	0.1	0.3	0.2	0.2
From Hamer (surface)	2.9	2.3	2.7	4.1	3.9	4.3	2.4	2.1	2.3	1.2	1.3	3.1	4.2
Subsurface Inflows	1.5	1.7	1.7	1.8	2.1	2.1	2.0	2.1	2.0	2.1	2.4	2.1	2.0
Evapotranspiration	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0
Recharge (-) Discharge (+)	*-4.2*	*-3.4*	*-2.1*	*-3.6*	*-1.8*	*-2.8*	*-3.1*	*-2.8*	*-2.7*	*-1.8*	*-3.2*	*-4.0*	*-3.3*
Surface Water Outflows	-1.0	-2.9	-4.4	-5.9	-5.5	-0.6	-0.7	-0.5	-0.4	-0.3	-1.0	-2.8	-3.6
To Diversion Canal	-1.4	-3.3	-4.8	-7.0	-7.9	-1.1	-1.2	-0.9	-0.7	-0.5	-1.3	-3.1	-4.1
To West Edmond Marsh	-0.9	-2.8	-4.2	-5.5	-4.7	-0.4	-0.5	-0.4	-0.3	-0.2	-1.0	-2.7	-3.5
Change in Storage	1.7	2.0	4.5	5.3	1.4	3.2	-1.8	-2.3	-1.1	0.7	4.6	4.3	4.3
Predicted WSE in ft													
EM-2S	209.48	209.46	209.62	209.76	209.61	209.54	209.21	209.00	209.00	209.00	209.28	209.38	209.40
East Edmond	212.59	212.54	212.57	212.58	212.37	212.61	212.44	212.22	212.12	212.17	212.47	212.61	212.69
Eastern East Edmond Marsh	212.25	212.44	212.97	213.25	212.75	212.80	212.43	212.04	211.80	211.74	212.06	212.46	212.88
Observed WSE in ft													
EM-2S	211.39	211.43	211.51	211.50	211.51	211.54	211.48	211.33	211.22	211.30	211.38	211.49	211.49
East Edmond (EM-2E)	212.33	212.43	212.59	212.59	212.68	212.81	212.73	212.32			212.34	212.53	212.51
East Edmond (EM-2W)	211.80	211.82	211.86	211.87	211.88	211.90	211.87	211.78	211.71	211.76	211.81	211.88	211.89
East Edmond (EM-3E)	212.69	212.80	212.95	212.96	213.04	213.19	213.08	212.66	212.49	212.59	212.69	212.91	212.94
East Edmond (EM-3W)	212.80	212.91	213.06	213.06	213.15	213.29	213.19	212.79	212.61	212.57	212.54	213.02	213.04
Eastern East Edmond (SCM-1)	212.95	213.07	213.21	213.25	213.33	213.46	213.22	212.98	212.76	212.86	212.97	213.20	213.26

Table F-11. Water Balance for East Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water — WY2016

Hydrologic Process	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Precipitation	4.1	4.7	4.4	2.1	0.8	0.4	0.2	2.2	1.3	5.0	7.1	12.0	6.9
Surface Water Inflows	4.3	3.8	4.3	3.8	1.3	0.3	0.2	0.1	0.0	0.2	0.3	2.9	4.3
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.2	0.2	0.2	0.1	0.0	0.0	0.0	0.1	0.0	0.2	0.3	0.5	0.3
From Hamer (surface)	4.1	3.7	4.1	3.8	1.3	0.3	0.2	0.0	0.0	0.0	0.0	2.4	4.0
Subsurface Inflows	1.9	1.7	1.9	1.8	1.8	1.7	1.8	1.7	1.5	1.5	2.3	2.0	1.8
Evapotranspiration	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0
Recharge (-) Discharge (+)	*-3.9*	*-3.3*	*-3.4*	*-3.9*	*-4.2*	*-3.8*	*-2.4*	*-2.0*	*-1.1*	*-2.4*	*0.1*	*-2.6*	*-4.6*
Surface Water Outflows	-3.8	-4.0	-3.1	-1.0	0.0	0.0	0.0	-0.2	-0.1	-0.1	-0.7	-6.3	-5.1
To Diversion Canal	-4.6	-5.2	-4.4	-1.8	0.0	0.0	0.0	-0.4	-0.2	-0.1	-0.8	-6.6	-6.9
To West Edmond Marsh	-3.5	-3.7	-2.8	-0.7	0.0	0.0	0.0	-0.2	-0.1	0.0	-0.6	-6.2	-4.6
Change in Storage	2.5	2.2	2.8	0.9	-3.4	-5.0	-4.6	-2.3	-0.8	3.3	8.7	8.1	3.2
Predicted WSE in ft													
EM-2S	209.29	209.20	209.12	209.00	209.00	209.00	209.00	209.00	209.00	209.28	210.01	210.49	210.46
East Edmond	212.63	212.54	212.57	212.60	212.32	211.90	211.52	211.43	211.43	211.70	212.38	212.55	212.48
Eastern East Edmond Marsh	213.01	212.99	212.89	212.66	212.37	211.96	211.57	211.28	211.17	211.41	212.10	213.11	212.99
Observed WSE in ft													
EM-2S	211.46	211.44	211.42	211.33	211.28	211.07	210.67	210.28	210.36	210.44	211.37	211.34	
East Edmond (EM-2E)	212.49	212.47	212.45	212.47	212.38	211.92	211.60	211.43	211.43	211.43	212.50	212.38	
East Edmond (EM-2W)	211.84	211.81	211.78	211.21	211.71	211.53	211.17	210.76	210.81	210.86	211.72	211.68	
East Edmond (EM-3E)	212.85	212.82	212.79	212.83	212.74	212.20	211.92	211.62	211.64	211.65	212.85	212.70	
East Edmond (EM-3W)	212.94	212.92	212.91	212.94	212.83	212.39	212.03	211.71	211.73	211.75	212.95	212.82	
Eastern East Edmond (SCM-1)	213.13	213.11	213.09	213.13	213.03	212.53	212.14	211.79	211.81	211.83	213.11	212.99	

Table F-11. Water Balance for East Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water — WY2017

Hydrologic Process	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Precipitation	5.8	5.9	1.8	1.0	2.3	1.3	0.2	1.5	9.3	6.9	3.9	3.4	8.6
Surface Water Inflows	4.1	4.3	3.4	1.8	2.5	2.0	0.2	0.7	0.7	2.9	4.4	4.2	4.1
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.2	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.4	0.3	0.1	0.1	0.3
From Hamer (surface)	3.9	4.1	3.3	1.7	2.4	2.0	0.2	0.6	0.2	2.6	4.2	4.1	3.8
Subsurface Inflows	1.7	1.7	1.8	1.9	2.3	2.2	2.2	2.0	2.0	2.4	2.1	2.2	1.8
Evapotranspiration	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6
Recharge (-) Discharge (+)	*-4.9*	*-5.1*	*-4.0*	*-3.2*	*-2.4*	*-2.4*	*-1.1*	*-0.9*	*-3.6*	*-3.3*	*-4.0*	*-5.7*	*-5.1*
Surface Water Outflows	-2.9	-2.9	-1.0	-0.5	-0.4	-0.4	-0.3	-0.1	-1.5	-3.2	-2.7	-3.1	-4.0
To Diversion Canal	-4.1	-4.0	-1.9	-1.0	-0.8	-0.7	-0.5	-0.3	-1.6	-3.5	-3.1	-4.4	-4.4
To West Edmond Marsh	-2.6	-2.6	-0.7	-0.4	-0.3	-0.3	-0.2	-0.1	-1.4	-3.1	-2.5	-2.8	-3.9
Change in Storage	3.2	2.6	0.0	-2.2	0.5	-1.7	-2.8	0.8	5.9	5.2	3.8	1.0	4.8
Predicted WSE in ft													
EM-2S	210.43	210.34	210.08	209.76	209.61	209.31	209.07	209.08	209.56	209.78	209.75	209.52	209.61
East Edmond	212.56	212.59	212.55	212.34	212.37	212.21	211.97	212.03	212.40	212.58	212.69	212.57	212.65
Eastern East Edmond Marsh	212.95	212.90	212.57	212.19	212.07	211.77	211.42	211.40	211.93	212.45	212.75	212.52	213.00
Observed WSE in ft													
EM-2S					211.28	211.15	210.81		210.79	211.31	211.32	211.17	211.47
East Edmond (EM-2E)					212.38	212.27	211.76		211.57	212.24	212.22	212.05	212.04
East Edmond (EM-2W)					211.68	211.57	211.27		211.29	211.90	211.78	211.57	211.59
East Edmond (EM-3E)					212.59	212.34	212.05		211.87	212.33	212.35	212.39	213.34
East Edmond (EM-3W)					212.81	212.60	212.19		212.00	212.69	212.66	212.50	212.46
Eastern East Edmond (SCM-1)					212.88	212.65	212.28		212.08	212.60	212.59	212.62	210.24

Table F-11. Water Balance for East Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water — WY 2018

Hydrologic Process	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Precipitation	8.7	4.6	2.8	1.8	0.0	0.1	1.0	5.2	7.2	5.8	7.2	3.3	2.3
Surface Water Inflows	4.4	4.2	4.3	3.4	0.0	0.1	1.6	1.7	2.1	3.7	4.4	3.8	4.3
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.2	0.3	0.2	0.3	0.1	0.1
From Hamer (surface)	4.0	4.1	4.2	3.3	0.0	0.1	1.6	1.5	1.8	3.5	4.2	3.7	4.2
Subsurface Inflows	2.3	2.3	2.4	2.5	2.8	3.3	2.8	2.0	2.2	2.3	2.1	2.2	2.3
Evapotranspiration	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3
Recharge (-) Discharge (+)	*-2.7*	*-3.2*	*-4.8*	*-5.3*	*-3.2*	*-2.3*	*-2.8*	*-3.3*	*-3.3*	*-4.5*	*-5.6*	*-2.5*	*-5.1*
Surface Water Outflows	-8.1	-2.6	-0.8	-0.4	0.0	-0.2	-0.1	-0.1	-1.4	-3.0	-4.0	-5.3	-0.5
To Diversion Canal	-10.6	-4.1	-1.5	-0.9	0.0	-0.5	-0.2	-0.2	-1.6	-3.4	-4.5	-7.3	-1.0
To West Edmond Marsh	-7.3	-2.1	-0.6	-0.3	0.0	-0.2	-0.1	-0.1	-1.4	-3.0	-3.8	-4.7	-0.4
Change in Storage	3.3	3.4	0.7	-1.8	-4.8	-3.0	0.2	4.5	6.2	4.3	4.1	1.0	2.1
Predicted WSE in ft													
EM-2S	209.62	209.61	209.33	209.00	209.00	209.00	209.00	209.26	209.63	209.71	209.72	209.54	209.37
East Edmond	212.38	212.53	212.56	212.39	211.99	211.73	211.74	212.11	212.52	212.64	212.68	212.42	212.57
Eastern East Edmond Marsh	212.82	212.62	212.39	212.06	211.66	211.29	211.25	211.58	212.11	212.53	212.96	212.50	212.49
Observed WSE in ft													
EM-2S	211.31	211.27		211.18	211.05	211.24	210.72			211.95		211.29	211.12
East Edmond (EM-2E)	212.14	212.21		212.34	212.18	211.95	211.82			212.59		212.35	212.14
East Edmond (EM-2W)	210.67	211.63		211.55	211.44	210.47	211.09			211.69		211.60	211.48
East Edmond (EM-3E)	212.37	212.47		212.67	212.88	212.52	212.03			212.56		212.51	212.40
East Edmond (EM-3W)	212.54	212.62		212.78	212.62	212.37	212.27			213.07		212.79	212.58
Eastern East Edmond (SCM-1)	212.62	212.68		212.95	212.65	212.56	212.64			212.89		212.76	212.65

Table F-11. Water Balance for East Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water — WY2019

Hydrologic Process	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Precipitation	6.1	0.7	0.9	0.2	0.3	1.8	4.0	3.8	6.4	3.4	4.8	1.6	3.6
Surface Water Inflows	4.0	0.8	1.5	0.2	0.2	0.1	0.2	0.8	2.2	4.2	4.0	3.2	3.5
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.2	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.3	0.1	0.2	0.0	0.1
From Hamer (surface)	3.8	0.8	1.5	0.2	0.2	0.0	0.0	0.6	1.9	4.1	3.9	3.1	3.4
Subsurface Inflows	2.2	2.3	2.3	2.6	2.4	2.4	2.4	2.7	2.9	2.5	2.0	2.1	2.0
Evapotranspiration	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0
Recharge (-) Discharge (+)	*-4.5*	*-5.6*	*-5.0*	*-3.5*	*-3.1*	*-2.2*	*-5.2*	*-2.3*	*-3.7*	*-5.3*	*-5.3*	*-6.0*	*-5.6*
Surface Water Outflows	-2.5	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.2	-1.0	-2.7	-0.5	-0.5
To Diversion Canal	-3.0	0.0	0.0	0.0	0.0	-0.2	-0.1	-0.1	-0.4	-1.3	-3.1	-1.0	-0.8
To West Edmond Marsh	-2.4	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-0.1	-0.9	-2.6	-0.4	-0.4
Change in Storage	3.3	-5.1	-3.9	-5.0	-4.1	-0.4	0.3	4.5	7.6	3.8	2.3	-1.0	1.0
Predicted WSE in ft													
EM-2S	209.34	209.00	209.00	209.00	209.00	209.00	209.03	209.35	209.82	209.80	209.68	209.35	209.16
East Edmond	212.66	212.23	211.91	211.49	211.43	211.43	211.45	211.82	212.44	212.69	212.67	212.57	212.63
Eastern East Edmond Marsh	212.74	212.32	211.99	211.57	211.23	211.15	211.15	211.49	212.03	212.24	212.46	212.19	212.11
Observed WSE in ft													
EM-2S	211.17	211.08	211.17	211.01	210.61	210.70	210.71	211.07	211.35	211.39	211.14	211.24	211.37
East Edmond (EM-2E)	212.37	212.41	212.23	212.05	211.65	211.73	211.78	212.21	212.63		212.55	212.37	212.63
East Edmond (EM-2W)	211.51	211.24	211.59	211.44	211.01	211.12	211.07	211.66	211.70		211.48	211.66	211.89
East Edmond (EM-3E)	212.48						212.06	212.42	212.65	212.71	212.83	212.69	212.67
East Edmond (EM-3W)	212.81	212.81	212.50	212.50	212.14	212.19	212.19	212.64	212.98	212.50	213.00	212.81	213.06
Eastern East Edmond (SCM-1)	212.77	212.59	212.85	212.01	211.75	211.84	212.57					212.88	212.90

Table F-11. Water Balance for East Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water — WY2020

Hydrologic Process	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Precipitation	1.1	0.7	1.0	0.8	3.5	3.9	1.7	6.5	9.6	4.2	3.5	1.5	3.1
Surface Water Inflows	2.0	0.7	0.5	0.0	0.2	0.2	0.1	0.3	2.0	4.2	4.4	2.9	3.2
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.0	0.0	0.0	0.0	0.2	0.2	0.1	0.3	0.4	0.2	0.1	0.0	0.1
From Hamer (surface)	2.0	0.7	0.5	0.0	0.0	0.0	0.0	0.0	1.6	4.0	4.3	2.9	3.1
Subsurface Inflows	1.9	1.7	1.7	1.5	1.7	2.1	2.0	1.8	2.6	2.1	1.9	2.0	1.9
Evapotranspiration	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2
Recharge (-) Discharge (+)	*-5.2*	*-4.0*	*-2.8*	*-2.7*	*-4.3*	*-0.2*	*0.5*	*-3.7*	*-2.3*	*-5.7*	*-3.6*	*-2.6*	*-3.6*
Surface Water Outflows	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	-1.1	-6.1	-2.4	-2.9	-1.4	-0.5
To Diversion Canal	0.0	0.0	-0.3	0.0	0.0	0.0	0.0	-1.2	-6.3	-2.9	-3.6	-2.3	-0.9
To West Edmond Marsh	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	-1.1	-6.0	-2.3	-2.7	-1.1	-0.4
Change in Storage	-3.5	-4.7	-4.2	-4.4	-1.3	5.0	3.8	3.8	5.8	1.8	2.1	0.5	1.1
Predicted WSE in ft													
EM-2S	209.00	209.00	209.00	209.00	209.00	209.41	209.73	210.05	210.41	210.23	210.06	209.88	209.72
East Edmond	212.34	211.95	211.59	211.43	211.43	211.84	212.16	212.39	212.37	212.34	212.30	212.27	212.34
Eastern East Edmond Marsh	211.82	211.43	210.99	210.63	210.52	210.94	211.26	211.61	212.47	212.60	212.68	212.38	212.29
Observed WSE in ft													
EM-2S		210.80	210.49	210.07	210.20	210.34		210.30	211.41	210.49			
East Edmond (EM-2E)		211.91	211.55	211.43	211.43	211.44		211.43	212.60	212.45			
East Edmond (EM-2W)		211.58	210.92	210.54		210.77		211.58	211.69	211.66			
East Edmond (EM-3E)						211.90		211.74	212.80	212.80			
East Edmond (EM-3W)		212.37	212.00	211.54	212.27	211.89		212.16	213.03	212.89			
Eastern East Edmond (SCM-1)													

Table F-11. Water Balance for East Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water — WY 2021

Hydrologic Process	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Precipitation	2.5	0.3	0.4	2.8	3.0	5.6	5.2	7.3	4.7	2.5	1.2	2.0	2.4
Surface Water Inflows	2.7	0.2	0.0	0.1	0.1	0.3	0.4	2.6	4.1	4.3	2.3	3.3	2.2
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.1	0.0	0.0	0.1	0.1	0.3	0.2	0.3	0.2	0.1	0.0	0.1	0.1
From Hamer (surface)	2.6	0.2	0.0	0.0	0.0	0.0	0.1	2.3	3.9	4.3	2.2	3.2	2.1
Subsurface Inflows	1.7	1.5	1.4	1.6	1.7	2.1	2.3	2.5	2.1	2.3	2.2	2.2	2.0
Evapotranspiration	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7
Recharge (-) Discharge (+)	*-3.2*	*-4.9*	*-4.5*	*-3.5*	*-3.3*	*-1.6*	*-2.6*	*-3.5*	*-4.5*	*-5.8*	*-6.2*	*-4.6*	*-4.3*
Surface Water Outflows	-0.4	0.0	0.0	0.0	0.0	0.0	-0.1	-4.6	-3.1	-1.5	0.0	-0.4	-0.3
To Diversion Canal	-0.8	0.0	0.0	0.0	0.0	0.0	-0.3	-4.9	-3.5	-2.2	0.0	-0.8	-0.7
To West Edmond Marsh	-0.3	0.0	0.0	0.0	0.0	0.0	-0.1	-4.6	-3.0	-1.3	0.0	-0.3	-0.3
Change in Storage	-0.4	-7.4	-6.7	-1.4	0.5	5.9	5.2	4.3	2.7	0.6	-2.6	-0.7	-1.6
Predicted WSE in ft													
EM-2S	209.48	209.00	209.00	209.00	209.04	209.53	209.95	210.12	210.03	209.75	209.35	209.03	209.00
East Edmond	212.29	211.67	211.43	211.43	211.47	211.96	212.38	212.37	212.35	212.30	212.09	212.02	211.86
Eastern East Edmond Marsh	212.09	211.47	210.92	210.80	210.84	211.33	211.70	212.31	212.60	212.44	212.23	212.00	211.71
Observed WSE in ft													
EM-2S		210.83	210.33		210.25			211.47			211.31	211.27	211.13
East Edmond (EM-2E)		211.43	211.43		211.43	212.93		212.54			212.27	212.16	212.04
East Edmond (EM-2W)			210.76		210.69			211.77	212.14	212.14	211.70	211.69	211.51
East Edmond (EM-3E)					211.47	212.18		212.88	213.54	212.83	212.43		
East Edmond (EM-3W)			211.69		211.56	212.50		212.99	212.50	212.50	212.73	212.60	212.50
Eastern East Edmond (SCM-1)													

Table F-11. Water Balance for East Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water WY 2021

Hydrologic Process	Jul	Aug	Sep
Precipitation	0.0	0.3	2.6
Surface Water Inflows	0.0	0.0	0.1
From Sequalitchew Lake	0.0	0.0	0.0
From Center Drive	0.0	0.0	0.1
From Hamer (surface)	0.0	0.0	0.0
Subsurface Inflows	2.0	1.7	1.8
Evapotranspiration	-4.5	-4.0	-2.3
Recharge (-) Discharge (+)	*-4.1*	*-4.6*	*-4.1*
Surface Water Outflows	0.0	0.0	0.0
To Diversion Canal	0.0	0.0	0.0
To West Edmond Marsh	0.0	0.0	0.0
Change in Storage	-6.6	-6.6	-1.9
Predicted WSE in ft			
EM-2S	209.00	209.00	209.00
East Edmond	211.43	211.43	211.43
Eastern East Edmond Marsh	211.16	210.61	210.45
Observed WSE in ft			
EM-2S	210.73		
East Edmond (EM-2E)	211.69	211.43	
East Edmond (EM-2W)	211.14		
East Edmond (EM-3E)			
East Edmond (EM-3W)	212.23	211.56	
Eastern East Edmond (SCM-1)		210.20	

Table F-12. Water Balance for West Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water	WY2004						WY2005						
Hydrologic Process	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Precipitation	2.0	1.0	3.8	0.9	0.1	3.6	2.9	4.0	3.2	4.3	4.3	0.6	4.5
Surface Water Inflows	8.8	0.0	0.7	0.8	0.6	0.1	0.0	0.1	1.4	2.0	5.1	0.0	0.9
From East Edmond	8.8	0.0	0.7	0.8	0.6	0.1	0.0	0.1	1.4	2.0	5.1	0.0	0.9
Evapotranspiration	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3
Recharge (-) Discharge (+)	-5.9	-5.4	-9.0	-8.1	-8.9	-6.6	-0.6	-3.1	-3.6	0.6	2.4	-1.9	-6.1
Surface Water Outflows	0.0	-0.3	-0.3	-0.3	-0.2	-0.1	0.0	0.0	0.0	0.0	-0.1	-0.2	-0.2
To Center Drive	0.0	-0.3	-0.3	-0.3	-0.2	-0.1	0.0	0.0	0.0	0.0	-0.1	-0.2	-0.2
Change in Storage	3.6	-6.7	-7.9	-10.3	-13.0	-6.9	0.0	0.0	0.4	6.9	11.8	-2.1	-2.2
Predicted WSE in ft	209.04	208.48	207.82	206.96	205.88	205.31	205.31	205.31	205.34	205.92	206.90	206.73	206.54
Observed WSE EM-1/EM-1A	209.10	208.59	207.26	206.55	205.27	205.27	205.27	205.86	206.15	207.67	209.18	207.97	206.63

Table F-12. Water Balance for West Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water — WY2006

Hydrologic Process	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Precipitation	5.4	3.9	3.8	1.4	0.2	1.6	3.3	6.7	6.5	12.2	3.2	2.6	3.9
Surface Water Inflows	6.7	0.8	3.3	0.8	0.0	0.0	0.0	0.0	0.0	24.9	1.7	1.9	3.4
From East Edmond	6.7	0.8	3.3	0.8	0.0	0.0	0.0	0.0	0.0	24.9	1.7	1.9	3.4
Evapotranspiration	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0
Recharge (-) Discharge (+)	0.5	-1.2	-6.2	-8.8	-7.2	0.7	-2.3	-2.4	0.8	-2.6	-4.8	-4.8	-4.9
Surface Water Outflows	-0.2	-0.2	-0.2	-0.2	-0.1	0.0	0.0	0.0	-0.1	-0.1	-0.2	-0.3	-0.3
To Center Drive	-0.2	-0.2	-0.2	-0.2	-0.1	0.0	0.0	0.0	-0.1	-0.1	-0.2	-0.3	-0.3
Change in Storage	10.5	0.1	-3.0	-11.4	-11.2	0.0	0.0	3.8	7.2	34.4	-0.8	-1.8	0.2
Predicted WSE in ft	207.42	207.43	207.18	206.23	205.31	205.31	205.31	205.63	206.23	209.09	209.03	208.88	208.90
Observed WSE EM-1/EM-1A	209.29	209.08	207.09	205.79	205.27	205.27	205.27	206.05	208.15	208.82	208.53	208.69	208.78

Table F-12. Water Balance for West Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water WY2007

Hydrologic Process	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Precipitation	2.1	2.2	0.4	0.0	0.8	1.6	14.4	8.6	6.5	4.5	5.7	1.7	1.1
Surface Water Inflows	0.8	0.6	0.0	0.4	0.1	0.0	131.8	13.3	14.0	4.4	13.2	3.3	0.7
From East Edmond	0.8	0.6	0.0	0.4	0.1	0.0	131.8	13.3	14.0	4.4	13.2	3.3	0.7
Evapotranspiration	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2
Recharge (-) Discharge (+)	-3.7	-6.7	-10.4	-9.1	-1.9	-0.6	-4.5	-2.6	-5.7	-5.2	-5.2	-5.2	-6.4
Surface Water Outflows	-0.3	-0.3	-0.3	-0.2	-0.1	0.0	-94.6	-19.6	-14.9	-3.1	-12.5	-0.3	-0.3
To Center Drive	-0.3	-0.3	-0.3	-0.2	-0.1	0.0	-94.6	-19.6	-14.9	-3.1	-12.5	-0.3	-0.3
Change in Storage	-4.3	-7.9	-14.8	-12.8	-3.4	0.0	46.7	-0.3	0.0	0.0	0.0	-2.4	-8.0
Predicted WSE in ft	208.54	207.89	206.65	205.59	205.31	205.31	209.20	209.18	209.18	209.18	209.18	208.97	208.30
Observed WSE EM-1/EM-1A	207.56	207.10	205.67	205.27	205.27	205.27	208.74	208.94	208.71	208.75	208.84	208.70	207.84

Table F-12. Water Balance for West Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water — WY2008

Hydrologic Process	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Precipitation	2.7	1.5	1.0	1.7	5.0	2.8	7.7	4.2	3.6	4.9	1.8	1.3	1.7
Surface Water Inflows	0.6	0.8	0.8	0.6	30.7	4.5	16.8	8.4	6.8	6.7	4.3	0.7	0.6
From East Edmond	0.6	0.8	0.8	0.6	30.7	4.5	16.8	8.4	6.8	6.7	4.3	0.7	0.6
Evapotranspiration	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7
Recharge (-) Discharge (+)	-7.8	-8.0	-7.0	-6.8	-6.8	-4.9	-4.7	-6.0	-6.0	-5.5	-5.9	-9.1	-9.0
Surface Water Outflows	-0.2	-0.3	-0.2	-0.1	0.0	-0.3	-3.6	-6.6	-3.9	-4.8	-0.3	-0.3	-0.2
To Center Drive	-0.2	-0.3	-0.2	-0.1	0.0	-0.3	-3.6	-6.6	-3.9	-4.8	-0.3	-0.3	-0.2
Change in Storage	-8.5	-10.4	-9.4	-6.9	27.8	1.7	16.2	0.0	0.0	0.0	-2.1	-10.6	-10.8
Predicted WSE in ft	207.59	206.72	205.94	205.37	207.68	207.83	209.18	209.18	209.18	209.18	209.00	208.12	207.22
Observed WSE EM-1/EM-1A	206.92	205.84	205.63	205.62	207.09	207.82	209.17	209.07	209.02	209.23	209.03	206.96	206.38

Table F-12. Water Balance for West Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water WY2009

Hydrologic Process	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Precipitation	0.9	2.1	0.5	2.6	8.3	5.2	7.3	1.6	5.3	3.5	3.4	1.3	0.0
Surface Water Inflows	0.6	0.3	1.0	0.4	32.2	6.4	8.8	4.2	4.0	3.6	1.9	0.8	0.0
From East Edmond	0.6	0.3	1.0	0.4	32.2	6.4	8.8	4.2	4.0	3.6	1.9	0.8	0.0
Evapotranspiration	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5
Recharge (-) Discharge (+)	-9.9	-8.4	0.8	-1.9	-4.7	-5.7	-6.7	-6.7	-4.1	-5.9	-7.2	-11.7	-15.2
Surface Water Outflows	-0.2	-0.1	0.0	0.0	0.0	-0.2	-4.1	-0.3	-2.2	-0.3	-0.3	-0.3	0.0
To Center Drive	-0.2	-0.1	0.0	0.0	0.0	-0.2	-4.1	-0.3	-2.2	-0.3	-0.3	-0.3	0.0
Change in Storage	-13.0	-10.0	0.0	0.0	35.4	5.6	5.4	-1.7	1.7	-1.1	-5.5	-13.6	-19.7
Predicted WSE in ft	206.14	205.31	205.31	205.31	208.26	208.73	209.18	209.03	209.18	209.08	208.63	207.50	205.86
Observed WSE EM-1/EM-1A	205.27	205.27		205.27	208.19	208.61	208.52	208.60	209.22	209.09	208.22	206.01	205.27

Table F-12. Water Balance for West Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water WY2010

Hydrologic Process	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Precipitation	1.9	2.8	5.6	8.9	3.0	8.0	3.3	3.3	3.3	4.6	4.3	0.4	0.2
Surface Water Inflows	0.6	0.7	0.7	77.1	2.5	11.5	9.4	0.6	6.0	4.2	3.3	0.0	0.7
From East Edmond	0.6	0.7	0.7	77.1	2.5	11.5	9.4	0.6	6.0	4.2	3.3	0.0	0.7
Evapotranspiration	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0
Recharge (-) Discharge (+)	-5.1	-1.1	-5.2	-4.4	-3.3	-5.3	-6.3	-6.6	-3.9	-8.6	-7.3	-11.5	-13.2
Surface Water Outflows	-0.1	0.0	0.0	-34.5	-2.4	-14.2	-5.8	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2
To Center Drive	-0.1	0.0	0.0	-34.5	-2.4	-14.2	-5.8	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2
Change in Storage	-6.7	0.0	0.0	46.7	-0.3	0.0	0.0	-4.2	3.3	-3.3	-3.7	-15.8	-16.5
Predicted WSE in ft	205.31	205.31	205.31	209.20	209.18	209.18	209.18	208.83	209.10	208.83	208.52	207.20	205.82
Observed WSE EM-1/EM-1A	205.27	205.27	205.98	209.21	209.55	208.68	208.58	208.34	209.17	207.87	207.82	206.07	206.07

Table F-12. Water Balance for West Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water WY2011

Hydrologic Process	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Precipitation	4.0	4.2	6.6	7.2	6.1	3.1	7.2	5.7	4.8	2.8	0.8	0.3	1.3
Surface Water Inflows	0.5	1.0	20.0	1.2	8.8	6.1	5.5	8.1	1.3	1.0	0.0	0.0	0.0
From East Edmond	0.5	1.0	20.0	1.2	8.8	6.1	5.5	8.1	1.3	1.0	0.0	0.0	0.0
Evapotranspiration	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3
Recharge (-) Discharge (+)	-2.8	-4.1	0.1	-0.3	-7.1	-6.5	-7.2	-4.5	1.8	-3.4	-6.3	-8.4	-9.3
Surface Water Outflows	-0.1	-0.1	-0.1	-0.3	-0.5	-2.2	-4.3	-7.4	-4.7	-0.3	-0.3	-0.2	-0.2
To Center Drive	-0.1	-0.1	-0.1	-0.3	-0.5	-2.2	-4.3	-7.4	-4.7	-0.3	-0.3	-0.2	-0.2
Change in Storage	-0.8	-0.1	26.1	7.8	7.3	0.0	0.0	0.0	0.0	-3.6	-10.3	-12.4	-10.5
Predicted WSE in ft	205.76	205.75	207.92	208.57	209.18	209.18	209.18	209.18	209.18	208.88	208.01	206.98	206.11
Observed WSE EM-1/EM-1A	206.07	206.05	208.98	209.46	207.57		208.99	209.34	209.95		207.28	206.60	206.03

Table F-12. Water Balance for West Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water	WY2012												WY2013
Hydrologic Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Precipitation	4.1	6.1	3.2	7.2	3.9	6.8	4.3	3.1	3.3	1.6	0.0	0.1	6.5
Surface Water Inflows	0.0	10.2	6.2	18.5	5.6	7.5	7.2	1.2	0.9	0.9	1.1	0.0	0.7
From East Edmond	0.0	10.2	6.2	18.5	5.6	7.5	7.2	1.2	0.9	0.9	1.1	0.0	0.7
Evapotranspiration	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0
Recharge (-) Discharge (+)	-6.7	-5.2	-2.6	-6.6	-4.7	-7.3	-7.7	-6.1	-5.9	-7.7	-8.6	-9.7	-8.0
Surface Water Outflows	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.1	-0.1
To Center Drive	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.1	-0.1
Change in Storage	-3.8	10.6	6.7	18.8	3.9	5.5	1.5	-5.3	-5.7	-10.0	-11.9	-12.0	-2.0
Predicted WSE in ft	205.79	206.68	207.23	208.80	209.13	209.59	209.71	209.26	208.79	207.95	206.96	205.96	205.80
Observed WSE EM-1/EM-1A	206.28	206.94	207.83	209.23	209.32	209.55	209.78	209.52	209.14		206.36	205.73	206.56

Table F-12. Water Balance for West Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water : WY2014

Hydrologic Process	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Precipitation	6.5	7.6	3.5	1.7	3.7	5.5	4.4	1.9	0.0	1.6	6.9	2.6	4.1
Surface Water Inflows	11.4	19.9	7.2	2.9	3.9	5.0	1.8	0.9	0.0	1.0	0.9	1.1	10.3
From East Edmond	11.4	19.9	7.2	2.9	3.9	5.0	1.8	0.9	0.0	1.0	0.9	1.1	10.3
Evapotranspiration	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5
Recharge (-) Discharge (+)	-4.0	-7.1	-6.4	-3.8	-4.7	-1.6	-9.1	-8.4	-11.3	-10.7	-2.7	3.7	-1.6
Surface Water Outflows	-0.1	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	0.0	-0.2	-0.1	-0.1	-0.2
To Center Drive	-0.1	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	0.0	-0.2	-0.1	-0.1	-0.2
Change in Storage	13.4	20.2	4.0	0.0	1.4	6.6	-6.4	-9.5	-15.8	-12.3	2.6	6.2	12.1
Predicted WSE in ft	206.91	208.60	208.93	208.93	209.05	209.60	209.06	208.27	206.95	205.93	206.15	206.67	207.68
Observed WSE EM-1/EM-1A	208.21	209.83	209.07	209.27	209.37	209.44	208.41	207.37	205.95	206.06	206.17	208.73	208.72

Table F-12. Water Balance for West Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water — WY2015

Hydrologic Process	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation	2.4	4.2	6.9	9.8	4.5	3.3	1.3	1.2	1.6	1.8	5.9	6.1	4.8
Surface Water Inflows	3.2	7.3	11.0	12.7	10.7	1.0	1.1	0.9	1.0	0.9	4.0	11.5	9.1
From East Edmond	3.2	7.3	11.0	12.7	10.7	1.0	1.1	0.9	1.0	0.9	4.0	11.5	9.1
Evapotranspiration	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0
Recharge (-) Discharge (+)	-1.3	-2.6	-4.7	-5.0	-5.2	-4.6	-6.1	-10.5	-9.4	-3.8	-2.2	-0.1	-4.0
Surface Water Outflows	-0.3	-0.2	-0.7	-16.3	-8.1	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.3
To Center Drive	-0.3	-0.2	-0.7	-16.3	-8.1	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.3
Change in Storage	4.0	8.6	12.0	-0.1	0.0	-3.8	-7.7	-13.2	-11.1	-3.6	6.5	16.8	9.6
Predicted WSE in ft	208.01	208.73	209.73	209.72	209.72	209.41	208.77	207.67	206.75	206.45	206.99	208.39	209.19
Observed WSE EM-1/EM-1A	207.55	208.55	209.72	209.98	210.01	209.99	209.05	205.30	205.87	206.07	208.63	208.73	209.84

Table F-12. Water Balance for West Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water — WY2016

Hydrologic Process	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Precipitation	4.1	4.7	4.4	2.1	0.8	0.4	0.2	2.2	1.3	5.0	7.1	12.0	6.9
Surface Water Inflows	8.0	8.4	6.4	1.7	0.0	0.0	0.0	0.9	1.3	0.8	10.2	26.7	10.5
From East Edmond	8.0	8.4	6.4	1.7	0.0	0.0	0.0	0.9	1.3	0.8	10.2	26.7	10.5
Evapotranspiration	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0
Recharge (-) Discharge (+)	-6.4	-6.4	-7.3	-6.4	-9.7	-12.1	-10.1	-4.6	-0.2	-4.8	3.1	-5.8	-8.0
Surface Water Outflows	-0.3	-5.2	-2.2	-0.3	-0.3	-0.2	-0.2	-0.1	0.0	0.0	0.0	-26.8	-2.8
To Center Drive	-0.3	-5.2	-2.2	-0.3	-0.3	-0.2	-0.2	-0.1	0.0	0.0	0.0	-26.8	-2.8
Change in Storage	5.4	1.0	0.0	-4.8	-12.3	-15.6	-14.6	-5.7	0.0	0.0	20.0	6.1	6.6
Predicted WSE in ft	209.64	209.73	209.72	209.32	208.29	206.99	205.77	205.31	205.31	205.31	206.98	209.70	209.73
Observed WSE EM-1/EM-1A	209.79	209.76	209.74	209.48	207.29	205.54	205.27	205.27	205.27	205.27	209.37	210.02	

Table F-12. Water Balance for West Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water — WY2017

Hydrologic Process	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Precipitation	5.8	5.9	1.8	1.0	2.3	1.3	0.2	1.5	9.3	6.9	3.9	3.4	8.6
Surface Water Inflows	5.7	6.0	1.7	1.0	0.7	0.7	0.7	0.4	25.2	11.3	9.5	7.2	8.9
From East Edmond	5.7	6.0	1.7	1.0	0.7	0.7	0.7	0.4	25.2	11.3	9.5	7.2	8.9
Evapotranspiration	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6
Recharge (-) Discharge (+)	-7.2	-7.5	-3.1	-5.6	-4.3	-9.4	-8.7	-5.7	-15.6	1.1	-3.1	-5.1	-0.4
Surface Water Outflows	-0.3	-0.3	-0.2	-0.3	-0.3	-0.3	-0.2	-0.1	-0.3	0.0	-0.3	-0.3	-9.9
To Center Drive	-0.3	-0.3	-0.2	-0.3	-0.3	-0.3	-0.2	-0.1	-0.3	0.0	-0.3	-0.3	-9.9
Change in Storage	3.5	2.8	-1.9	-7.1	-5.3	-12.2	-12.0	-6.2	17.5	18.7	10.1	5.3	6.6
Predicted WSE in ft	209.47	209.41	208.68	208.51	208.39	207.50	206.20	205.31	207.22	207.31	208.76	209.02	209.73
Observed WSE EM-1/EM-1A					208.90	206.26	205.31		206.87	208.72	209.45	209.29	209.86

Table F-12. Water Balance for West Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water — WY2018

Hydrologic Process	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Precipitation	8.7	4.6	2.8	1.8	0.0	0.1	1.0	5.2	7.2	5.8	7.2	3.3	2.3
Surface Water Inflows	16.8	4.7	1.4	0.8	0.0	0.6	0.3	0.3	8.1	13.1	10.0	12.2	0.8
From East Edmond	16.8	4.7	1.4	0.8	0.0	0.6	0.3	0.3	8.1	13.1	10.0	12.2	0.8
Evapotranspiration	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3
Recharge (-) Discharge (+)	0.1	0.6	-1.4	-4.3	-7.7	-8.4	-8.8	-8.2	-0.5	3.1	0.2	-5.3	-4.2
Surface Water Outflows	-17.8	-1.4	-0.3	-0.3	0.0	-0.3	-0.2	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3
To Center Drive	-17.8	-1.4	-0.3	-0.3	0.0	-0.3	-0.2	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3
Change in Storage	6.6	6.6	-0.7	-5.7	-12.2	-12.0	-10.0	-3.8	14.2	21.8	17.3	9.3	-2.6
Predicted WSE in ft	209.73	209.73	209.12	208.70	207.86	207.01	206.15	205.79	206.97	208.49	208.67	209.58	208.91
Observed WSE EM-1/EM-1A	210.22	208.64		209.58	207.22	206.67	205.31			209.98		209.98	209.67

Table F-12. Water Balance for West Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water — WY2019

Hydrologic Process	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Precipitation	6.1	0.7	0.9	0.2	0.3	1.8	4.0	3.8	6.4	3.4	4.8	1.6	3.6
Surface Water Inflows	6.3	0.0	0.0	0.0	0.0	0.3	0.2	0.7	0.8	3.2	6.8	0.8	1.0
From East Edmond	6.3	0.0	0.0	0.0	0.0	0.3	0.2	0.7	0.8	3.2	6.8	0.8	1.0
Evapotranspiration	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0
Recharge (-) Discharge (+)	-6.0	-8.7	-11.9	-13.0	-13.5	-11.6	-9.8	-2.2	1.6	-1.6	-1.6	-6.4	-6.2
Surface Water Outflows	-2.8	-0.3	-0.3	-0.2	-0.3	-0.2	-0.1	-0.3	-0.3	-0.4	-0.3	-0.3	-0.3
To Center Drive	-2.8	-0.3	-0.3	-0.2	-0.3	-0.2	-0.1	-0.3	-0.3	-0.4	-0.3	-0.3	-0.3
Change in Storage	1.6	-11.5	-15.0	-17.5	-17.5	-12.1	-6.8	1.5	8.5	4.6	9.1	-5.5	-3.9
Predicted WSE in ft	209.72	208.75	208.02	207.33	206.50	205.96	205.40	205.92	207.62	208.98	209.69	208.47	208.72
Observed WSE EM-1/EM-1A	209.97	208.18	205.31	205.31	205.31	205.31	205.31	206.55	209.32	209.38	209.41	208.53	208.79

Table F-12. Water Balance for West Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water — WY2020

Hydrologic Process	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Precipitation	1.1	0.7	1.0	0.8	3.5	3.9	1.7	6.5	9.6	4.2	3.5	1.5	3.1
Surface Water Inflows	0.0	0.0	0.4	0.0	0.0	0.0	0.0	4.7	21.8	5.1	6.0	2.5	0.8
From East Edmond	0.0	0.0	0.4	0.0	0.0	0.0	0.0	4.7	21.8	5.1	6.0	2.5	0.8
Evapotranspiration	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2
Recharge (-) Discharge (+)	-11.9	-14.7	-16.0	-13.0	-4.5	-6.8	-7.1	-10.5	-4.3	-1.8	-8.7	-6.1	-8.2
Surface Water Outflows	-0.4	-0.3	-0.3	-0.2	-0.1	-0.2	-0.3	-0.3	-6.6	-0.2	-0.3	-0.3	-0.3
To Center Drive	-0.4	-0.3	-0.3	-0.2	-0.1	-0.2	-0.3	-0.3	-6.6	-0.2	-0.3	-0.3	-0.3
Change in Storage	-14.4	-18.0	-19.4	-16.3	-3.5	-4.1	-6.2	0.4	20.5	6.8	-0.8	-4.3	-7.7
Predicted WSE in ft	208.40	207.56	206.65	205.59	205.64	205.80	206.15	207.71	209.72	209.29	209.67	209.37	209.08
Observed WSE EM-1/EM-1A		205.31	205.31	205.31	205.31	205.31		206.97	209.81	209.35			

Table F-12. Water Balance for West Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water — WY2021

Hydrologic Process	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Precipitation	2.5	0.3	0.4	2.8	3.0	5.6	5.2	7.3	4.7	2.5	1.2	2.0	2.4
Surface Water Inflows	0.7	0.0	0.0	0.0	0.0	0.0	0.4	11.6	6.7	2.9	0.0	0.7	0.6
From East Edmond	0.7	0.0	0.0	0.0	0.0	0.0	0.4	11.6	6.7	2.9	0.0	0.7	0.6
Evapotranspiration	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7
Recharge (-) Discharge (+)	-10.6	-15.8	-14.9	-10.0	-9.4	-1.6	-4.3	-6.6	-8.0	-7.6	-6.8	-13.4	-12.0
Surface Water Outflows	-0.3	-0.3	-0.3	-0.2	-0.2	-0.3	-0.4	-5.8	-1.9	-0.3	-0.3	-0.3	-0.2
To Center Drive	-0.3	-0.3	-0.3	-0.2	-0.2	-0.3	-0.4	-5.8	-1.9	-0.3	-0.3	-0.3	-0.2
Change in Storage	-11.4	-20.3	-18.8	-9.8	-7.7	3.1	1.0	6.4	1.0	-3.7	-7.9	-14.2	-12.8
Predicted WSE in ft	208.46	207.08	206.11	205.93	205.81	207.25	208.47	209.72	209.73	209.42	209.06	208.14	207.22
Observed WSE EM-1/EM-1A			205.31		205.31	206.87		209.40	209.72	209.15	208.13	205.31	205.31

Table F-12. Water Balance for West Edmond Marsh - Existing Conditions

Monthly Average in Inches of Water WY2021

Hydrologic Process	Jul	Aug	Sep
Precipitation	0.0	0.3	2.6
Surface Water Inflows	0.0	0.0	0.0
From East Edmond	0.0	0.0	0.0
Evapotranspiration	-4.5	-4.0	-2.3
Recharge (-) Discharge (+)	-10.7	-1.3	-0.7
Surface Water Outflows	0.0	-0.1	0.0
To Center Drive	0.0	-0.1	0.0
Change in Storage	-15.1	-5.1	-0.5
Predicted WSE in ft	205.73	205.35	205.31
Observed WSE EM-1/EM-1A	205.31	206.87	

Table F-13. Water Balance for Bell, McKay, and Hamer Marshes with Mining - Low Groundwater

Monthly Average in Inches of Water	WY2004					WY2005							
Hydrologic Process	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Precipitation	2.0	1.0	3.8	0.9	0.1	3.6	2.9	4.0	3.2	4.3	4.3	0.6	4.5
Surface Water Inflows	6.3	1.5	17.8	1.6	0.0	19.4	13.9	22.2	13.7	21.1	21.1	0.3	22.5
Runoff from Ft. Lewis - Outfall 002	3.8	0.8	10.9	0.8	0.0	11.9	8.5	13.6	8.4	12.9	13.0	0.0	13.8
Runoff from Ft. Lewis - Outfall 003	2.5	0.7	6.9	0.8	0.0	7.5	5.4	8.6	5.3	8.1	8.1	0.3	8.7
Evapotranspiration	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3
Recharge (-) Discharge (+)	-2.5	-2.6	-3.1	-3.4	-3.2	-3.5	-2.0	-2.0	-2.4	-2.1	-1.4	-3.6	-5.4
Surface Water Outflows	-5.9	-2.4	-13.7	-1.9	-0.1	-14.8	-10.5	-17.1	-10.3	-16.4	-16.4	-0.9	-17.6
To Diversion Canal	-4.8	-1.5	-13.7	-1.9	-0.1	-14.8	-10.5	-17.1	-10.3	-16.4	-16.4	-0.6	-17.6
To Seq. Ck. Marsh (surface)	-1.1	-0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.3	0.0
Subsurface Outflows	-1.3	-1.0	-1.3	-1.0	-0.8	-1.1	-1.1	-1.3	-1.1	-1.3	-1.6	-0.9	-1.2
Change in Storage	-2.7	-5.5	0.4	-7.5	-8.6	-0.3	0.9	4.8	2.5	5.6	6.0	-5.1	1.5
Predicted WSE in feet													
Bell	218.34	217.88	217.91	217.28	216.57	216.54	216.62	217.02	217.22	217.69	218.19	217.77	217.89
McKay	216.19	215.73	215.76	215.13	214.42	214.39	214.47	214.87	215.07	215.54	216.04	215.62	215.74
Hamer	214.41	213.95	213.98	213.35	212.64	212.61	212.69	213.09	213.29	213.76	214.26	213.84	213.96
Observed WSE ('04) in feet													
Bell						216.36	217.40	217.36	217.72	218.30	219.11	217.92	216.95
McKay	216.19	215.81	214.71	214.26				213.70	213.84	214.35	215.15	214.68	213.74
Hamer	214.41	214.17	213.61	213.34	212.76	211.93	212.68	212.95	213.27	213.50	213.93	213.69	213.28

Table F-13. Water Balance for Bell, McKay, and Hamer Marshes with Mining - Low Groundwater

Monthly Average in Inches of Water — WY2006

Hydrologic Process	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Precipitation	5.4	3.9	3.8	1.4	0.2	1.6	3.3	6.7	6.5	12.2	3.2	2.6	3.9
Surface Water Inflows	28.7	16.4	15.5	3.2	0.0	6.0	25.4	69.0	42.9	100.4	10.5	8.7	16.1
Runoff from Ft. Lewis - Outfall 002	17.6	10.1	9.5	1.9	0.0	3.6	15.6	42.2	26.2	60.5	6.5	5.3	9.9
Runoff from Ft. Lewis - Outfall 003	11.1	6.3	6.0	1.4	0.0	2.4	9.8	26.8	16.7	39.9	4.1	3.4	6.2
Evapotranspiration	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0
Recharge (-) Discharge (+)	-2.1	-2.1	-3.3	-4.5	-12.0	-9.6	-6.7	1.3	-1.1	0.0	-2.8	-2.3	-2.6
Surface Water Outflows	-23.1	-13.6	-12.9	-3.4	-0.2	-4.9	-19.2	-57.8	-35.7	-95.2	-10.4	-8.9	-14.1
To Diversion Canal	-23.1	-12.6	-11.9	-2.8	-0.2	-4.9	-19.2	-57.8	-35.7	-95.2	-7.9	-6.5	-12.4
To Seq. Ck. Marsh (surface)	0.0	-1.1	-1.0	-0.5	0.0	0.0	0.0	0.0	0.0	0.0	-2.4	-2.4	-1.7
Subsurface Outflows	-1.6	-1.5	-1.3	-1.0	-0.4	-0.3	-0.8	-2.3	-1.7	-2.2	-1.3	-1.4	-1.4
Change in Storage	5.3	-0.2	-1.9	-8.8	-16.3	-9.5	1.0	16.5	10.8	15.2	-1.4	-2.6	-0.1
Predicted WSE in feet													
Bell	218.34	218.32	218.17	217.43	216.07	215.28	215.36	216.74	217.64	218.90	218.79	218.57	218.56
McKay	216.19	216.17	216.02	215.28	213.92	213.57	213.65	215.02	215.92	217.19	217.07	216.85	216.85
Hamer	214.41	214.39	214.24	213.50	212.14	211.35	211.43	212.81	213.71	214.97	214.86	214.64	214.63
Observed WSE ('04) in feet													
Bell			218.33	217.05	215.63			218.25	217.95				
McKay	216.07	215.43	214.48	213.57				214.39	214.34	216.95	216.28	216.60	216.49
Hamer	214.26	214.05	213.69	213.13	212.13	211.67	211.69	213.20	213.27	214.09	213.65	214.13	214.14

Table F-13. Water Balance for Bell, McKay, and Hamer Marshes with Mining - Low Groundwater

Monthly Average in Inches of Water	WY2007												
Hydrologic Process	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Precipitation	2.1	2.2	0.4	0.0	0.8	1.6	14.4	8.6	6.5	4.5	5.7	1.7	1.1
Surface Water Inflows	6.7	6.8	0.0	0.0	1.1	5.9	153.8	58.3	33.0	16.8	26.1	4.3	2.2
Runoff from Ft. Lewis - Outfall 002	4.1	4.1	0.0	0.0	0.5	3.5	92.3	35.4	20.2	10.3	16.0	2.6	1.2
Runoff from Ft. Lewis - Outfall 003	2.6	2.7	0.0	0.0	0.6	2.4	61.5	22.8	12.8	6.5	10.1	1.7	1.0
Evapotranspiration	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2
Recharge (-) Discharge (+)	-0.5	-1.4	-1.9	-2.5	-2.9	-4.1	5.9	1.8	-0.5	-1.2	-0.6	-2.1	-1.8
Surface Water Outflows	-6.9	-6.0	-0.4	0.0	-1.7	-4.8	-150.9	-51.3	-35.3	-17.9	-28.0	-6.0	-3.3
To Diversion Canal	-5.1	-5.2	-0.4	0.0	-1.7	-4.8	-150.9	-51.3	-32.5	-15.2	-24.9	-3.2	-1.7
To Seq. Ck. Marsh (surface)	-1.8	-0.9	0.0	0.0	0.0	0.0	0.0	0.0	-2.8	-2.8	-3.1	-2.8	-1.5
Subsurface Outflows	-1.6	-1.3	-1.2	-1.0	-0.8	-0.7	-2.2	-2.4	-2.0	-1.6	-1.9	-1.5	-1.5
Change in Storage	-3.4	-3.5	-7.6	-7.5	-5.9	-3.0	20.5	14.9	1.7	0.0	0.0	-5.6	-6.5
Predicted WSE in feet													
Bell	218.28	217.99	217.35	216.73	216.24	215.99	217.70	218.94	219.08	219.08	219.08	218.62	218.08
McKay	216.57	216.27	215.64	215.02	214.52	214.27	215.98	217.22	217.37	217.37	217.37	216.90	216.36
Hamer	214.35	214.06	213.42	212.80	212.31	212.06	213.77	215.01	215.15	215.15	215.15	214.69	214.15
Observed WSE ('04) in feet													
Bell			218.46	217.75	217.19	216.57							
McKay	216.06	216.27	214.34	213.60			216.87	217.29	217.02	216.97	216.90	217.35	216.64
Hamer	214.89	214.08	213.26	212.65	212.31	212.19	214.53	215.05	214.60	214.64	214.72	214.14	214.21

Table F-13. Water Balance for Bell, McKay, and Hamer Marshes with Mining - Low Groundwater

Monthly Average in Inches of Water — WY2008

Hydrologic Process	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Precipitation	2.7	1.5	1.0	1.7	5.0	2.8	7.7	4.2	3.6	4.9	1.8	1.3	1.7
Surface Water Inflows	9.1	4.3	2.1	5.8	29.4	11.0	49.4	18.6	12.9	22.0	4.5	2.8	4.4
Runoff from Ft. Lewis - Outfall 002	5.6	2.5	1.1	3.5	18.0	6.7	30.1	11.4	7.9	13.5	2.7	1.6	2.6
Runoff from Ft. Lewis - Outfall 003	3.5	1.7	1.0	2.3	11.4	4.3	19.3	7.2	5.0	8.5	1.8	1.2	1.8
Evapotranspiration	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7
Recharge (-) Discharge (+)	-2.3	-1.7	-1.8	-1.0	-0.5	-1.5	0.2	-1.6	-2.3	-2.4	-2.6	-1.1	-2.8
Surface Water Outflows	-7.1	-3.5	-2.2	-4.6	-23.4	-8.3	-42.6	-16.5	-12.3	-20.1	-6.3	-4.0	-3.6
To Diversion Canal	-6.9	-3.5	-2.2	-4.6	-23.4	-8.3	-42.6	-14.4	-9.8	-17.4	-3.5	-2.5	-3.5
To Seq. Ck. Marsh (surface)	-0.3	0.0	0.0	0.0	0.0	0.0	0.0	-2.1	-2.4	-2.7	-2.8	-1.6	-0.1
Subsurface Outflows	-1.4	-1.3	-1.1	-1.2	-1.5	-1.4	-2.2	-1.8	-1.6	-1.8	-1.4	-1.6	-1.2
Change in Storage	-2.7	-5.2	-6.0	-1.7	7.9	2.2	12.5	2.9	-0.2	1.4	-6.1	-5.8	-5.3
Predicted WSE in feet													
Bell	217.85	217.42	216.92	216.78	217.44	217.62	218.67	218.91	218.90	219.01	218.51	218.02	217.58
McKay	216.14	215.70	215.20	215.06	215.73	215.91	216.95	217.19	217.18	217.30	216.79	216.31	215.86
Hamer	213.92	213.49	212.99	212.85	213.51	213.69	214.74	214.98	214.97	215.08	214.58	214.09	213.65
Observed WSE ('04) in feet													
Bell				218.18									
McKay	216.01	214.98	214.26	213.68	215.97	214.67	216.83	216.83	216.91	216.98	215.93	215.06	214.63
Hamer	213.85	213.68	213.29	213.04	213.88	213.81	214.52	214.47	214.43	214.52	214.23	214.75	213.55

Table F-13. Water Balance for Bell, McKay, and Hamer Marshes with Mining - Low Groundwater

Monthly Average in Inches of Water WY2009

Hydrologic Process	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Precipitation	0.9	2.1	0.5	2.6	8.3	5.2	7.3	1.6	5.3	3.5	3.4	1.3	0.0
Surface Water Inflows	1.5	8.3	0.2	11.8	64.3	27.5	41.4	3.6	25.4	12.9	13.2	3.0	0.0
Runoff from Ft. Lewis - Outfall 002	0.8	5.0	0.0	7.2	39.1	16.9	25.3	2.1	15.6	7.9	8.1	1.7	0.0
Runoff from Ft. Lewis - Outfall 003	0.8	3.3	0.2	4.6	25.2	10.6	16.1	1.5	9.8	5.0	5.1	1.3	0.0
Evapotranspiration	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5
Recharge (-) Discharge (+)	-3.0	-3.1	-2.5	-3.0	2.6	-1.2	-1.7	-3.0	-2.3	-2.9	-2.2	-3.0	-4.6
Surface Water Outflows	-1.9	-6.3	-0.7	-8.9	-56.3	-22.0	-36.0	-5.2	-22.0	-12.1	-12.0	-4.0	0.0
To Diversion Canal	-1.9	-6.3	-0.7	-8.9	-56.3	-22.0	-35.3	-2.8	-20.3	-9.8	-10.0	-2.7	0.0
To Seq. Ck. Marsh (surface)	0.0	0.0	0.0	0.0	0.0	0.0	-0.6	-2.4	-1.7	-2.3	-2.0	-1.3	0.0
Subsurface Outflows	-1.1	-1.0	-0.8	-0.8	-1.8	-1.7	-1.9	-1.4	-1.8	-1.5	-1.6	-1.2	-0.9
Change in Storage	-8.1	-4.0	-5.6	0.7	16.6	7.8	9.1	-5.0	3.2	-2.1	-2.4	-7.6	-10.0
Predicted WSE in feet													
Bell	216.91	216.57	216.11	216.16	217.55	218.20	218.95	218.54	218.81	218.63	218.44	217.80	216.97
McKay	215.19	214.86	214.39	214.45	215.83	216.48	217.24	216.83	217.09	216.92	216.72	216.09	215.25
Hamer	212.98	212.64	212.18	212.23	213.62	214.27	215.02	214.61	214.88	214.70	214.51	213.87	213.04
Observed WSE ('04) in feet													
Bell													
McKay					216.11	214.61	216.38	215.34	216.31	215.69	215.73	214.44	
Hamer	212.98	212.63	212.51	212.39	214.37	213.94	214.42	214.08	214.34	214.18	214.24	213.49	212.68

Table F-13. Water Balance for Bell, McKay, and Hamer Marshes with Mining - Low Groundwater

Monthly Average in Inches of Water WY2010

Hydrologic Process	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Precipitation	1.9	2.8	5.6	8.9	3.0	8.0	3.3	3.3	3.3	4.6	4.3	0.4	0.2
Surface Water Inflows	6.3	12.9	36.8	60.0	11.0	47.2	10.7	12.0	12.2	20.0	17.5	0.0	0.0
Runoff from Ft. Lewis - Outfall 002	3.8	7.9	22.6	36.5	6.7	28.8	6.6	7.4	7.5	12.3	10.7	0.0	0.0
Runoff from Ft. Lewis - Outfall 003	2.5	5.0	14.2	23.6	4.3	18.5	4.1	4.6	4.7	7.7	6.7	0.0	0.0
Evapotranspiration	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0
Recharge (-) Discharge (+)	-3.6	-3.1	-2.1	0.5	-1.2	-0.1	-1.7	-1.2	-1.0	-1.7	-1.6	-3.5	-3.5
Surface Water Outflows	-4.9	-9.7	-29.8	-53.4	-9.3	-45.7	-10.9	-12.0	-11.9	-18.2	-15.9	-0.4	-0.2
To Diversion Canal	-4.9	-9.7	-29.8	-53.4	-8.3	-44.2	-8.1	-9.1	-9.3	-15.7	-13.6	-0.1	-0.2
To Seq. Ck. Marsh (surface)	0.0	0.0	0.0	0.0	-1.0	-1.5	-2.8	-2.9	-2.7	-2.5	-2.4	-0.3	0.0
Subsurface Outflows	-0.9	-1.0	-1.4	-1.9	-1.7	-2.1	-1.8	-1.8	-1.8	-1.8	-1.7	-1.3	-1.1
Change in Storage	-5.1	-0.5	8.0	13.7	1.8	7.4	-0.9	-0.9	-1.1	-0.2	-1.2	-9.3	-8.5
Predicted WSE in feet													
Bell	216.54	216.50	217.17	218.31	218.46	219.08	219.01	218.93	218.84	218.82	218.73	217.95	217.24
McKay	214.83	214.79	215.46	216.60	216.75	217.37	217.29	217.21	217.12	217.11	217.01	216.23	215.52
Hamer	212.61	212.57	213.24	214.38	214.53	215.15	215.08	215.00	214.91	214.89	214.80	214.02	213.31
Observed WSE ('04) in feet													
Bell													
McKay				216.08	215.95	216.60	216.40	216.04	216.36	216.01	215.95	214.27	214.28
Hamer	212.35	212.48	213.05	214.46	214.53	214.80	214.56	214.47	214.59	214.32	214.44	213.62	213.02

Table F-13. Water Balance for Bell, McKay, and Hamer Marshes with Mining - Low Groundwater

Monthly Average in Inches of Water	WY2011												
Hydrologic Process	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Precipitation	4.0	4.2	6.6	7.2	6.1	3.1	7.2	5.7	4.8	2.8	0.8	0.3	1.3
Surface Water Inflows	18.2	20.0	36.4	40.0	28.8	9.7	37.6	25.4	20.0	8.9	0.9	0.0	3.2
Runoff from Ft. Lewis - Outfall 002	11.2	12.3	22.2	24.4	17.6	6.0	23.0	15.5	12.3	5.4	0.4	0.0	1.8
Runoff from Ft. Lewis - Outfall 003	7.0	7.7	14.1	15.6	11.2	3.8	14.7	9.8	7.7	3.5	0.5	0.0	1.3
Evapotranspiration	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3
Recharge (-) Discharge (+)	-1.5	-2.6	-0.6	-1.4	-0.9	-1.5	-0.6	-2.5	-1.8	-1.8	-0.5	-0.5	-1.1
Surface Water Outflows	-14.0	-15.5	-30.4	-37.9	-32.5	-10.1	-40.9	-25.2	-18.8	-9.6	-1.7	-0.3	-2.8
To Diversion Canal	-14.0	-15.5	-30.4	-36.1	-29.4	-7.3	-37.9	-22.3	-15.8	-6.7	-0.7	-0.2	-2.8
To Seq. Ck. Marsh (surface)	0.0	0.0	0.0	-1.8	-3.1	-2.8	-2.9	-3.0	-3.1	-2.9	-1.0	0.0	0.0
Subsurface Outflows	-1.4	-1.5	-1.9	-1.8	-1.5	-1.3	-1.5	-1.4	-1.5	-1.3	-2.7	-2.0	-1.6
Change in Storage	2.9	3.6	9.5	6.0	0.0	-0.6	0.6	0.0	-0.5	-4.7	-7.7	-6.5	-3.5
Predicted WSE in feet													
Bell	217.48	217.78	218.58	219.08	219.08	219.03	219.08	219.08	219.04	218.65	218.00	217.47	217.18
McKay	215.77	216.07	216.86	217.37	217.37	217.31	217.37	217.37	217.33	216.93	216.29	215.75	215.46
Hamer	213.55	213.85	214.65	215.15	215.15	215.10	215.15	215.15	215.11	214.72	214.07	213.54	213.25
Observed WSE ('04) in feet													
Bell													
McKay	214.29	215.23	216.18	216.90	217.01	217.07	217.13						
Hamer	213.60	213.51	214.64	214.45	214.30	214.29	214.28	214.31	214.72	214.68	214.63	214.01	213.35

Table F-13. Water Balance for Bell, McKay, and Hamer Marshes with Mining - Low Groundwater

Monthly Average in Inches of Water	WY2012												WY2013
Hydrologic Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Precipitation	4.1	6.1	3.2	7.2	3.9	6.8	4.3	3.1	3.3	1.6	0.0	0.1	6.5
Surface Water Inflows	19.3	34.1	12.6	40.0	13.4	33.5	16.5	10.7	11.8	4.3	0.0	0.0	38.6
Runoff from Ft. Lewis - Outfall 002	11.9	20.8	7.7	24.4	8.2	20.5	10.1	6.5	7.3	2.5	0.0	0.0	23.6
Runoff from Ft. Lewis - Outfall 003	7.4	13.2	4.9	15.6	5.2	13.0	6.4	4.1	4.6	1.7	0.0	0.0	15.0
Evapotranspiration	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0
Recharge (-) Discharge (+)	-1.5	-1.8	-2.4	-1.0	-2.1	-0.7	-2.4	-1.3	-1.5	-0.8	-0.7	-1.8	-0.9
Surface Water Outflows	-14.9	-28.1	-10.2	-35.3	-13.2	-36.8	-15.8	-11.0	-11.2	-5.2	0.0	-0.1	-32.2
To Diversion Canal	-14.9	-28.1	-9.5	-34.2	-10.4	-33.7	-12.8	-8.0	-9.0	-3.5	0.0	-0.1	-32.2
To Seq. Ck. Marsh (surface)	0.0	0.0	-0.7	-1.1	-2.8	-3.1	-3.0	-2.9	-2.2	-1.7	0.0	0.0	0.0
Subsurface Outflows	-1.6	-1.8	-1.6	-2.0	-1.4	-1.5	-1.3	-1.4	-1.4	-1.4	-1.3	-1.1	-1.6
Change in Storage	4.3	8.1	1.7	8.8	0.0	0.0	-0.7	-3.1	-2.6	-6.0	-6.0	-5.3	9.5
Predicted WSE in feet													
Bell	217.54	218.21	218.35	219.08	219.08	219.08	219.02	218.76	218.54	218.04	217.54	217.10	217.89
McKay	215.82	216.50	216.63	217.37	217.37	217.37	217.31	217.04	216.83	216.33	215.83	215.39	216.18
Hamer	213.61	214.28	214.42	215.15	215.15	215.15	215.09	214.83	214.61	214.11	213.61	213.17	213.96
Observed WSE ('04) in feet													
Bell					219.68	219.77	219.87	219.91	219.77	219.42	219.07	218.23	218.84
McKay	214.03	214.15	214.78	215.42	215.25	215.08	214.91	214.89	215.43	215.18	214.93	213.70	214.59
Hamer	213.44	213.63	214.25	215.05	214.90	215.03	215.15	215.00	214.78	214.40	214.02	213.24	213.96

Table F-13. Water Balance for Bell, McKay, and Hamer Marshes with Mining - Low Groundwater

Monthly Average in Inches of Water — WY2014

Hydrologic Process	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Precipitation	6.5	7.6	3.5	1.7	3.7	5.5	4.4	1.9	0.0	1.6	6.9	2.6	4.1
Surface Water Inflows	35.4	44.0	12.7	3.9	14.5	24.8	18.5	5.2	0.0	4.8	40.5	9.5	17.3
Runoff from Ft. Lewis - Outfall 002	21.6	26.8	7.8	2.4	8.9	15.2	11.4	3.1	0.0	2.8	24.7	5.8	10.6
Runoff from Ft. Lewis - Outfall 003	13.7	17.2	4.9	1.6	5.6	9.6	7.1	2.1	0.0	1.9	15.8	3.7	6.7
Evapotranspiration	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5
Recharge (-) Discharge (+)	-0.8	0.7	-1.3	-2.2	-1.5	-3.8	-3.2	-2.3	-1.9	-3.2	-0.7	0.4	-0.3
Surface Water Outflows	-29.5	-45.4	-12.7	-5.7	-13.5	-22.5	-17.1	-6.2	0.0	-3.9	-34.1	-7.1	-13.6
To Diversion Canal	-29.5	-43.3	-9.7	-3.0	-11.1	-20.0	-14.4	-4.1	0.0	-3.9	-34.1	-7.1	-13.4
To Seq. Ck. Marsh (surface)	0.0	-2.1	-3.1	-2.7	-2.4	-2.4	-2.7	-2.2	0.0	0.0	0.0	0.0	-0.2
Subsurface Outflows	-1.9	-1.9	-1.6	-1.2	-1.5	-1.3	-1.3	-1.2	-1.2	-1.0	-1.5	-1.6	-1.6
Change in Storage	9.2	5.0	0.6	-3.9	0.5	0.8	-2.0	-6.3	-7.5	-5.8	8.8	2.6	5.3
Predicted WSE in feet													
Bell	218.66	219.08	219.13	218.81	218.85	218.91	218.75	218.23	217.60	217.12	217.85	218.07	218.52
McKay	216.95	217.37	217.42	217.09	217.13	217.20	217.04	216.51	215.89	215.41	216.14	216.36	216.80
Hamer	214.73	215.15	215.20	214.88	214.92	214.98	214.82	214.30	213.67	213.19	213.92	214.14	214.59
Observed WSE ('04) in feet													
Bell	219.44	219.62	219.81	219.57	219.35	219.49	219.46	219.25	218.80	218.09	219.27	219.36	219.48
McKay	215.49	215.65	215.47	215.46	215.49	215.57	215.97	216.22	214.67	213.77	214.98	216.08	216.03
Hamer	214.68	214.86	215.05	214.97	215.11	215.07	214.61	214.57	213.93	213.35	214.07	214.78	214.76

Table F-13. Water Balance for Bell, McKay, and Hamer Marshes with Mining - Low Groundwater

Monthly Average in Inches of Water — WY2015

Hydrologic Process	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation	2.4	4.2	6.9	9.8	4.5	3.3	1.3	1.2	1.6	1.8	5.9	6.1	4.8
Surface Water Inflows	8.0	18.1	34.5	58.6	17.9	11.8	2.5	2.5	4.2	5.5	31.7	30.4	20.8
Runoff from Ft. Lewis - Outfall 002	4.9	11.1	21.0	35.5	11.0	7.2	1.4	1.4	2.5	3.3	19.4	18.6	12.7
Runoff from Ft. Lewis - Outfall 003	3.1	7.0	13.4	23.1	6.9	4.5	1.1	1.1	1.7	2.2	12.3	11.8	8.0
Evapotranspiration	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0
Recharge (-) Discharge (+)	-2.9	-2.1	-1.9	-1.0	-2.2	-0.7	0.0	0.4	-0.3	1.1	0.3	-1.9	-0.2
Surface Water Outflows	-7.6	-15.2	-30.9	-61.7	-17.9	-12.6	-3.7	-3.7	-4.0	-4.3	-25.9	-26.8	-19.4
To Diversion Canal	-6.0	-14.0	-29.1	-58.3	-14.0	-8.9	-1.6	-2.0	-3.4	-4.3	-25.9	-25.0	-16.4
To Seq. Ck. Marsh (surface)	-1.6	-1.2	-1.9	-3.4	-3.9	-3.7	-2.1	-1.7	-0.5	0.0	0.0	-1.7	-3.0
Subsurface Outflows	-1.4	-1.6	-1.6	-1.6	-1.7	-1.6	-1.5	-1.7	-1.5	-1.7	-2.1	-1.9	-2.0
Change in Storage	-1.6	3.3	6.4	2.8	-1.4	-2.9	-5.2	-5.7	-4.0	0.0	8.9	5.5	4.1
Predicted WSE in feet													
Bell	218.38	218.66	219.19	219.43	219.32	219.07	218.64	218.16	217.83	217.84	218.58	219.03	219.37
McKay	216.67	216.94	217.48	217.72	217.60	217.36	216.93	216.45	216.12	216.12	216.86	217.32	217.66
Hamer	214.45	214.73	215.26	215.50	215.39	215.14	214.71	214.23	213.90	213.91	214.65	215.10	215.44
Observed WSE ('04) in feet													
Bell	218.67	219.27	219.76										
McKay	215.03	215.78	216.09	215.95	216.19	215.94	215.82	215.62	215.27	215.36	215.45	215.97	216.17
Hamer	214.33	214.68	215.58	215.43			215.02	214.50	214.15	214.20	214.25	214.93	215.39

Table F-13. Water Balance for Bell, McKay, and Hamer Marshes with Mining - Low Groundwater

Monthly Average in Inches of Water — WY2016

Hydrologic Process	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Precipitation	4.1	4.7	4.4	2.1	0.8	0.4	0.2	2.2	1.3	5.0	7.1	12.0	6.9
Surface Water Inflows	16.1	17.6	17.6	5.8	1.0	0.0	0.0	7.7	3.5	31.3	43.2	88.5	34.0
Runoff from Ft. Lewis - Outfall 002	9.9	10.8	10.8	3.5	0.5	0.0	0.0	4.7	2.0	19.2	26.4	53.4	20.8
Runoff from Ft. Lewis - Outfall 003	6.2	6.8	6.8	2.3	0.5	0.0	0.0	3.0	1.5	12.1	16.8	35.1	13.2
Evapotranspiration	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0
Recharge (-) Discharge (+)	-1.4	-2.1	-1.2	-2.5	-1.5	-2.1	-1.6	-3.3	-2.3	-4.0	2.5	0.3	-0.9
Surface Water Outflows	-16.4	-18.2	-17.7	-7.9	-1.8	-0.4	-0.2	-5.9	-3.2	-24.9	-36.7	-84.1	-37.4
To Diversion Canal	-12.5	-14.6	-13.7	-4.2	-0.6	-0.2	-0.2	-5.9	-3.2	-24.9	-36.7	-83.7	-33.6
To Seq. Ck. Marsh (surface)	-3.8	-3.6	-4.0	-3.7	-1.2	-0.3	0.0	0.0	0.0	0.0	0.0	-0.4	-3.8
Subsurface Outflows	-1.7	-1.4	-1.8	-1.3	-1.4	-1.3	-1.3	-1.1	-1.0	-1.2	-1.8	-2.1	-1.7
Change in Storage	0.7	0.0	0.0	-5.8	-6.1	-7.1	-7.4	-4.3	-4.0	5.3	13.9	14.6	0.9
Predicted WSE in feet													
Bell	219.43	219.43	219.43	218.94	218.43	217.84	217.23	216.87	216.53	216.97	218.13	219.35	219.43
McKay	217.72	217.72	217.72	217.23	216.72	216.13	215.51	215.15	214.82	215.26	216.42	217.64	217.72
Hamer	215.50	215.50	215.50	215.01	214.50	213.91	213.30	212.94	212.60	213.04	214.20	215.42	215.50
Observed WSE ('04) in feet													
Bell					219.23	219.09	218.69	217.87	217.69	217.50	219.85		
McKay	216.10	215.99	215.89	215.65	215.44	214.58	213.88				215.69	216.17	
Hamer	215.29	215.29	215.29	215.26	214.68	213.91	213.36	212.70	212.67	212.64	215.55		

Table F-13. Water Balance for Bell, McKay, and Hamer Marshes with Mining - Low Groundwater

Monthly Average in Inches of Water — WY2017

Hydrologic Process	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Precipitation	5.8	5.9	1.8	1.0	2.3	1.3	0.2	1.5	9.3	6.9	3.9	3.4	8.6
Surface Water Inflows	24.6	27.1	4.4	1.6	7.0	2.9	0.0	4.1	65.7	36.3	15.2	12.4	42.9
Runoff from Ft. Lewis - Outfall 002	15.1	16.6	2.6	0.9	4.2	1.7	0.0	2.4	39.9	22.2	9.4	7.6	26.1
Runoff from Ft. Lewis - Outfall 003	9.5	10.5	1.8	0.7	2.7	1.2	0.0	1.7	25.8	14.1	5.9	4.8	16.8
Evapotranspiration	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6
Recharge (-) Discharge (+)	-0.8	-0.9	0.1	1.1	0.9	1.0	-0.2	0.0	-3.4	0.8	0.5	-0.9	-0.9
Surface Water Outflows	-27.3	-29.1	-6.2	-2.6	-7.6	-4.2	-0.2	-3.4	-58.8	-31.6	-14.9	-13.3	-47.5
To Diversion Canal	-23.6	-25.1	-2.9	-0.9	-5.3	-2.5	-0.1	-3.4	-58.8	-30.5	-11.7	-9.4	-44.0
To Seq. Ck. Marsh (surface)	-3.7	-4.0	-3.2	-1.7	-2.3	-1.7	-0.1	0.0	0.0	-1.0	-3.2	-3.8	-3.4
Subsurface Outflows	-1.7	-1.7	-1.7	-1.9	-1.8	-1.8	-1.6	-1.6	-1.7	-2.2	-2.0	-1.9	-1.6
Change in Storage	0.0	0.0	-3.6	-4.0	-2.9	-5.2	-5.7	-1.8	10.0	9.7	2.7	-0.2	0.9
Predicted WSE in feet													
Bell	219.43	219.43	219.13	218.80	218.56	218.12	217.65	217.50	218.34	219.15	219.37	219.35	219.43
McKay	217.72	217.72	217.41	217.08	216.85	216.41	215.94	215.79	216.63	217.43	217.65	217.64	217.72
Hamer	215.50	215.50	215.20	214.87	214.63	214.19	213.72	213.57	214.41	215.22	215.44	215.42	215.50
Observed WSE ('04) in feet													
Bell							219.47		218.88				
McKay					215.60	215.55	214.85		214.09	215.95	216.30	216.16	216.16
Hamer					212.25	214.62	213.94		213.45	215.32			

Table F-13. Water Balance for Bell, McKay, and Hamer Marshes with Mining - Low Groundwater

Monthly Average in Inches of Water — WY2018

Hydrologic Process	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Precipitation	8.7	4.6	2.8	1.8	0.0	0.1	1.0	5.2	7.2	5.8	7.2	3.3	2.3
Surface Water Inflows	48.5	18.4	9.3	4.6	0.0	0.0	1.8	26.6	38.8	26.6	36.8	10.6	7.0
Runoff from Ft. Lewis - Outfall 002	29.5	11.3	5.7	2.7	0.0	0.0	0.9	16.3	23.7	16.3	22.4	6.5	4.3
Runoff from Ft. Lewis - Outfall 003	19.0	7.1	3.6	1.8	0.0	0.0	0.8	10.3	15.1	10.3	14.3	4.1	2.7
Evapotranspiration	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3
Recharge (-) Discharge (+)	1.5	-1.0	0.0	1.1	1.9	2.6	0.8	1.2	-1.0	0.6	0.2	-0.1	0.9
Surface Water Outflows	-55.3	-18.4	-11.0	-6.3	0.0	-0.1	-2.0	-21.3	-34.4	-27.3	-42.4	-11.6	-9.2
To Diversion Canal	-51.3	-14.5	-7.0	-3.5	0.0	0.0	-1.9	-21.3	-32.9	-24.1	-38.3	-8.0	-5.3
To Seq. Ck. Marsh (surface)	-4.0	-3.9	-4.0	-2.9	0.0	-0.1	-0.1	0.0	-1.5	-3.2	-4.0	-3.6	-3.9
Subsurface Outflows	-2.2	-1.9	-1.9	-1.9	-2.1	-2.3	-2.0	-2.5	-2.2	-2.2	-1.9	-1.9	-2.0
Change in Storage	0.0	-0.1	-3.9	-4.5	-4.7	-3.7	-2.7	8.2	7.9	3.5	0.0	-0.3	-2.3
Predicted WSE in feet													
Bell	219.43	219.42	219.09	218.72	218.33	218.02	217.79	218.48	219.14	219.43	219.43	219.41	219.22
McKay	217.72	217.71	217.38	217.00	216.61	216.30	216.08	216.77	217.42	217.72	217.72	217.69	217.50
Hamer	215.50	215.49	215.16	214.79	214.40	214.09	213.86	214.55	215.21	215.50	215.50	215.48	215.29
Observed WSE ('04) in feet													
Bell							219.80						
McKay	216.28	216.12		215.96	216.02	215.96	216.12			216.35		216.30	216.35
Hamer				215.45	214.76	213.95	213.83						

Table F-13. Water Balance for Bell, McKay, and Hamer Marshes with Mining - Low Groundwater

Monthly Average in Inches of Water — WY2019

Hydrologic Process	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Precipitation	6.1	0.7	0.9	0.2	0.3	1.8	4.0	3.8	6.4	3.4	4.8	1.6	3.6
Surface Water Inflows	27.5	0.3	1.3	0.0	0.0	5.5	18.6	16.9	33.7	12.8	18.6	3.7	13.4
Runoff from Ft. Lewis - Outfall 002	16.8	0.0	0.6	0.0	0.0	3.3	11.4	10.4	20.6	7.8	11.4	2.2	8.2
Runoff from Ft. Lewis - Outfall 003	10.7	0.3	0.6	0.0	0.0	2.2	7.2	6.5	13.1	4.9	7.2	1.5	5.2
Evapotranspiration	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0
Recharge (-) Discharge (+)	-1.5	-0.8	-0.5	0.0	-0.9	-0.2	-2.2	0.6	1.3	0.2	-1.3	-1.0	-3.1
Surface Water Outflows	-25.9	-1.0	-2.2	-0.2	-0.3	-4.3	-14.3	-12.9	-28.0	-12.4	-17.5	-5.3	-12.8
To Diversion Canal	-22.6	-0.2	-0.8	0.0	-0.3	-4.3	-14.3	-12.9	-27.9	-9.7	-14.7	-2.4	-10.2
To Seq. Ck. Marsh (surface)	-3.3	-0.8	-1.4	-0.2	0.0	0.0	0.0	0.0	0.0	-2.7	-2.7	-2.8	-2.6
Subsurface Outflows	-1.8	-1.8	-1.8	-1.9	-1.6	-1.7	-1.8	-2.1	-2.5	-2.2	-1.8	-1.8	-1.6
Change in Storage	2.4	-5.9	-5.9	-6.3	-6.5	-1.3	3.2	5.7	10.9	1.8	2.3	-4.1	-2.5
Predicted WSE in feet													
Bell	219.42	218.93	218.43	217.90	217.36	217.26	217.53	218.00	218.91	219.06	219.25	218.91	218.70
McKay	217.70	217.21	216.72	216.19	215.65	215.54	215.81	216.29	217.20	217.34	217.54	217.20	216.99
Hamer	215.49	215.00	214.50	213.97	213.43	213.33	213.60	214.07	214.98	215.13	215.32	214.98	214.77
Observed WSE ('04) in feet													
Bell				219.79	219.20	219.09	218.29					219.89	219.77
McKay	216.38	214.68	214.31	214.30	213.97	213.79		214.25	214.52	214.67	215.96	214.44	214.37
Hamer		215.01	214.47	214.10	213.30	213.11	212.99	213.63	214.85		215.27	214.79	214.64

Table F-13. Water Balance for Bell, McKay, and Hamer Marshes with Mining - Low Groundwater

Monthly Average in Inches of Water	WY2020												
Hydrologic Process	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Precipitation	1.1	0.7	1.0	0.8	3.5	3.9	1.7	6.5	9.6	4.2	3.5	1.5	3.1
Surface Water Inflows	2.1	0.4	2.0	1.4	18.1	21.8	5.7	38.7	65.6	15.9	12.9	3.7	12.1
Runoff from Ft. Lewis - Outfall 002	1.2	0.1	1.1	0.6	11.1	13.4	3.4	23.7	39.8	9.8	7.9	2.2	7.4
Runoff from Ft. Lewis - Outfall 003	1.0	0.3	0.9	0.7	7.0	8.4	2.3	15.0	25.8	6.1	5.0	1.5	4.7
Evapotranspiration	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2
Recharge (-) Discharge (+)	-2.9	-2.5	-3.1	-3.5	-2.2	0.9	0.3	-2.2	1.7	-1.8	-4.6	-2.9	-2.5
Surface Water Outflows	-3.2	-1.0	-2.2	-1.9	-13.7	-16.8	-4.5	-32.3	-59.2	-15.2	-13.0	-5.2	-10.1
To Diversion Canal	-1.6	-0.8	-2.2	-1.9	-13.7	-16.8	-4.5	-32.3	-59.2	-12.3	-9.8	-2.9	-9.1
To Seq. Ck. Marsh (surface)	-1.6	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-2.8	-3.2	-2.3	-1.0
Subsurface Outflows	-1.4	-1.2	-1.2	-0.9	-1.2	-1.7	-1.3	-1.4	-2.4	-1.7	-1.3	-1.1	-1.2
Change in Storage	-7.5	-7.5	-7.9	-8.2	2.1	7.2	1.4	9.4	15.3	0.9	-3.7	-6.0	-1.9
Predicted WSE in feet													
Bell	218.08	217.45	216.79	216.11	216.29	216.89	217.00	217.78	219.06	219.14	218.83	218.33	218.17
McKay	216.36	215.74	215.08	214.40	214.57	215.17	215.29	216.07	217.35	217.42	217.11	216.61	216.46
Hamer	214.15	213.52	212.86	212.18	212.36	212.96	213.07	213.85	215.13	215.21	214.90	214.40	214.24
Observed WSE ('04) in feet													
Bell		218.58	217.47	216.86		218.20				219.71			
McKay		213.99			214.92			213.72	215.28	214.65			
Hamer		213.47	212.68		212.25			213.55	215.55	215.03			

Table F-13. Water Balance for Bell, McKay, and Hamer Marshes with Mining - Low Groundwater

Monthly Average in Inches of Water WY2021

Hydrologic Process	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Precipitation	2.5	0.3	0.4	2.8	3.0	5.6	5.2	7.3	4.7	2.5	1.2	2.0	2.4
Surface Water Inflows	8.1	0.0	0.0	12.9	14.7	29.6	25.3	37.3	17.8	7.9	2.1	5.7	7.3
Runoff from Ft. Lewis - Outfall 002	4.9	0.0	0.0	7.9	9.0	18.1	15.5	22.8	10.9	4.8	1.2	3.5	4.5
Runoff from Ft. Lewis - Outfall 003	3.2	0.0	0.0	5.0	5.7	11.5	9.8	14.5	6.9	3.1	0.9	2.3	2.9
Evapotranspiration	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7
Recharge (-) Discharge (+)	-1.7	-3.0	-3.5	-1.5	0.4	3.5	5.4	4.8	3.0	4.2	2.2	3.8	3.7
Surface Water Outflows	-6.7	-0.3	-0.4	-9.7	-11.0	-23.9	-20.9	-46.4	-23.3	-11.2	-3.3	-7.8	-8.9
To Diversion Canal	-6.1	-0.3	-0.4	-9.7	-11.0	-23.9	-20.3	-42.7	-19.7	-7.2	-1.1	-4.3	-5.5
To Seq. Ck. Marsh (surface)	-0.5	0.0	0.0	0.0	0.0	0.0	-0.7	-3.7	-3.6	-4.0	-2.2	-3.5	-3.3
Subsurface Outflows	-1.2	-0.9	-0.7	-0.9	-0.9	-1.0	-1.5	-1.8	-1.7	-2.1	-1.7	-1.7	-1.5
Change in Storage	-2.6	-8.5	-8.2	1.3	5.2	13.3	13.5	1.2	0.0	0.0	-1.4	-1.1	-0.6
Predicted WSE in feet													
Bell	217.95	217.25	216.56	216.67	217.10	218.21	219.33	219.43	219.43	219.43	219.31	219.22	219.17
McKay	216.24	215.53	214.85	214.96	215.39	216.49	217.61	217.72	217.72	217.72	217.59	217.50	217.45
Hamer	214.02	213.32	212.63	212.74	213.17	214.28	215.40	215.50	215.50	215.50	215.38	215.29	215.24
Observed WSE ('04) in feet													
Bell					217.23			219.68			219.71	219.41	218.99
McKay						213.87		214.86	214.88	215.59	214.57	214.46	214.38
Hamer						213.15		215.23	215.30	214.89	214.51	214.01	213.58

Table F-13. Water Balance for Bell, McKay, and Hamer Marshes with Mining - Low Groundwater

Monthly Average in Inches of Water	WY2021		
Hydrologic Process	Jul	Aug	Sep
Precipitation	0.0	0.3	2.6
Surface Water Inflows	0.0	0.0	8.3
Runoff from Ft. Lewis - Outfall 002	0.0	0.0	5.1
Runoff from Ft. Lewis - Outfall 003	0.0	0.0	3.2
Evapotranspiration	-4.5	-4.0	-2.3
Recharge (-) Discharge (+)	5.3	2.1	2.5
Surface Water Outflows	0.0	-0.3	-8.7
To Diversion Canal	0.0	0.0	-6.3
To Seq. Ck. Marsh (surface)	0.0	-0.2	-2.4
Subsurface Outflows	-1.5	-1.5	-1.7
Change in Storage	-0.7	-3.4	0.7
Predicted WSE in feet			
Bell	219.11	218.83	218.89
McKay	217.40	217.11	217.17
Hamer	215.18	214.90	214.96
Observed WSE ('04) in feet			
Bell	218.05		
McKay		213.27	
Hamer	212.68	212.25	

Table F-14. Water Balance for East Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water	WY2004						WY2005						
Hydrologic Process	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Precipitation	2.0	1.0	3.8	0.9	0.1	3.6	2.9	4.0	3.2	4.3	4.3	0.6	4.5
Surface Water Inflows	0.3	0.9	0.1	0.0	0.0	0.2	0.1	0.2	0.1	0.2	0.2	0.3	0.2
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.1	0.0	0.1	0.0	0.0	0.2	0.1	0.2	0.1	0.2	0.2	0.0	0.2
From Hamer (surface)	1.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Subsurface Inflows	1.2	0.9	1.2	0.9	0.8	0.9	1.0	1.1	1.0	1.3	1.5	0.9	1.1
Evapotranspiration	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3
Recharge (-) Discharge (+)	*-5.7*	*-4.2*	*-3.4*	*-2.1*	*-1.0*	*-2.2*	*-0.9*	*-1.0*	*-1.9*	*-1.9*	*-2.5*	*-2.7*	*-4.1*
Surface Water Outflows	1.1	0.0	-0.6	0.0	0.0	0.0	0.0	0.0	-0.2	-0.3	-0.4	0.0	-0.4
To Diversion Canal	-1.5	0.0	-0.4	0.0	0.0	0.0	0.0	0.0	-0.1	-0.2	-0.3	0.0	-0.3
To West Edmond Marsh	2.0	0.0	-0.2	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.2	0.0	-0.2
Change in Storage	-1.5	-3.4	-1.7	-3.9	-4.6	-1.5	0.8	3.3	1.8	3.8	3.3	-1.4	0.2
Predicted WSE in ft													
EM-2S	212.62	212.26	212.12	211.80	211.41	211.29	211.35	211.63	211.78	212.10	212.37	212.23	212.25
East Edmond	212.62	212.33	212.17	211.85	211.47	211.43	211.50	211.77	211.92	212.22	212.49	212.37	212.37
Eastern East Edmond Marsh	212.36	212.07	211.77	211.44	211.06	210.92	210.99	211.26	211.36	211.61	211.78	211.66	211.55
Observed WSE in ft													
EM-2S	210.72	210.74	210.76	210.70	210.40	209.82	209.92	210.33	210.61	210.76	210.86	210.79	210.64
East Edmond (EM-2E)	212.62	212.50	212.35	212.25	211.85	211.43	211.43	211.80	212.12	212.31	212.47	212.40	212.19
East Edmond (EM-2W)	211.15	211.15	211.22	211.20	210.91	210.32	210.41	210.80	211.08	211.20	211.26	211.24	211.09
East Edmond (EM-3E)	212.42	212.29	212.14	212.04	211.69	211.07	211.43	211.70	211.93	212.09	212.15	212.17	211.97
East Edmond (EM-3W)	212.42	212.29	212.15	212.04	211.70	211.10	211.57	211.70	211.94	212.04	212.26	212.20	211.98
Eastern East Edmond (SCM-1)	212.39	212.26	212.09	211.98	211.58	210.96	211.20	211.63	211.84	212.08	212.27	212.17	211.95

Table F-14. Water Balance for East Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water — WY2006

Hydrologic Process	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Precipitation	5.4	3.9	3.8	1.4	0.2	1.6	3.3	6.7	6.5	12.2	3.2	2.6	3.9
Surface Water Inflows	0.2	1.2	1.1	0.6	0.0	0.1	0.2	0.3	0.3	0.6	2.5	2.4	1.8
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.2	0.2	0.1	0.0	0.0	0.1	0.2	0.3	0.3	0.6	0.1	0.1	0.1
From Hamer (surface)	0.0	1.1	1.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	2.4	2.3	1.7
Subsurface Inflows	1.5	1.5	1.3	1.0	0.3	0.3	0.5	1.4	1.5	2.0	1.3	1.4	1.4
Evapotranspiration	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0
Recharge (-) Discharge (+)	*-2.1*	*-2.6*	*-1.4*	*-2.6*	*-3.4*	*-4.8*	*-3.9*	*-1.0*	*-2.7*	*-1.6*	*-3.9*	*-4.3*	*-3.5*
Surface Water Outflows	-0.5	-0.4	-0.5	-0.4	0.0	0.0	0.0	0.0	0.0	-5.0	-0.7	-0.9	-1.3
To Diversion Canal	-0.2	-0.3	-0.3	-0.3	0.0	0.0	0.0	0.0	0.0	0.0	-0.4	-0.5	-0.4
To West Edmond Marsh	-0.3	-0.2	-0.3	-0.2	0.0	0.0	0.0	0.0	0.0	-5.9	-0.3	-0.5	-1.1
Change in Storage	2.8	0.6	0.8	-4.3	-6.9	-5.1	-1.0	7.0	5.7	7.3	2.3	0.3	0.5
Predicted WSE in ft													
EM-2S	212.47	212.44	212.43	212.02	211.44	211.02	210.93	211.51	211.98	212.59	212.57	212.40	212.31
East Edmond	212.58	212.61	212.66	212.28	211.71	211.43	211.43	212.01	212.48	212.60	212.76	212.74	212.70
Eastern East Edmond Marsh	211.70	211.63	211.60	211.13	210.55	210.12	210.04	210.62	211.09	212.16	212.20	212.06	212.01
Observed WSE in ft													
EM-2S	210.94	210.90	210.69	210.42	209.82	209.15	209.21	210.48	210.71	210.98	210.88	210.58	210.57
East Edmond (EM-2E)	212.55	212.63	212.47	212.13	211.43	211.43	211.43	211.89	212.22	212.63	212.62	212.51	212.55
East Edmond (EM-2W)	211.28	211.32	211.14	210.88	210.28	209.64	209.67	210.87	211.12	211.31	211.25	210.92	210.89
East Edmond (EM-3E)	212.32	212.40	212.26	211.92	211.13			211.78	212.02	212.42	212.37	212.27	212.30
East Edmond (EM-3W)	212.50	212.41	212.25	211.92	211.15	210.44	210.58	211.75	212.02	212.42	212.38	212.26	212.29
Eastern East Edmond (SCM-1)	212.25	212.43	212.29	211.88	211.08	210.95	210.57	211.69	211.99	212.58	212.47	212.20	212.32

Table F-14. Water Balance for East Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water — WY2007

Hydrologic Process	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Precipitation	2.1	2.2	0.4	0.0	0.8	1.6	14.4	8.6	6.5	4.5	5.7	1.7	1.1
Surface Water Inflows	1.8	0.9	0.0	0.0	0.0	0.1	0.7	0.4	3.2	3.2	3.5	3.1	1.6
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.1	0.1	0.0	0.0	0.0	0.1	0.7	0.4	0.3	0.2	0.2	0.1	0.0
From Hamer (surface)	1.7	0.9	0.0	0.0	0.0	0.0	0.0	0.0	2.9	3.0	3.3	3.1	1.6
Subsurface Inflows	1.5	1.3	1.2	1.0	0.7	0.6	2.0	2.2	2.1	1.8	2.1	1.7	1.5
Evapotranspiration	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2
Recharge (-) Discharge (+)	*-3.3*	*-1.3*	*-2.1*	*0.3*	*-1.4*	*-1.5*	*-0.1*	*0.6*	*-1.6*	*-1.5*	*-0.1*	*-1.9*	*-2.2*
Surface Water Outflows	-0.6	-0.5	0.0	-0.1	0.0	0.0	-5.8	-5.4	-6.2	-4.2	-6.9	-2.2	-0.7
To Diversion Canal	-0.4	-0.3	0.0	-0.1	0.0	0.0	0.0	-0.5	-3.4	-1.1	-2.5	-1.9	-0.5
To West Edmond Marsh	-0.3	-0.2	0.0	0.0	0.0	0.0	-6.7	-6.2	-3.7	-4.0	-5.7	-0.4	-0.3
Change in Storage	-1.3	-0.8	-5.0	-2.8	-2.1	-0.2	9.8	5.6	6.5	3.4	4.2	2.3	-1.4
Predicted WSE in ft													
EM-2S	212.06	211.92	211.51	211.28	211.10	211.09	211.90	212.37	212.67	212.70	212.78	212.71	212.46
East Edmond	212.57	212.49	212.07	211.84	211.66	211.65	211.90	211.85	212.09	212.03	211.91	212.06	211.92
Eastern East Edmond Marsh	211.75	211.56	211.15	210.89	210.71	210.69	212.07	212.75	212.43	212.64	212.56	212.10	211.82
Observed WSE in ft													
EM-2S	210.71	210.85	210.62	210.36	210.21	210.06	211.03	211.01	210.90	210.87	210.83	210.79	210.82
East Edmond (EM-2E)	212.55	212.63	212.53	211.36	211.43	211.65	211.87	211.94	211.78	211.79	211.80	211.65	211.73
East Edmond (EM-2W)	211.08	211.28	211.06	210.74	210.64	210.49	211.37	211.37	211.26	211.26	211.22	211.15	211.24
East Edmond (EM-3E)	212.28	212.39	212.04	211.75	211.51	211.32	212.52	212.61	212.44	212.46	212.43	212.30	212.37
East Edmond (EM-3W)	212.27	212.40	212.03	211.75	211.50	211.31	212.51	212.60	212.42	212.42	212.42	212.29	212.36
Eastern East Edmond (SCM-1)	212.26	212.46	211.97	211.70	211.38	211.33	212.58	212.67	212.49	212.48	212.49	212.29	212.44

Table F-14. Water Balance for East Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water WY2008

Hydrologic Process	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Precipitation	2.7	1.5	1.0	1.7	5.0	2.8	7.7	4.2	3.6	4.9	1.8	1.3	1.7
Surface Water Inflows	0.4	0.0	0.0	0.1	0.2	0.1	0.4	2.3	2.6	3.1	3.0	1.6	0.2
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.1	0.0	0.0	0.1	0.2	0.1	0.4	0.2	0.1	0.2	0.1	0.0	0.1
From Hamer (surface)	0.3	0.0	0.0	0.0	0.0	0.0	0.0	2.1	2.5	2.9	2.9	1.6	0.1
Subsurface Inflows	1.4	1.3	1.1	1.1	1.4	1.3	2.1	1.9	1.6	1.9	1.5	1.6	1.3
Evapotranspiration	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7
Recharge (-) Discharge (+)	*-1.5*	*0.8*	*-0.1*	*-0.7*	*-0.8*	*-1.2*	*-0.7*	*-2.5*	*-2.0*	*-2.5*	*-2.3*	*-2.5*	*-1.0*
Surface Water Outflows	-0.5	-0.4	-0.3	-0.1	-0.3	-1.4	-4.1	-2.2	-4.2	-2.8	-2.7	-0.7	-0.5
To Diversion Canal	-0.4	-0.3	-0.2	-0.1	-0.1	-0.2	-0.3	-0.6	-1.7	-1.0	-1.6	-0.5	-0.3
To West Edmond Marsh	-0.2	-0.2	-0.1	0.0	-0.3	-1.4	-4.7	-2.0	-3.3	-2.4	-1.4	-0.3	-0.2
Change in Storage	-0.9	-1.0	-2.0	-0.2	4.6	1.2	4.7	3.8	2.1	3.7	0.6	-1.4	-1.8
Predicted WSE in ft													
EM-2S	212.36	212.28	212.12	212.10	212.48	212.58	212.97	213.11	213.08	213.15	212.95	212.70	212.54
East Edmond	211.82	211.73	211.56	211.54	211.89	211.88	211.87	212.02	211.93	212.04	211.96	211.82	211.65
Eastern East Edmond Marsh	211.61	211.42	211.17	211.12	211.50	211.60	212.26	212.54	212.39	212.52	212.09	211.80	211.52
Observed WSE in ft													
EM-2S	210.87	210.86	210.68	210.52	210.85	210.93	211.00	210.98	210.95	210.94	210.83	210.79	210.70
East Edmond (EM-2E)	211.66	211.60	211.45	211.27	211.66	211.77	211.92	211.86	211.80	211.86	211.68	211.69	211.63
East Edmond (EM-2W)	211.30	211.28	211.11	210.95	211.29	211.32	211.37	211.35	211.34	211.32	211.28	211.21	211.15
East Edmond (EM-3E)	212.31	212.23	212.09	211.93	212.32	212.40	212.56	212.50	212.44	212.50	212.37	212.33	212.27
East Edmond (EM-3W)	212.29	212.24	212.09	211.91	212.31	212.40	212.54	212.49	212.43	212.49	212.35	212.33	212.25
Eastern East Edmond (SCM-1)	212.35	212.29	212.13	212.06	212.38	212.48	212.63	212.58	212.52	212.55	212.43	212.39	212.32

Table F-14. Water Balance for East Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water WY2009

Hydrologic Process	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Precipitation	0.9	2.1	0.5	2.6	8.3	5.2	7.3	1.6	5.3	3.5	3.4	1.3	0.0
Surface Water Inflows	0.0	0.1	0.0	0.1	0.4	0.2	1.0	2.6	1.9	2.6	2.1	1.4	0.0
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.0	0.1	0.0	0.1	0.4	0.2	0.3	0.0	0.2	0.1	0.1	0.0	0.0
From Hamer (surface)	0.0	0.0	0.0	0.0	0.0	0.0	0.7	2.5	1.7	2.5	2.0	1.3	0.0
Subsurface Inflows	1.1	0.9	0.7	0.7	1.6	1.7	2.0	1.4	1.8	1.6	1.6	1.2	0.9
Evapotranspiration	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5
Recharge (-) Discharge (+)	*-0.5*	*0.5*	*-0.1*	*-1.8*	*-1.0*	*-2.0*	*-2.2*	*-3.0*	*-3.1*	*-3.4*	*-3.1*	*-2.5*	*-1.8*
Surface Water Outflows	-0.4	-0.1	-0.1	0.0	-1.6	-2.6	-3.4	-1.8	-2.4	-1.4	-0.9	-0.7	0.0
To Diversion Canal	-0.2	-0.1	0.0	0.0	0.0	-0.3	-0.4	-1.5	-0.5	-0.7	-0.5	-0.5	0.0
To West Edmond Marsh	-0.1	0.0	0.0	0.0	-1.9	-2.8	-3.8	-0.4	-2.4	-0.9	-0.5	-0.3	0.0
Change in Storage	-3.2	-0.4	-1.2	0.5	7.0	2.3	4.3	1.6	2.2	1.4	0.2	-2.5	-5.3
Predicted WSE in ft													
EM-2S	212.27	212.24	212.13	212.18	212.76	212.95	213.25	213.17	213.22	213.13	212.98	212.66	212.21
East Edmond	211.43	211.43	211.43	211.47	211.90	211.86	211.91	212.00	211.99	212.03	212.01	211.77	211.43
Eastern East Edmond Marsh	211.17	211.09	210.97	211.01	211.75	212.02	212.51	212.14	212.32	212.25	212.11	211.74	211.29
Observed WSE in ft													
EM-2S	210.43	210.28	210.14	210.00	210.90	210.97	210.95	210.92	210.89	210.87	210.93	210.61	210.18
East Edmond (EM-2E)	211.43	211.43	211.43	211.43	211.72	211.81	211.81	211.76	211.54	211.44	211.72	211.43	211.43
East Edmond (EM-2W)	210.88	210.70	210.56	210.41	211.31	211.34	211.33	211.30	211.36	211.36	211.37	211.04	210.58
East Edmond (EM-3E)	211.92	211.63	211.47	211.30	212.41	212.42	212.44	212.39	212.25	212.31	212.38	211.93	211.59
East Edmond (EM-3W)	211.92	211.67	211.50	211.33	212.32	212.40	212.43	212.37	212.25	212.29	212.36	211.94	211.67
Eastern East Edmond (SCM-1)	211.96	211.71	211.54	211.38	212.39	212.48	212.53	212.47	212.33	212.37	212.44	211.94	211.51

Table F-14. Water Balance for East Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water WY2010

Hydrologic Process	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Precipitation	1.9	2.8	5.6	8.9	3.0	8.0	3.3	3.3	3.3	4.6	4.3	0.4	0.2
Surface Water Inflows	0.1	0.1	0.3	0.4	1.1	1.9	3.2	3.4	2.9	2.8	2.6	0.3	0.0
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.1	0.1	0.3	0.4	0.1	0.4	0.1	0.1	0.1	0.2	0.2	0.0	0.0
From Hamer (surface)	0.0	0.0	0.0	0.0	1.0	1.5	3.1	3.2	2.8	2.6	2.5	0.3	0.0
Subsurface Inflows	0.9	0.9	1.2	1.9	1.8	2.1	2.0	2.0	1.9	1.9	1.8	1.4	1.1
Evapotranspiration	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0
Recharge (-) Discharge (+)	*-1.5*	*-1.3*	*-2.0*	*-1.3*	*-2.5*	*-3.0*	*-2.2*	*-3.4*	*-2.9*	*-3.1*	*-3.0*	*-2.4*	*-1.7*
Surface Water Outflows	-0.2	0.0	0.0	-3.5	-1.5	-3.9	-5.5	-0.9	-2.2	-2.0	-1.3	0.0	0.0
To Diversion Canal	-0.1	0.0	0.0	-0.2	-0.5	-0.5	-2.8	-0.5	-0.6	-0.8	-0.6	0.0	0.0
To West Edmond Marsh	-0.1	0.0	0.0	-4.1	-1.3	-4.3	-3.6	-0.4	-2.0	-1.6	-1.0	0.0	0.0
Change in Storage	-2.7	0.1	4.1	5.3	2.0	4.7	2.1	3.6	1.3	1.3	1.0	-4.8	-4.4
Predicted WSE in ft													
EM-2S	211.98	211.99	212.34	212.78	212.86	213.13	213.05	213.08	212.96	212.85	212.73	212.30	211.93
East Edmond	211.43	211.44	211.78	211.88	211.94	211.97	211.85	212.12	212.06	212.04	212.04	211.64	211.43
Eastern East Edmond Marsh	211.01	211.02	211.35	212.06	212.15	212.71	212.18	212.31	212.34	212.29	212.23	211.83	211.46
Observed WSE in ft													
EM-2S	210.12	210.11	210.47	211.06	211.04	211.03	211.03	210.86	211.15	211.13	211.10	210.88	210.61
East Edmond (EM-2E)	211.43	211.43	211.43	211.75	211.52	211.58	211.64	211.90	211.59	212.04	211.93	211.73	211.43
East Edmond (EM-2W)	210.51	210.52	210.90	211.41	211.41	211.39	211.40	211.24	211.58	211.54	211.52	211.36	211.03
East Edmond (EM-3E)	211.49	211.46	211.74	212.41	212.33	212.49	212.38	212.42	212.43	212.55	212.48	212.25	211.93
East Edmond (EM-3W)	211.48	211.46	211.72	212.31	212.25	212.27	212.22	212.39	212.25	212.54	212.44	212.25	211.96
Eastern East Edmond (SCM-1)	211.45	211.46	211.78	212.48	212.40	212.57	212.45	212.49	212.52	212.62	212.55	212.24	211.87

Table F-14. Water Balance for East Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water WY2011

Hydrologic Process	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Precipitation	4.0	4.2	6.6	7.2	6.1	3.1	7.2	5.7	4.8	2.8	0.8	0.3	1.3
Surface Water Inflows	0.2	0.2	0.3	2.2	3.5	2.9	3.2	3.2	3.4	3.0	1.0	0.0	0.0
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.2	0.2	0.3	0.3	0.2	0.1	0.3	0.2	0.2	0.1	0.0	0.0	0.0
From Hamer (surface)	0.0	0.0	0.0	1.9	3.2	2.8	3.0	3.0	3.2	2.9	1.0	0.0	0.0
Subsurface Inflows	1.4	1.4	2.0	1.9	1.6	1.3	1.5	1.4	1.5	1.3	2.7	2.4	1.7
Evapotranspiration	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3
Recharge (-) Discharge (+)	*-1.0*	*-2.0*	*-1.6*	*-3.4*	*-4.7*	*-3.6*	*-4.7*	*-3.8*	*-4.1*	*-3.8*	*-26.0*	*3.3*	*1.0*
Surface Water Outflows	-0.3	-0.4	-2.7	-0.7	-2.6	-2.4	-3.0	-3.8	-1.2	-1.0	0.0	0.0	0.0
To Diversion Canal	-0.2	-0.3	-0.3	-0.5	-0.6	-0.9	-0.8	-1.7	-0.8	-0.7	0.0	0.0	0.0
To West Edmond Marsh	-0.1	-0.2	-3.0	-0.3	-2.5	-2.0	-2.8	-2.9	-0.5	-0.4	0.0	0.0	0.0
Change in Storage	2.1	2.6	3.8	7.5	4.0	1.2	3.2	1.7	1.9	-0.9	-26.1	2.0	1.8
Predicted WSE in ft													
EM-2S	212.11	212.32	212.64	213.11	213.18	213.04	213.06	212.96	212.85	212.53	210.28	210.44	210.59
East Edmond	211.60	211.80	211.87	212.47	212.60	212.53	212.56	212.46	212.58	212.47	211.43	211.60	211.75
Eastern East Edmond Marsh	211.55	211.66	212.10	212.56	212.87	212.80	213.02	212.80	212.71	212.42	210.25	210.42	210.57
Observed WSE in ft													
EM-2S	211.01	211.05	211.33	211.43	211.30	211.27	211.25	211.27	211.30	211.22	206.59	211.06	210.85
East Edmond (EM-2E)	211.73	211.75	211.95	212.18	212.13	212.20	212.27	212.30	212.37			212.01	211.69
East Edmond (EM-2W)	211.46	211.48	211.73	211.78	211.68	211.65	211.61	211.58	211.68			211.48	211.33
East Edmond (EM-3E)	212.23	212.37	212.59	212.73	212.73	212.73	212.73	212.76	212.88			212.49	212.06
East Edmond (EM-3W)	212.23	212.25	212.43	212.70	212.63	212.69	212.75	212.77	212.85			212.50	212.18
Eastern East Edmond (SCM-1)	212.28	212.32	212.67	212.81	212.78	212.79	212.80	212.83	212.95			212.58	212.26

Table F-14. Water Balance for East Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water	WY2012												WY2013
Hydrologic Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Precipitation	4.1	6.1	3.2	7.2	3.9	6.8	4.3	3.1	3.3	1.6	0.0	0.1	6.5
Surface Water Inflows	0.2	0.3	0.8	1.4	3.1	3.4	3.2	3.0	2.3	1.7	0.0	0.0	0.3
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.2	0.3	0.1	0.3	0.1	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.3
From Hamer (surface)	0.0	0.0	0.7	1.1	3.0	3.1	3.0	2.9	2.1	1.7	0.0	0.0	0.0
Subsurface Inflows	1.7	1.8	1.7	2.0	1.5	1.6	1.3	1.4	1.3	1.3	1.3	1.1	1.6
Evapotranspiration	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0
Recharge (-) Discharge (+)	*-0.3*	*-1.8*	*-2.2*	*-1.3*	*-2.9*	*-3.7*	*-2.8*	*-3.6*	*-3.2*	*-2.1*	*-0.5*	*-1.4*	*-2.1*
Surface Water Outflows	0.0	-1.2	-1.5	-4.0	-1.8	-3.2	-2.7	-1.4	-0.9	-0.8	-0.6	0.0	-0.2
To Diversion Canal	0.0	0.0	-0.2	-0.3	-0.5	-0.6	-0.9	-0.9	-0.6	-0.5	-0.4	0.0	-0.1
To West Edmond Marsh	0.0	-1.3	-1.5	-4.5	-1.7	-3.4	-2.2	-0.6	-0.4	-0.3	-0.2	0.0	-0.1
Change in Storage	4.7	4.5	2.0	4.8	3.3	3.4	1.7	0.1	-0.5	-2.3	-3.4	-2.6	5.2
Predicted WSE in ft													
EM-2S	210.98	211.36	211.47	211.77	211.80	211.82	211.71	211.48	211.26	210.93	210.65	210.44	210.87
East Edmond	212.14	212.40	212.44	212.47	212.60	212.60	212.55	212.51	212.44	212.22	211.92	211.71	212.13
Eastern East Edmond Marsh	210.96	211.45	211.64	212.29	212.52	212.85	212.84	212.56	212.33	211.95	211.51	211.30	211.67
Observed WSE in ft													
EM-2S	210.97	211.29	211.31	211.37	211.36	211.38	211.40	211.41	211.36	211.25	211.14	210.84	211.08
East Edmond (EM-2E)	211.83	212.03	212.25	212.50	212.52	212.55	212.57	212.63	212.54	212.34	212.13	211.72	212.01
East Edmond (EM-2W)	211.40	211.67	211.71	211.72	211.75	211.76	211.77	211.78	211.75	211.65	211.55	211.31	211.50
East Edmond (EM-3E)	212.19	212.38	212.61	212.85	212.88	212.92	212.95	213.00	212.91	212.70	212.50	212.09	212.37
East Edmond (EM-3W)	212.29	212.50	212.73	212.98	212.99	213.02	213.05	213.11	213.03	212.82	212.61	212.20	212.48
Eastern East Edmond (SCM-1)	212.40	212.59	212.85	213.10	213.12	213.15	213.18	213.35	213.17	212.95	212.74	212.21	212.55

Table F-14. Water Balance for East Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water | WY2014

Hydrologic Process	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Precipitation	6.5	7.6	3.5	1.7	3.7	5.5	4.4	1.9	0.0	1.6	6.9	2.6	4.1
Surface Water Inflows	0.3	2.4	3.3	2.8	2.5	2.6	2.8	2.2	0.0	0.1	0.3	0.1	0.4
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.3	0.3	0.1	0.0	0.1	0.2	0.2	0.1	0.0	0.1	0.3	0.1	0.2
From Hamer (surface)	0.0	2.1	3.1	2.8	2.4	2.4	2.7	2.1	0.0	0.0	0.0	0.0	0.2
Subsurface Inflows	1.8	1.9	1.6	1.2	1.4	1.2	1.3	1.2	1.1	1.0	1.5	1.6	1.7
Evapotranspiration	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5
Recharge (-) Discharge (+)	*-2.3*	*-2.0*	*-3.9*	*-3.7*	*-3.5*	*-3.8*	*-4.5*	*-3.2*	*-1.3*	*-1.1*	*-1.1*	*-1.0*	*-1.9*
Surface Water Outflows	-1.5	-3.6	-2.1	-1.4	-1.9	-2.0	-1.0	-0.9	0.0	-0.5	-0.3	-0.5	-1.3
To Diversion Canal	-0.3	-0.4	-0.7	-0.7	-0.7	-0.6	-0.7	-0.6	0.0	-0.3	-0.2	-0.3	-0.3
To West Edmond Marsh	-1.5	-4.0	-1.8	-0.9	-1.6	-1.7	-0.4	-0.4	0.0	-0.2	-0.1	-0.2	-1.2
Change in Storage	4.4	5.9	2.6	0.5	1.3	1.8	0.4	-2.1	-4.6	-2.7	5.1	2.0	2.6
Predicted WSE in ft													
EM-2S	211.23	211.55	211.50	211.32	211.23	211.18	210.99	210.64	210.25	210.03	210.46	210.62	210.82
East Edmond	212.37	212.53	212.59	212.56	212.53	212.53	212.53	212.32	211.94	211.70	212.12	212.27	212.39
Eastern East Edmond Marsh	212.03	212.67	212.78	212.66	212.65	212.70	212.51	212.14	211.76	211.41	211.76	211.80	211.98
Observed WSE in ft													
EM-2S	211.31	211.47	211.40	211.40	211.39	211.44	211.43	211.37	211.19	210.88	211.31	211.51	211.47
East Edmond (EM-2E)	212.29	212.69	212.64	212.56	212.59	212.63	212.48	212.39	212.03	211.66	212.05	212.55	212.52
East Edmond (EM-2W)	211.69	211.83	211.78	211.75	211.76	211.81	211.82	211.80	211.64	211.36	211.76	211.89	211.86
East Edmond (EM-3E)	212.65	213.05	212.99	212.91	213.01	212.99	212.86	212.77	212.41	212.03	212.41	212.93	212.88
East Edmond (EM-3W)	212.76	213.17	213.11	213.04	213.06	213.10	212.96	212.88	212.51	212.15	212.53	213.03	212.99
Eastern East Edmond (SCM-1)	212.90	213.32	213.27	213.18	213.21	213.26	213.10	213.03	212.65	212.26	212.66	213.16	213.14

Table F-14. Water Balance for East Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water — WY2015

Hydrologic Process	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation	2.4	4.2	6.9	9.8	4.5	3.3	1.3	1.2	1.6	1.8	5.9	6.1	4.8
Surface Water Inflows	1.7	1.4	2.1	3.9	4.0	4.0	2.2	1.7	0.6	0.1	0.3	2.0	3.3
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.1	0.2	0.3	0.4	0.2	0.1	0.0	0.0	0.0	0.1	0.3	0.2	0.2
From Hamer (surface)	1.6	1.2	1.8	3.5	3.9	3.9	2.2	1.6	0.6	0.0	0.0	1.8	3.1
Subsurface Inflows	1.4	1.6	1.6	1.6	1.7	1.7	1.6	1.6	1.6	1.8	2.1	1.9	2.1
Evapotranspiration	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0
Recharge (-) Discharge (+)	*-3.4*	*-2.6*	*-1.5*	*-4.0*	*-2.0*	*-2.6*	*-2.9*	*-2.4*	*-1.7*	*-0.8*	*-2.3*	*-3.1*	*-2.5*
Surface Water Outflows	-0.8	-2.4	-3.6	-4.1	-6.6	-1.0	-1.0	-0.8	-0.6	-0.4	-0.3	-2.0	-3.1
To Diversion Canal	-0.4	-0.4	-0.4	-0.7	-3.2	-0.7	-0.7	-0.5	-0.4	-0.3	-0.2	-0.3	-0.5
To West Edmond Marsh	-0.4	-2.5	-4.0	-4.4	-4.6	-0.4	-0.4	-0.3	-0.2	-0.2	-0.1	-2.0	-3.2
Change in Storage	1.7	2.1	4.6	5.7	1.6	2.8	-2.0	-2.8	-2.2	0.4	4.8	4.3	4.4
Predicted WSE in ft													
EM-2S	210.83	210.90	211.13	211.31	211.12	211.03	210.68	210.32	210.09	210.12	210.53	210.74	210.85
East Edmond	212.49	212.46	212.51	212.62	212.37	212.57	212.37	212.11	211.91	211.93	212.32	212.51	212.61
Eastern East Edmond Marsh	211.97	212.16	212.70	213.25	212.70	212.71	212.33	211.91	211.58	211.51	211.82	212.20	212.63
Observed WSE in ft													
EM-2S	211.39	211.43	211.51	211.50	211.51	211.54	211.48	211.33	211.22	211.30	211.38	211.49	211.49
East Edmond (EM-2E)	212.33	212.43	212.59	212.59	212.68	212.81	212.73	212.32			212.34	212.53	212.51
East Edmond (EM-2W)	211.80	211.82	211.86	211.87	211.88	211.90	211.87	211.78	211.71	211.76	211.81	211.88	211.89
East Edmond (EM-3E)	212.69	212.80	212.95	212.96	213.04	213.19	213.08	212.66	212.49	212.59	212.69	212.91	212.94
East Edmond (EM-3W)	212.80	212.91	213.06	213.06	213.15	213.29	213.19	212.79	212.61	212.57	212.54	213.02	213.04
Eastern East Edmond (SCM-1)	212.95	213.07	213.21	213.25	213.33	213.46	213.22	212.98	212.76	212.86	212.97	213.20	213.26

Table F-14. Water Balance for East Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water — WY2016

Hydrologic Process	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Precipitation	4.1	4.7	4.4	2.1	0.8	0.4	0.2	2.2	1.3	5.0	7.1	12.0	6.9
Surface Water Inflows	4.1	3.9	4.3	3.8	1.2	0.3	0.0	0.1	0.0	0.2	0.3	1.0	4.2
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.2	0.2	0.2	0.1	0.0	0.0	0.0	0.1	0.0	0.2	0.3	0.5	0.3
From Hamer (surface)	4.0	3.7	4.1	3.8	1.2	0.3	0.0	0.0	0.0	0.0	0.0	0.4	4.0
Subsurface Inflows	1.8	1.5	1.8	1.4	1.4	1.2	1.3	1.1	1.0	1.0	1.8	2.1	1.7
Evapotranspiration	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0
Recharge (-) Discharge (+)	*-4.0*	*-3.8*	*-3.6*	*-4.0*	*-4.0*	*-3.5*	*-2.0*	*-1.9*	*-1.0*	*-2.2*	*0.2*	*-1.8*	*-5.4*
Surface Water Outflows	-2.7	-3.4	-4.0	-1.4	0.0	0.0	0.0	-0.3	-0.1	0.0	-0.4	-5.8	-3.0
To Diversion Canal	-0.6	-1.0	-1.6	-0.9	0.0	0.0	0.0	-0.2	-0.1	0.0	-0.1	-0.4	-1.1
To West Edmond Marsh	-2.7	-3.2	-3.0	-0.6	0.0	0.0	0.0	-0.1	0.0	0.0	-0.3	-6.6	-2.4
Change in Storage	3.4	2.5	2.6	0.7	-3.8	-5.3	-5.0	-2.6	-1.1	3.1	8.7	6.7	5.0
Predicted WSE in ft													
EM-2S	210.80	210.69	210.56	210.31	209.89	209.42	209.01	209.00	209.00	209.26	209.98	210.50	210.59
East Edmond	212.66	212.60	212.56	212.57	212.25	211.81	211.43	211.43	211.43	211.69	212.39	212.39	212.61
Eastern East Edmond Marsh	212.88	213.00	212.86	212.62	212.30	211.86	211.44	211.14	211.02	211.27	211.96	212.89	213.10
Observed WSE in ft													
EM-2S	211.46	211.44	211.42	211.33	211.28	211.07	210.67	210.28	210.36	210.44	211.37	211.34	
East Edmond (EM-2E)	212.49	212.47	212.45	212.47	212.38	211.92	211.60	211.43	211.43	211.43	212.50	212.38	
East Edmond (EM-2W)	211.84	211.81	211.78	211.21	211.71	211.53	211.17	210.76	210.81	210.86	211.72	211.68	
East Edmond (EM-3E)	212.85	212.82	212.79	212.83	212.74	212.20	211.92	211.62	211.64	211.65	212.85	212.70	
East Edmond (EM-3W)	212.94	212.92	212.91	212.94	212.83	212.39	212.03	211.71	211.73	211.75	212.95	212.82	
Eastern East Edmond (SCM-1)	213.13	213.11	213.09	213.13	213.03	212.53	212.14	211.79	211.81	211.83	213.11	212.99	

Table F-14. Water Balance for East Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water — WY2017

Hydrologic Process	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Precipitation	5.8	5.9	1.8	1.0	2.3	1.3	0.2	1.5	9.3	6.9	3.9	3.4	8.6
Surface Water Inflows	4.0	4.4	3.4	1.8	2.5	1.7	0.1	0.0	0.4	1.3	3.6	4.1	3.9
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.2	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.4	0.3	0.2	0.1	0.3
From Hamer (surface)	3.8	4.2	3.3	1.7	2.4	1.7	0.1	0.0	0.0	1.0	3.5	4.0	3.6
Subsurface Inflows	1.7	1.8	1.8	1.9	1.8	1.8	1.6	1.5	1.6	2.2	2.2	2.0	1.6
Evapotranspiration	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6
Recharge (-) Discharge (+)	*-4.4*	*-5.3*	*-3.9*	*-3.1*	*-2.5*	*-2.2*	*-0.8*	*-0.4*	*-3.4*	*-2.6*	*-3.5*	*-6.4*	*-5.3*
Surface Water Outflows	-5.1	-2.8	-2.0	-0.9	-0.7	-0.6	-0.4	-0.2	-0.4	-3.0	-2.1	-1.9	-3.9
To Diversion Canal	-2.0	-1.3	-1.3	-0.6	-0.5	-0.4	-0.3	-0.1	-0.1	-0.3	-0.5	-0.7	-0.6
To West Edmond Marsh	-4.0	-2.0	-1.0	-0.4	-0.3	-0.3	-0.2	-0.1	-0.3	-3.2	-2.0	-1.5	-4.2
Change in Storage	2.5	3.6	0.1	-2.0	0.1	-2.2	-3.0	0.3	6.6	4.0	4.2	1.7	3.9
Predicted WSE in ft													
EM-2S	210.48	210.43	210.16	209.85	209.66	209.33	209.07	209.09	209.64	209.89	209.95	209.76	209.79
East Edmond	212.49	212.62	212.54	212.34	212.32	212.12	211.85	211.87	212.39	212.45	212.63	212.65	212.63
Eastern East Edmond Marsh	212.92	212.93	212.56	212.19	212.02	211.68	211.31	211.27	211.79	212.25	212.56	212.54	212.99
Observed WSE in ft													
EM-2S					211.28	211.15	210.81		210.79	211.31	211.32	211.17	211.47
East Edmond (EM-2E)					212.38	212.27	211.76		211.57	212.24	212.22	212.05	212.04
East Edmond (EM-2W)					211.68	211.57	211.27		211.29	211.90	211.78	211.57	211.59
East Edmond (EM-3E)					212.59	212.34	212.05		211.87	212.33	212.35	212.39	213.34
East Edmond (EM-3W)					212.81	212.60	212.19		212.00	212.69	212.66	212.50	212.46
Eastern East Edmond (SCM-1)					212.88	212.65	212.28		212.08	212.60	212.59	212.62	210.24

Table F-14. Water Balance for East Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water — WY 2018

Hydrologic Process	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Precipitation	8.7	4.6	2.8	1.8	0.0	0.1	1.0	5.2	7.2	5.8	7.2	3.3	2.3
Surface Water Inflows	4.4	4.2	4.2	3.1	0.0	0.1	0.1	0.2	1.9	3.6	4.5	3.8	4.3
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.2	0.3	0.2	0.3	0.1	0.1
From Hamer (surface)	4.1	4.1	4.1	3.0	0.0	0.1	0.1	0.0	1.6	3.4	4.2	3.7	4.2
Subsurface Inflows	2.2	2.0	1.9	2.0	2.3	2.5	2.2	2.7	2.4	2.3	2.0	1.9	2.1
Evapotranspiration	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3
Recharge (-) Discharge (+)	*-2.8*	*-3.7*	*-4.9*	*-5.1*	*-2.8*	*-1.9*	*-1.9*	*-1.9*	*-3.2*	*-4.5*	*-5.7*	*-3.1*	*-5.3*
Surface Water Outflows	-8.6	-2.8	-1.4	-0.8	0.0	-0.4	-0.1	0.0	-0.7	-2.7	-3.5	-5.2	-1.0
To Diversion Canal	-3.2	-1.6	-0.9	-0.5	0.0	-0.2	-0.1	0.0	-0.2	-0.4	-0.6	-2.1	-0.7
To West Edmond Marsh	-7.0	-1.6	-0.6	-0.3	0.0	-0.1	0.0	0.0	-0.6	-2.8	-3.7	-3.9	-0.4
Change in Storage	4.2	3.6	0.3	-2.3	-5.0	-3.3	-0.9	5.2	7.2	4.3	4.3	1.4	1.6
Predicted WSE in ft													
EM-2S	209.80	209.76	209.44	209.00	209.00	209.00	209.00	209.43	209.90	209.98	209.98	209.80	209.58
East Edmond	212.40	212.57	212.54	212.32	211.90	211.61	211.53	211.96	212.51	212.64	212.69	212.48	212.58
Eastern East Edmond Marsh	212.76	212.61	212.33	211.96	211.54	211.16	211.05	211.47	212.02	212.44	212.87	212.55	212.46
Observed WSE in ft													
EM-2S	211.31	211.27		211.18	211.05	211.24	210.72			211.95		211.29	211.12
East Edmond (EM-2E)	212.14	212.21		212.34	212.18	211.95	211.82			212.59		212.35	212.14
East Edmond (EM-2W)	210.67	211.63		211.55	211.44	210.47	211.09			211.69		211.60	211.48
East Edmond (EM-3E)	212.37	212.47		212.67	212.88	212.52	212.03			212.56		212.51	212.40
East Edmond (EM-3W)	212.54	212.62		212.78	212.62	212.37	212.27			213.07		212.79	212.58
Eastern East Edmond (SCM-1)	212.62	212.68		212.95	212.65	212.56	212.64			212.89		212.76	212.65

Table F-14. Water Balance for East Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water — WY2019

Hydrologic Process	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Precipitation	6.1	0.7	0.9	0.2	0.3	1.8	4.0	3.8	6.4	3.4	4.8	1.6	3.6
Surface Water Inflows	3.7	0.8	1.5	0.2	0.0	0.1	0.2	0.2	0.3	3.0	3.1	3.0	2.8
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.2	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.3	0.1	0.2	0.0	0.1
From Hamer (surface)	3.5	0.8	1.4	0.2	0.0	0.0	0.0	0.0	0.0	2.8	2.9	3.0	2.7
Subsurface Inflows	1.9	1.9	1.9	2.0	1.8	1.7	1.9	2.3	2.7	2.3	1.9	1.9	1.6
Evapotranspiration	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0
Recharge (-) Discharge (+)	*-4.5*	*-5.5*	*-4.7*	*-3.2*	*-2.8*	*-1.9*	*-4.9*	*-1.8*	*-2.8*	*-4.5*	*-4.6*	*-5.4*	*-5.0*
Surface Water Outflows	-2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	-0.5	-2.2	-0.7	-0.6
To Diversion Canal	-0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.3	-0.4	-0.5	-0.4
To West Edmond Marsh	-2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.2	-2.3	-0.3	-0.2
Change in Storage	2.9	-5.3	-4.2	-5.3	-4.7	-0.7	0.1	3.9	6.5	3.9	2.3	-0.5	0.7
Predicted WSE in ft													
EM-2S	209.53	209.03	209.00	209.00	209.00	209.00	209.01	209.33	209.87	209.96	209.91	209.62	209.46
East Edmond	212.63	212.19	211.84	211.43	211.43	211.43	211.44	211.76	212.29	212.60	212.60	212.54	212.58
Eastern East Edmond Marsh	212.66	212.22	211.87	211.43	211.04	210.97	210.98	211.31	211.79	211.98	212.20	211.98	211.88
Observed WSE in ft													
EM-2S	211.17	211.08	211.17	211.01	210.61	210.70	210.71	211.07	211.35	211.39	211.14	211.24	211.37
East Edmond (EM-2E)	212.37	212.41	212.23	212.05	211.65	211.73	211.78	212.21	212.63		212.55	212.37	212.63
East Edmond (EM-2W)	211.51	211.24	211.59	211.44	211.01	211.12	211.07	211.66	211.70		211.48	211.66	211.89
East Edmond (EM-3E)	212.48						212.06	212.42	212.65	212.71	212.83	212.69	212.67
East Edmond (EM-3W)	212.81	212.81	212.50	212.50	212.14	212.19	212.19	212.64	212.98	212.50	213.00	212.81	213.06
Eastern East Edmond (SCM-1)	212.77	212.59	212.85	212.01	211.75	211.84	212.57					212.88	212.90

Table F-14. Water Balance for East Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water — WY2020

Hydrologic Process	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Precipitation	1.1	0.7	1.0	0.8	3.5	3.9	1.7	6.5	9.6	4.2	3.5	1.5	3.1
Surface Water Inflows	1.6	0.2	0.0	0.0	0.2	0.2	0.1	0.3	0.4	3.1	3.6	2.3	1.1
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.0	0.0	0.0	0.0	0.2	0.2	0.1	0.3	0.4	0.1	0.1	0.0	0.1
From Hamer (surface)	1.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	3.4	2.3	1.0
Subsurface Inflows	1.4	1.2	1.1	0.9	1.1	1.6	1.2	1.3	2.3	1.8	1.3	1.1	1.2
Evapotranspiration	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2
Recharge (-) Discharge (+)	*-4.5*	*-3.3*	*-2.0*	*-2.2*	*-3.8*	*0.5*	*1.4*	*-3.1*	*-1.5*	*-4.6*	*-2.8*	*-2.2*	*-1.9*
Surface Water Outflows	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	-1.0	-4.8	-2.2	-2.3	-1.0	-0.8
To Diversion Canal	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	-0.2	-0.5	-0.6	-0.7	-0.6
To West Edmond Marsh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-1.2	-5.5	-2.2	-2.2	-0.5	-0.4
Change in Storage	-3.5	-4.9	-4.4	-4.5	-1.3	5.1	3.9	3.9	5.3	1.8	2.1	0.4	0.0
Predicted WSE in ft													
EM-2S	209.03	209.00	209.00	209.00	209.00	209.43	209.75	210.07	210.51	210.41	210.30	210.14	210.06
East Edmond	212.28	211.88	211.51	211.43	211.43	211.86	212.18	212.40	212.38	212.35	212.34	212.33	212.30
Eastern East Edmond Marsh	211.59	211.18	210.78	210.41	210.30	210.72	211.05	211.46	212.26	212.41	212.54	212.36	212.17
Observed WSE in ft													
EM-2S		210.80	210.49	210.07	210.20	210.34		210.30	211.41	210.49			
East Edmond (EM-2E)		211.91	211.55	211.43	211.43	211.44		211.43	212.60	212.45			
East Edmond (EM-2W)		211.58	210.92	210.54		210.77		211.58	211.69	211.66			
East Edmond (EM-3E)						211.90		211.74	212.80	212.80			
East Edmond (EM-3W)		212.37	212.00	211.54	212.27	211.89		212.16	213.03	212.89			
Eastern East Edmond (SCM-1)													

Table F-14. Water Balance for East Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water — WY 2021

Hydrologic Process	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Precipitation	2.5	0.3	0.4	2.8	3.0	5.6	5.2	7.3	4.7	2.5	1.2	2.0	2.4
Surface Water Inflows	0.6	0.0	0.0	0.1	0.1	0.2	0.9	4.1	4.0	4.4	2.4	3.8	3.5
From Sequalitchew Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
From Center Drive	0.1	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.2	0.1	0.0	0.1	0.1
From Hamer (surface)	0.5	0.0	0.0	0.0	0.0	0.0	0.6	3.9	3.8	4.3	2.4	3.8	3.5
Subsurface Inflows	1.2	0.9	0.7	0.8	0.7	0.9	1.4	1.8	1.8	2.3	1.9	1.8	1.6
Evapotranspiration	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7
Recharge (-) Discharge (+)	*-0.8*	*-2.1*	*-1.9*	*-0.1*	*2.3*	*7.1*	*8.4*	*5.0*	*2.2*	*0.1*	*0.0*	*1.7*	*1.9*
Surface Water Outflows	-0.7	0.0	0.0	-0.1	-0.1	-3.6	-7.2	-10.8	-7.4	-6.6	-1.4	-3.2	-4.6
To Diversion Canal	-0.5	0.0	0.0	0.0	-0.1	-0.2	-0.7	-3.3	-3.1	-3.3	-0.6	-0.7	-1.8
To West Edmond Marsh	-0.3	0.0	0.0	0.0	-0.1	-4.1	-8.3	-9.8	-5.8	-4.2	-1.0	-3.2	-3.6
Change in Storage	-0.5	-5.4	-4.8	1.2	5.0	9.2	7.6	8.5	6.4	3.8	2.5	3.0	2.2
Predicted WSE in ft													
EM-2S	209.97	209.51	209.12	209.22	209.64	210.41	210.99	211.37	211.58	211.54	211.55	211.49	211.38
East Edmond	212.23	211.78	211.43	211.53	211.94	212.37	212.32	212.20	212.25	212.21	212.34	212.32	212.21
Eastern East Edmond Marsh	211.95	211.50	211.10	211.18	211.56	212.56	213.00	213.00	212.99	212.49	212.55	212.80	212.62
Observed WSE in ft													
EM-2S		210.83	210.33		210.25			211.47			211.31	211.27	211.13
East Edmond (EM-2E)		211.43	211.43		211.43	212.93		212.54			212.27	212.16	212.04
East Edmond (EM-2W)			210.76		210.69			211.77	212.14	212.14	211.70	211.69	211.51
East Edmond (EM-3E)					211.47	212.18		212.88	213.54	212.83	212.43		
East Edmond (EM-3W)			211.69		211.56	212.50		212.99	212.50	212.50	212.73	212.60	212.50
Eastern East Edmond (SCM-1)													

Table F-14. Water Balance for East Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water WY 2021

Hydrologic Process	Jul	Aug	Sep
Precipitation	0.0	0.3	2.6
Surface Water Inflows	0.0	0.3	2.7
From Sequalitchew Lake	0.0	0.0	0.0
From Center Drive	0.0	0.0	0.1
From Hamer (surface)	0.0	0.3	2.6
Subsurface Inflows	1.7	1.7	1.8
Evapotranspiration	-4.5	-4.0	-2.3
Recharge (-) Discharge (+)	*3.0*	*0.4*	*0.1*
Surface Water Outflows	-1.4	-0.8	-0.6
To Diversion Canal	-1.0	-0.5	-0.4
To West Edmond Marsh	-0.6	-0.3	-0.2
Change in Storage	-0.4	-1.7	4.7
Predicted WSE in ft			
EM-2S	211.34	211.18	211.35
East Edmond	212.12	211.94	212.32
Eastern East Edmond Marsh	212.27	211.95	212.19
Observed WSE in ft			
EM-2S	210.73		
East Edmond (EM-2E)	211.69	211.43	
East Edmond (EM-2W)	211.14		
East Edmond (EM-3E)			
East Edmond (EM-3W)	212.23	211.56	
Eastern East Edmond (SCM-1)		210.20	

Table F-15. Water Balance for West Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water	WY2004						WY2005						
Hydrologic Process	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Precipitation	2.0	1.0	3.8	0.9	0.1	3.6	2.9	4.0	3.2	4.3	4.3	0.6	4.5
Surface Water Inflows	-8.8	0.0	1.0	0.0	0.0	0.3	0.0	0.0	1.3	1.7	3.0	0.0	3.1
From East Edmond	-8.8	0.0	1.0	0.0	0.0	0.3	0.0	0.0	1.3	1.7	3.0	0.0	3.1
Evapotranspiration	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3
Recharge (-) Discharge (+)	-44.6	-33.6	-11.5	2.8	4.4	0.1	-0.6	-2.9	-3.9	-6.0	-7.3	-0.1	-6.3
Surface Water Outflows	0.0	-0.3	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
To Center Drive	0.0	-0.3	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Change in Storage	-52.6	-34.9	-10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Predicted WSE in ft	209.04	206.13	205.31	205.31	205.31	205.31	205.31	205.31	205.31	205.31	205.31	205.31	205.31
Observed WSE EM-1/EM-1A	209.10	208.59	207.26	206.55	205.27	205.27	205.27	205.86	206.15	207.67	209.18	207.97	206.63

Table F-15. Water Balance for West Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water — WY2006

Hydrologic Process	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Precipitation	5.4	3.9	3.8	1.4	0.2	1.6	3.3	6.7	6.5	12.2	3.2	2.6	3.9
Surface Water Inflows	5.3	3.4	6.1	2.8	0.0	0.0	0.0	0.0	0.0	106.7	0.7	1.9	6.8
From East Edmond	5.3	3.4	6.1	2.8	0.0	0.0	0.0	0.0	0.0	106.7	0.7	1.9	6.8
Evapotranspiration	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0
Recharge (-) Discharge (+)	-8.8	-4.1	-6.2	0.3	3.8	0.7	-2.3	-6.2	-6.5	-26.0	-23.2	-23.0	-15.3
Surface Water Outflows	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-46.1	-0.3	-0.3	-0.1
To Center Drive	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-46.1	-0.3	-0.3	-0.1
Change in Storage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46.7	-20.2	-20.0	-6.7
Predicted WSE in ft	205.31	205.31	205.31	205.31	205.31	205.31	205.31	205.31	205.31	209.20	207.52	205.86	205.31
Observed WSE EM-1/EM-1A	209.29	209.08	207.09	205.79	205.27	205.27	205.27	206.05	208.15	208.82	208.53	208.69	208.78

Table F-15. Water Balance for West Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water — WY2007

Hydrologic Process	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Precipitation	2.1	2.2	0.4	0.0	0.8	1.6	14.4	8.6	6.5	4.5	5.7	1.7	1.1
Surface Water Inflows	4.8	3.4	0.0	0.7	0.0	0.0	111.0	13.0	8.7	9.9	20.2	1.5	1.8
From East Edmond	4.8	3.4	0.0	0.7	0.0	0.0	111.0	13.0	8.7	9.9	20.2	1.5	1.8
Evapotranspiration	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2
Recharge (-) Discharge (+)	-3.7	-1.9	4.1	3.3	1.5	-0.6	-28.1	-25.8	-23.8	-21.9	-23.2	-21.5	-5.2
Surface Water Outflows	0.0	0.0	0.0	0.0	0.0	0.0	-50.1	-0.3	-0.3	-0.2	-0.2	-0.2	-0.1
To Center Drive	0.0	0.0	0.0	0.0	0.0	0.0	-50.1	-0.3	-0.3	-0.2	-0.2	-0.2	-0.1
Change in Storage	0.0	0.0	0.0	0.0	0.0	0.0	46.7	-4.6	-9.0	-8.3	1.2	-20.5	-5.6
Predicted WSE in ft	205.31	205.31	205.31	205.31	205.31	205.31	209.20	208.82	208.07	207.38	207.48	205.77	205.31
Observed WSE EM-1/EM-1A	207.56	207.10	205.67	205.27	205.27	205.27	208.74	208.94	208.71	208.75	208.84	208.70	207.84

Table F-15. Water Balance for West Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water WY2008

Hydrologic Process	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Precipitation	2.7	1.5	1.0	1.7	5.0	2.8	7.7	4.2	3.6	4.9	1.8	1.3	1.7
Surface Water Inflows	3.6	2.9	1.9	0.8	4.7	23.5	80.7	4.3	11.5	9.6	8.4	5.0	3.7
From East Edmond	3.6	2.9	1.9	0.8	4.7	23.5	80.7	4.3	11.5	9.6	8.4	5.0	3.7
Evapotranspiration	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7
Recharge (-) Discharge (+)	-2.6	0.1	1.0	-0.2	-8.7	-25.8	-34.8	-28.2	-24.7	-23.0	-14.6	-3.1	-1.6
Surface Water Outflows	0.0	0.0	0.0	0.0	0.0	0.0	-6.9	-0.3	-0.2	-0.2	-0.1	0.0	0.0
To Center Drive	0.0	0.0	0.0	0.0	0.0	0.0	-6.9	-0.3	-0.2	-0.2	-0.1	0.0	0.0
Change in Storage	0.0	0.0	0.0	0.0	0.0	0.0	46.7	-19.9	-10.4	-10.0	-6.5	0.0	0.0
Predicted WSE in ft	205.31	205.31	205.31	205.31	205.31	205.31	209.20	207.54	206.68	205.85	205.31	205.31	205.31
Observed WSE EM-1/EM-1A	206.92	205.84	205.63	205.62	207.09	207.82	209.17	209.07	209.02	209.23	209.03	206.96	206.38

Table F-15. Water Balance for West Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water WY2009

Hydrologic Process	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Precipitation	0.9	2.1	0.5	2.6	8.3	5.2	7.3	1.6	5.3	3.5	3.4	1.3	0.0
Surface Water Inflows	2.4	0.8	0.4	0.0	29.7	11.2	21.4	1.7	41.9	3.6	9.5	5.1	0.0
From East Edmond	2.4	0.8	0.4	0.0	29.7	11.2	21.4	1.7	41.9	3.6	9.5	5.1	0.0
Evapotranspiration	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5
Recharge (-) Discharge (+)	1.2	1.1	1.4	-1.5	-26.5	-23.0	-20.5	-15.0	-27.6	-22.8	-10.0	-2.7	4.5
Surface Water Outflows	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	0.0	-0.2	0.0	0.0	0.0
To Center Drive	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	0.0	-0.2	0.0	0.0	0.0
Change in Storage	0.0	0.0	0.0	0.0	11.0	-6.8	8.1	-12.4	18.3	-17.8	-0.4	0.0	0.0
Predicted WSE in ft	205.31	205.31	205.31	205.31	206.22	205.66	206.34	205.31	206.83	205.35	205.31	205.31	205.31
Observed WSE EM-1/EM-1A	205.27	205.27		205.27	208.19	208.61	208.52	208.60	209.22	209.09	208.22	206.01	205.27

Table F-15. Water Balance for West Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water WY2010

Hydrologic Process	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Precipitation	1.9	2.8	5.6	8.9	3.0	8.0	3.3	3.3	3.3	4.6	4.3	0.4	0.2
Surface Water Inflows	1.3	0.0	0.1	69.6	2.8	14.7	12.1	1.8	11.5	28.6	4.0	0.0	0.0
From East Edmond	1.3	0.0	0.1	69.6	2.8	14.7	12.1	1.8	11.5	28.6	4.0	0.0	0.0
Evapotranspiration	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0
Recharge (-) Discharge (+)	0.8	-0.5	-4.7	-33.3	-29.2	-21.3	-21.3	-16.7	-15.5	-20.8	-13.8	4.1	3.8
Surface Water Outflows	0.0	0.0	0.0	0.0	-0.3	-0.2	-0.2	-0.2	0.0	0.0	-0.1	0.0	0.0
To Center Drive	0.0	0.0	0.0	0.0	-0.3	-0.2	-0.2	-0.2	0.0	0.0	-0.1	0.0	0.0
Change in Storage	0.0	0.0	0.0	44.8	-23.7	1.1	-6.6	-13.0	-2.6	9.2	-9.3	0.0	0.0
Predicted WSE in ft	205.31	205.31	205.31	209.04	207.07	207.16	206.61	205.53	205.31	206.08	205.31	205.31	205.31
Observed WSE EM-1/EM-1A	205.27	205.27	205.98	209.21	209.55	208.68	208.58	208.34	209.17	207.87	207.82	206.07	206.07

Table F-15. Water Balance for West Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water WY2011

Hydrologic Process	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Precipitation	4.0	4.2	6.6	7.2	6.1	3.1	7.2	5.7	4.8	2.8	0.8	0.3	1.3
Surface Water Inflows	1.6	2.7	50.6	1.0	10.9	8.8	17.6	17.8	3.1	8.1	0.0	0.0	0.0
From East Edmond	1.6	2.7	50.6	1.0	10.9	8.8	17.6	17.8	3.1	8.1	0.0	0.0	0.0
Evapotranspiration	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3
Recharge (-) Discharge (+)	-3.2	-5.8	-29.7	-21.0	-20.5	-19.0	-21.9	-22.0	-8.1	-7.1	3.7	3.7	1.0
Surface Water Outflows	0.0	0.0	0.0	-0.3	-0.2	-0.1	0.0	-0.1	-0.1	0.0	0.0	0.0	0.0
To Center Drive	0.0	0.0	0.0	-0.3	-0.2	-0.1	0.0	-0.1	-0.1	0.0	0.0	0.0	0.0
Change in Storage	0.0	0.0	27.0	-13.1	-3.7	-7.9	1.6	-0.5	-3.5	0.0	0.0	0.0	0.0
Predicted WSE in ft	205.31	205.31	207.56	206.47	206.16	205.50	205.64	205.60	205.31	205.31	205.31	205.31	205.31
Observed WSE EM-1/EM-1A	206.07	206.05	208.98	209.46	207.57		208.99	209.34	209.95		207.28	206.60	206.03

Table F-15. Water Balance for West Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water	WY2012												WY2013
Hydrologic Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Precipitation	4.1	6.1	3.2	7.2	3.9	6.8	4.3	3.1	3.3	1.6	0.0	0.1	6.5
Surface Water Inflows	0.0	23.6	28.1	27.2	7.5	21.1	10.0	11.1	7.1	6.1	4.3	0.0	1.4
From East Edmond	0.0	23.6	28.1	27.2	7.5	21.1	10.0	11.1	7.1	6.1	4.3	0.0	1.4
Evapotranspiration	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0
Recharge (-) Discharge (+)	-3.0	-28.5	-26.2	-24.0	-19.1	-22.9	-22.1	-12.2	-6.7	-3.2	-0.4	2.2	-6.9
Surface Water Outflows	0.0	0.0	0.0	-0.1	-0.2	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0
To Center Drive	0.0	0.0	0.0	-0.1	-0.2	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0
Change in Storage	0.0	0.8	5.1	10.3	-8.5	3.6	-10.0	-1.3	0.0	0.0	0.0	0.0	0.0
Predicted WSE in ft	205.31	205.38	205.80	206.66	205.95	206.24	205.41	205.31	205.31	205.31	205.31	205.31	205.31
Observed WSE EM-1/EM-1A	206.28	206.94	207.83	209.23	209.32	209.55	209.78	209.52	209.14		206.36	205.73	206.56

Table F-15. Water Balance for West Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water WY2014

Hydrologic Process	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Precipitation	6.5	7.6	3.5	1.7	3.7	5.5	4.4	1.9	0.0	1.6	6.9	2.6	4.1
Surface Water Inflows	26.3	24.2	8.1	5.7	30.5	7.8	2.7	6.9	0.0	3.4	1.8	3.8	21.7
From East Edmond	26.3	24.2	8.1	5.7	30.5	7.8	2.7	6.9	0.0	3.4	1.8	3.8	21.7
Evapotranspiration	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5
Recharge (-) Discharge (+)	-27.6	-26.2	-18.4	-10.2	-22.4	-17.5	-7.9	-5.1	4.5	-1.0	-6.4	-5.4	-21.6
Surface Water Outflows	0.0	-0.1	-0.1	0.0	0.0	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0
To Center Drive	0.0	-0.1	-0.1	0.0	0.0	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0
Change in Storage	4.7	5.5	-6.9	-3.4	10.5	-6.4	-4.1	0.0	0.0	0.0	0.0	0.0	3.7
Predicted WSE in ft	205.70	206.16	205.59	205.31	206.18	205.65	205.31	205.31	205.31	205.31	205.31	205.31	205.62
Observed WSE EM-1/EM-1A	208.21	209.83	209.07	209.27	209.37	209.44	208.41	207.37	205.95	206.06	206.17	208.73	208.72

Table F-15. Water Balance for West Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water — WY2015

Hydrologic Process	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation	2.4	4.2	6.9	9.8	4.5	3.3	1.3	1.2	1.6	1.8	5.9	6.1	4.8
Surface Water Inflows	2.6	44.7	14.5	16.3	17.2	1.9	8.0	6.1	4.2	2.6	2.4	36.7	14.4
From East Edmond	2.6	44.7	14.5	16.3	17.2	1.9	8.0	6.1	4.2	2.6	2.4	36.7	14.4
Evapotranspiration	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0
Recharge (-) Discharge (+)	-8.6	-23.6	-22.2	-24.7	-25.4	-18.6	-6.5	-2.8	-1.8	-2.1	-7.3	-22.8	-22.6
Surface Water Outflows	-0.1	0.0	-0.2	-0.2	-0.2	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	-0.2
To Center Drive	-0.1	0.0	-0.2	-0.2	-0.2	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	-0.2
Change in Storage	-3.8	25.2	-1.5	0.0	-5.9	-16.8	-1.0	0.0	0.0	0.0	0.0	19.5	-3.6
Predicted WSE in ft	205.31	207.41	207.28	207.28	206.79	205.39	205.31	205.31	205.31	205.31	205.31	206.94	206.64
Observed WSE EM-1/EM-1A	207.55	208.55	209.72	209.98	210.01	209.99	209.05	205.30	205.87	206.07	208.63	208.73	209.84

Table F-15. Water Balance for West Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water — WY2016

Hydrologic Process	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Precipitation	4.1	4.7	4.4	2.1	0.8	0.4	0.2	2.2	1.3	5.0	7.1	12.0	6.9
Surface Water Inflows	11.9	14.2	13.5	3.8	0.0	0.0	0.0	1.6	0.6	0.1	4.7	120.1	5.4
From East Edmond	11.9	14.2	13.5	3.8	0.0	0.0	0.0	1.6	0.6	0.1	4.7	120.1	5.4
Evapotranspiration	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0
Recharge (-) Discharge (+)	-18.8	-19.8	-20.8	-11.0	2.3	3.3	4.2	0.2	1.0	-4.1	-33.8	-27.9	-24.6
Surface Water Outflows	-0.2	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-97.8	-0.1
To Center Drive	-0.2	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-97.8	-0.1
Change in Storage	-3.0	-1.6	-4.3	-7.2	0.0	0.0	0.0	0.0	0.6	0.0	-22.5	6.3	-12.5
Predicted WSE in ft	206.39	206.26	205.90	205.31	205.31	205.31	205.31	205.31	205.36	205.31	205.31	209.57	206.03
Observed WSE EM-1/EM-1A	209.79	209.76	209.74	209.48	207.29	205.54	205.27	205.27	205.27	205.27	209.37	210.02	

Table F-15. Water Balance for West Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water — WY2017

Hydrologic Process	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Precipitation	5.8	5.9	1.8	1.0	2.3	1.3	0.2	1.5	9.3	6.9	3.9	3.4	8.6
Surface Water Inflows	17.6	7.4	6.3	7.4	5.3	4.8	3.1	0.5	5.8	19.6	36.2	3.4	78.2
From East Edmond	17.6	7.4	6.3	7.4	5.3	4.8	3.1	0.5	5.8	19.6	36.2	3.4	78.2
Evapotranspiration	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6
Recharge (-) Discharge (+)	-23.2	-20.3	-24.1	-17.4	-15.6	-5.5	3.8	-0.7	-10.9	-29.2	-21.4	-18.9	-14.2
Surface Water Outflows	-0.2	-0.2	0.0	0.0	-0.4	0.0	0.0	0.0	0.0	0.0	-1.3	-0.1	-29.3
To Center Drive	-0.2	-0.2	0.0	0.0	-0.4	0.0	0.0	0.0	0.0	0.0	-1.3	-0.1	-29.3
Change in Storage	-0.6	-8.5	-18.1	-12.2	-12.1	-3.9	3.1	-1.1	3.1	-3.2	17.4	-12.2	42.6
Predicted WSE in ft	207.11	205.90	205.31	205.31	205.31	205.31	205.57	205.31	205.57	205.31	209.01	205.46	209.71
Observed WSE EM-1/EM-1A					208.90	206.26	205.31		206.87	208.72	209.45	209.29	209.86

Table F-15. Water Balance for West Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water — WY2018

Hydrologic Process	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Precipitation	8.7	4.6	2.8	1.8	0.0	0.1	1.0	5.2	7.2	5.8	7.2	3.3	2.3
Surface Water Inflows	16.1	6.8	11.2	2.0	0.0	2.4	0.2	0.3	10.1	52.9	8.4	73.8	1.0
From East Edmond	16.1	6.8	11.2	2.0	0.0	2.4	0.2	0.3	10.1	52.9	8.4	73.8	1.0
Evapotranspiration	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3
Recharge (-) Discharge (+)	-15.1	-16.2	-10.9	-6.2	4.5	3.9	1.3	-4.2	-23.5	-13.5	-21.8	-18.2	-21.7
Surface Water Outflows	0.0	0.0	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-21.9	0.0
To Center Drive	0.0	0.0	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-21.9	0.0
Change in Storage	8.4	-6.7	-0.2	-6.0	0.0	2.4	0.2	0.3	-6.7	45.1	-6.2	36.4	-19.7
Predicted WSE in ft	206.21	205.31	205.58	205.31	205.31	205.51	205.33	205.33	205.31	209.13	205.31	209.69	205.31
Observed WSE EM-1/EM-1A	210.22	208.64		209.58	207.22	206.67	205.31			209.98		209.98	209.67

Table F-15. Water Balance for West Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water — WY2019

Hydrologic Process	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Precipitation	6.1	0.7	0.9	0.2	0.3	1.8	4.0	3.8	6.4	3.4	4.8	1.6	3.6
Surface Water Inflows	43.2	0.0	0.0	0.0	0.0	0.2	0.0	0.0	1.6	4.2	14.3	1.4	4.5
From East Edmond	43.2	0.0	0.0	0.0	0.0	0.2	0.0	0.0	1.6	4.2	14.3	1.4	4.5
Evapotranspiration	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0
Recharge (-) Discharge (+)	-22.3	-7.9	-4.4	-1.8	-0.7	0.6	-4.3	-28.8	-35.7	-13.6	-11.8	-25.0	-18.2
Surface Water Outflows	-0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	-0.5	0.0	0.0	-0.5
To Center Drive	-0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	-0.5	0.0	0.0	-0.5
Change in Storage	24.4	-10.5	-7.1	-6.1	-4.3	0.2	-1.4	-25.5	-28.0	-6.6	6.7	-23.4	-12.7
Predicted WSE in ft	208.28	205.31	205.31	205.31	205.31	205.32	205.31	205.31	205.31	205.61	206.15	205.31	205.31
Observed WSE EM-1/EM-1A	209.97	208.18	205.31	205.31	205.31	205.31	205.31	206.55	209.32	209.38	209.41	208.53	208.79

Table F-15. Water Balance for West Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water WY2020

Hydrologic Process	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Precipitation	1.1	0.7	1.0	0.8	3.5	3.9	1.7	6.5	9.6	4.2	3.5	1.5	3.1
Surface Water Inflows	0.0	0.0	0.8	0.0	0.0	0.0	0.0	21.4	23.9	9.3	9.7	2.8	6.4
From East Edmond	0.0	0.0	0.8	0.0	0.0	0.0	0.0	21.4	23.9	9.3	9.7	2.8	6.4
Evapotranspiration	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2
Recharge (-) Discharge (+)	-5.1	-3.9	3.5	-0.2	-3.0	-6.7	-22.9	-14.2	-15.0	-21.9	-29.6	-29.2	-16.0
Surface Water Outflows	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.0	-0.3	-0.3	-0.4	-0.9
To Center Drive	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.0	-0.3	-0.3	-0.4	-0.9
Change in Storage	-7.4	-6.9	0.8	-3.4	-1.8	-3.8	-21.7	13.6	18.5	-9.2	-17.9	-27.2	-10.5
Predicted WSE in ft	205.31	205.31	205.38	205.31	205.31	205.31	205.31	206.75	206.85	206.64	205.79	205.31	205.92
Observed WSE EM-1/EM-1A		205.31	205.31	205.31	205.31	205.31		206.97	209.81	209.35			

Table F-15. Water Balance for West Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water WY2021

Hydrologic Process	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Precipitation	2.5	0.3	0.4	2.8	3.0	5.6	5.2	7.3	4.7	2.5	1.2	2.0	2.4
Surface Water Inflows	1.8	0.0	0.0	0.4	0.9	69.3	18.5	42.5	12.5	17.7	4.3	19.2	15.4
From East Edmond	1.8	0.0	0.0	0.4	0.9	69.3	18.5	42.5	12.5	17.7	4.3	19.2	15.4
Evapotranspiration	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7
Recharge (-) Discharge (+)	-4.8	-1.9	-0.6	-3.0	-4.3	-29.4	-29.4	-19.6	-20.8	-21.0	-8.0	-0.8	1.3
Surface Water Outflows	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.2	-0.1	-0.1	-0.1	0.0	0.0
To Center Drive	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.2	-0.1	-0.1	-0.1	0.0	0.0
Change in Storage	-4.3	-6.1	-4.2	-2.1	-1.5	44.9	-5.8	30.1	-4.2	-2.1	-4.5	17.3	15.4
Predicted WSE in ft	205.31	205.31	205.31	205.31	205.31	209.05	206.46	209.14	206.04	206.08	205.52	206.75	206.59
Observed WSE EM-1/EM-1A			205.31		205.31	206.87		209.40	209.72	209.15	208.13	205.31	205.31

Table F-15. Water Balance for West Edmond Marsh with Mining - Low Groundwater

Monthly Average in Inches of Water WY2021

Hydrologic Process	Jul	Aug	Sep
Precipitation	0.0	0.3	2.6
Surface Water Inflows	2.5	2.0	4.2
From East Edmond	2.5	2.0	4.2
Evapotranspiration	-4.5	-4.0	-2.3
Recharge (-) Discharge (+)	4.5	2.1	-0.9
Surface Water Outflows	0.0	0.0	0.0
To Center Drive	0.0	0.0	0.0
Change in Storage	2.5	0.4	3.6
Predicted WSE in ft	205.52	205.34	205.61
Observed WSE EM-1/EM-1A	205.31	206.87	

Table F-16. Water Balance for Bell, McKay, and Hamer Marshes with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water	WY2004					WY2005							
Hydrologic Process	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Precipitation	2.0	1.0	3.8	0.9	0.1	3.6	2.9	4.0	3.2	4.3	4.3	0.6	4.5
Surface Water Inflows	6.3	1.5	17.0	1.4	0.0	17.4	12.3	18.7	11.7	19.0	18.4	0.3	21.4
Runoff from Ft. Lewis - Outfall 002	3.8	0.8	10.4	0.7	0.0	10.7	7.5	11.5	7.2	11.7	11.3	0.0	13.2
Runoff from Ft. Lewis - Outfall 003	2.5	0.7	6.5	0.7	0.0	6.7	4.8	7.2	4.5	7.3	7.1	0.3	8.3
Evapotranspiration	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3
Recharge (-) Discharge (+)	-2.6	-2.0	-4.3	-3.7	-3.0	-5.3	-4.8	-6.2	-6.1	-5.1	-2.2	-3.6	-7.6
Surface Water Outflows	-7.4	-2.4	-0.6	-2.3	0.0	0.0	0.0	0.0	-2.2	-10.3	-17.5	-0.9	-1.4
To Diversion Canal	-4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-7.6	-14.3	0.0	-0.6
To E. East Edmond (surface)	-2.6	-2.4	-0.6	-2.3	0.0	0.0	0.0	0.0	-2.2	-2.7	-3.2	-0.9	-0.8
Subsurface Outflows	-6.2	-4.2	-5.6	-3.5	-3.2	-4.1	-4.5	-5.7	-4.6	-5.2	-4.9	-3.9	-5.6
Change in Storage	-9.2	-8.1	7.2	-10.8	-10.6	7.6	3.6	9.8	1.5	2.7	-1.9	-8.1	10.0
Predicted WSE in feet													
Bell	218.34	217.66	218.26	217.36	216.48	217.11	217.41	218.23	218.35	218.58	218.42	217.74	218.58
McKay	216.19	215.51	216.11	215.21	214.33	214.96	215.26	216.08	216.20	216.43	216.27	215.59	216.43
Hamer	214.91	214.23	214.83	213.93	213.05	213.68	213.98	214.80	214.92	215.15	214.99	214.31	215.15
Observed WSE ('04) in feet													
Bell						216.36	217.40	217.36	217.72	218.30	219.11	217.92	216.95
McKay	216.19	215.81	214.71	214.26				213.70	213.84	214.35	215.15	214.68	213.74
Hamer	214.41	214.17	213.61	213.34	212.76	211.93	212.68	212.95	213.27	213.50	213.93	213.69	213.28

Table F-16. Water Balance for Bell, McKay, and Hamer Marshes with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water — WY2006

Hydrologic Process	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Precipitation	5.4	3.9	3.8	1.4	0.2	1.6	3.3	6.7	6.5	12.2	3.2	2.6	3.9
Surface Water Inflows	24.9	16.4	14.9	3.4	0.0	6.1	21.6	46.3	33.2	87.3	10.6	9.0	16.1
Runoff from Ft. Lewis - Outfall 002	15.3	10.1	9.2	2.0	0.0	3.6	13.2	28.3	20.3	52.6	6.5	5.5	9.9
Runoff from Ft. Lewis - Outfall 003	9.6	6.3	5.8	1.4	0.0	2.5	8.3	18.0	12.9	34.7	4.1	3.5	6.2
Evapotranspiration	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0
Recharge (-) Discharge (+)	-2.3	-3.0	-2.9	-4.2	-11.3	-9.5	-9.4	-5.9	-4.1	0.9	-1.4	-1.8	-2.8
Surface Water Outflows	-23.2	-6.8	-14.6	-1.8	0.0	0.0	0.0	-11.3	-30.9	-94.5	-10.9	-2.5	-7.4
To Diversion Canal	-20.1	-3.9	-11.4	0.0	0.0	0.0	0.0	-11.3	-27.6	-91.3	-8.0	0.0	-4.8
To E. East Edmond (surface)	-3.1	-2.9	-3.1	-1.8	0.0	0.0	0.0	0.0	-3.2	-3.2	-2.9	-2.5	-2.6
Subsurface Outflows	-4.7	-5.3	-4.1	-3.6	-1.8	-1.8	-3.7	-7.4	-4.9	-5.6	-4.4	-5.3	-5.3
Change in Storage	-1.9	1.9	-6.5	-9.3	-16.9	-5.9	10.8	27.9	-0.3	0.3	-3.5	0.9	2.6
Predicted WSE in feet													
Bell	218.42	218.58	218.04	217.26	215.85	215.36	216.26	218.58	218.56	218.58	218.29	218.36	218.58
McKay	216.27	216.43	215.89	215.11	213.70	213.57	214.47	216.79	216.77	216.79	216.50	216.57	216.79
Hamer	214.99	215.15	214.61	213.83	212.42	211.93	212.83	215.15	215.13	215.15	214.86	214.93	215.15
Observed WSE ('04) in feet													
Bell			218.33	217.05	215.63			218.25	217.95				
McKay	216.07	215.43	214.48	213.57				214.39	214.34	216.95	216.28	216.60	216.49
Hamer	214.26	214.05	213.69	213.13	212.13	211.67	211.69	213.20	213.27	214.09	213.65	214.13	214.14

Table F-16. Water Balance for Bell, McKay, and Hamer Marshes with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water — WY2007

Hydrologic Process	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Precipitation	2.1	2.2	0.4	0.0	0.8	1.6	14.4	8.6	6.5	4.5	5.7	1.7	1.1
Surface Water Inflows	6.5	6.9	0.0	0.0	1.1	6.0	153.8	50.6	33.2	17.8	27.6	4.5	2.2
Runoff from Ft. Lewis - Outfall 002	3.9	4.2	0.0	0.0	0.5	3.6	92.3	30.8	20.3	10.9	16.9	2.7	1.2
Runoff from Ft. Lewis - Outfall 003	2.5	2.7	0.0	0.0	0.6	2.4	61.5	19.8	12.9	6.9	10.7	1.8	1.0
Evapotranspiration	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2
Recharge (-) Discharge (+)	0.3	-1.0	-1.1	-1.3	-1.9	-3.7	2.7	2.7	1.1	0.2	0.9	-0.4	0.0
Surface Water Outflows	-8.2	-1.5	-0.4	0.0	0.0	0.0	-129.6	-56.2	-35.2	-16.9	-27.4	-6.2	-1.6
To Diversion Canal	-4.9	0.0	0.0	0.0	0.0	0.0	-129.6	-52.9	-32.0	-14.0	-24.2	-3.3	0.0
To E. East Edmond (surface)	-3.2	-1.5	-0.4	0.0	0.0	0.0	0.0	-3.2	-3.2	-2.9	-3.2	-2.9	-1.6
Subsurface Outflows	-4.6	-4.6	-3.8	-3.2	-3.0	-2.9	-8.8	-5.8	-5.6	-5.0	-5.6	-4.4	-4.3
Change in Storage	-7.0	-1.8	-9.4	-8.5	-5.3	0.0	32.0	0.0	0.0	0.0	0.0	-6.8	-5.9
Predicted WSE in feet													
Bell	218.00	217.85	217.06	216.36	215.91	215.91	218.58	218.58	218.58	218.58	218.58	218.02	217.53
McKay	216.20	216.06	215.27	214.57	214.12	214.12	216.79	216.79	216.79	216.79	216.79	216.23	215.74
Hamer	214.57	214.42	213.63	212.93	212.48	212.48	215.15	215.15	215.15	215.15	215.15	214.59	214.10
Observed WSE ('04) in feet													
Bell			218.46	217.75	217.19	216.57							
McKay	216.06	216.27	214.34	213.60			216.87	217.29	217.02	216.97	216.90	217.35	216.64
Hamer	214.89	214.08	213.26	212.65	212.31	212.19	214.53	215.05	214.60	214.64	214.72	214.14	214.21

Table F-16. Water Balance for Bell, McKay, and Hamer Marshes with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water WY2008

Hydrologic Process	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Precipitation	2.7	1.5	1.0	1.7	5.0	2.8	7.7	4.2	3.6	4.9	1.8	1.3	1.7
Surface Water Inflows	9.6	4.3	2.1	5.5	27.8	9.6	44.6	17.9	13.5	22.9	4.7	2.8	4.6
Runoff from Ft. Lewis - Outfall 002	5.9	2.5	1.1	3.3	17.1	5.9	27.2	11.0	8.3	14.1	2.8	1.6	2.8
Runoff from Ft. Lewis - Outfall 003	3.7	1.7	1.0	2.2	10.8	3.7	17.4	6.9	5.2	8.9	1.9	1.2	1.9
Evapotranspiration	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7
Recharge (-) Discharge (+)	-1.8	-1.3	-1.4	-1.0	-4.3	-2.9	0.4	-0.4	-0.8	-1.1	-1.1	0.3	-1.9
Surface Water Outflows	-0.1	-0.6	0.0	0.0	0.0	-10.1	-40.3	-17.1	-13.1	-17.1	-6.5	-1.5	-0.3
To Diversion Canal	0.0	0.0	0.0	0.0	0.0	-7.2	-38.5	-13.9	-10.3	-14.4	-3.5	0.0	0.0
To E. East Edmond (surface)	-0.1	-0.6	0.0	0.0	0.0	-2.9	-1.7	-3.2	-2.9	-2.7	-3.0	-1.5	-0.3
Subsurface Outflows	-4.8	-4.2	-3.8	-4.0	-6.8	-4.2	-6.1	-5.3	-4.8	-5.7	-4.3	-4.5	-4.1
Change in Storage	1.9	-4.9	-6.0	-0.1	20.7	-5.3	6.3	-0.6	-2.1	2.7	-7.3	-4.8	-3.6
Predicted WSE in feet													
Bell	217.69	217.28	216.77	216.77	218.50	218.05	218.58	218.53	218.35	218.58	217.97	217.57	217.27
McKay	215.89	215.49	214.98	214.98	216.70	216.26	216.79	216.74	216.56	216.79	216.18	215.78	215.48
Hamer	214.26	213.85	213.34	213.34	215.07	214.62	215.15	215.10	214.92	215.15	214.54	214.14	213.84
Observed WSE ('04) in feet													
Bell				218.18									
McKay	216.01	214.98	214.26	213.68	215.97	214.67	216.83	216.83	216.91	216.98	215.93	215.06	214.63
Hamer	213.85	213.68	213.29	213.04	213.88	213.81	214.52	214.47	214.43	214.52	214.23	214.75	213.55

Table F-16. Water Balance for Bell, McKay, and Hamer Marshes with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water WY2009

Hydrologic Process	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Precipitation	0.9	2.1	0.5	2.6	8.3	5.2	7.3	1.6	5.3	3.5	3.4	1.3	0.0
Surface Water Inflows	1.5	7.8	0.2	11.8	57.5	23.9	39.9	3.6	25.4	13.0	13.2	3.0	0.0
Runoff from Ft. Lewis - Outfall 002	0.8	4.7	0.0	7.2	35.0	14.7	24.4	2.2	15.6	8.0	8.1	1.7	0.0
Runoff from Ft. Lewis - Outfall 003	0.8	3.1	0.2	4.6	22.5	9.2	15.6	1.5	9.8	5.0	5.1	1.3	0.0
Evapotranspiration	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5
Recharge (-) Discharge (+)	-2.1	-3.0	-2.1	-4.3	-1.2	-2.3	-0.5	-1.7	-1.7	-1.6	-2.4	-2.6	-3.7
Surface Water Outflows	0.0	0.0	0.0	0.0	-31.7	-22.3	-40.6	-5.2	-15.5	-13.0	-2.2	-4.3	0.0
To Diversion Canal	0.0	0.0	0.0	0.0	-31.7	-19.1	-37.6	-2.6	-13.8	-9.9	0.0	-2.1	0.0
To E. East Edmond (surface)	0.0	0.0	0.0	0.0	0.0	-3.2	-3.1	-2.6	-1.7	-3.1	-2.2	-2.3	0.0
Subsurface Outflows	-3.5	-3.6	-2.8	-3.7	-7.2	-5.1	-5.4	-4.1	-5.8	-4.5	-5.4	-3.9	-3.3
Change in Storage	-7.7	-0.6	-6.5	5.3	25.3	-0.6	0.6	-6.3	6.3	-4.6	3.3	-10.2	-11.4
Predicted WSE in feet													
Bell	216.63	216.58	216.03	216.48	218.58	218.53	218.58	218.05	218.58	218.20	218.48	217.63	216.68
McKay	214.83	214.78	214.24	214.68	216.79	216.74	216.79	216.26	216.79	216.41	216.69	215.84	214.88
Hamer	213.20	213.15	212.60	213.05	215.15	215.10	215.15	214.62	215.15	214.77	215.05	214.20	213.25
Observed WSE ('04) in feet													
Bell													
McKay					216.11	214.61	216.38	215.34	216.31	215.69	215.73	214.44	
Hamer	212.98	212.63	212.51	212.39	214.37	213.94	214.42	214.08	214.34	214.18	214.24	213.49	212.68

Table F-16. Water Balance for Bell, McKay, and Hamer Marshes with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water WY2010

Hydrologic Process	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Precipitation	1.9	2.8	5.6	8.9	3.0	8.0	3.3	3.3	3.3	4.6	4.3	0.4	0.2
Surface Water Inflows	6.7	11.5	31.3	52.2	10.6	47.2	11.4	13.0	12.3	20.9	17.6	0.0	0.0
Runoff from Ft. Lewis - Outfall 002	4.0	7.1	19.2	31.7	6.5	28.8	7.0	8.0	7.5	12.9	10.8	0.0	0.0
Runoff from Ft. Lewis - Outfall 003	2.6	4.5	12.1	20.5	4.1	18.5	4.4	5.0	4.8	8.1	6.8	0.0	0.0
Evapotranspiration	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0
Recharge (-) Discharge (+)	-3.6	-4.0	-6.7	-0.5	-0.7	1.5	-0.1	-0.2	0.6	-1.0	-0.2	-1.9	-1.8
Surface Water Outflows	0.0	0.0	-1.8	-54.9	-11.2	-47.4	-11.5	-7.0	-12.4	-12.6	-16.8	-0.4	0.0
To Diversion Canal	0.0	0.0	-1.8	-51.8	-8.0	-44.9	-8.6	-4.2	-9.3	-10.0	-13.7	0.0	0.0
To E. East Edmond (surface)	0.0	0.0	0.0	-3.1	-3.2	-2.5	-2.9	-2.8	-3.1	-2.6	-3.1	-0.4	0.0
Subsurface Outflows	-3.4	-3.7	-6.4	-5.2	-4.9	-6.0	-4.7	-5.8	-5.0	-5.7	-4.8	-4.2	-3.6
Change in Storage	-2.4	4.2	21.0	0.0	-3.3	3.3	-2.2	2.2	-3.1	3.1	-3.6	-10.5	-9.1
Predicted WSE in feet													
Bell	216.48	216.83	218.58	218.58	218.31	218.58	218.40	218.58	218.32	218.58	218.28	217.40	216.64
McKay	214.69	215.04	216.79	216.79	216.52	216.79	216.61	216.79	216.53	216.79	216.49	215.61	214.84
Hamer	213.05	213.40	215.15	215.15	214.88	215.15	214.97	215.15	214.89	215.15	214.85	213.97	213.21
Observed WSE ('04) in feet													
Bell													
McKay				216.08	215.95	216.60	216.40	216.04	216.36	216.01	215.95	214.27	214.28
Hamer	212.35	212.48	213.05	214.46	214.53	214.80	214.56	214.47	214.59	214.32	214.44	213.62	213.02

Table F-16. Water Balance for Bell, McKay, and Hamer Marshes with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water WY2011

Hydrologic Process	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Precipitation	4.0	4.2	6.6	7.2	6.1	3.1	7.2	5.7	4.8	2.8	0.8	0.3	1.3
Surface Water Inflows	19.3	19.1	33.2	38.5	30.5	10.3	40.7	26.9	21.2	9.6	0.9	0.0	3.2
Runoff from Ft. Lewis - Outfall 002	11.9	11.7	20.3	23.5	18.7	6.3	24.9	16.5	13.0	5.9	0.4	0.0	1.8
Runoff from Ft. Lewis - Outfall 003	7.4	7.4	12.9	15.0	11.8	4.0	15.9	10.4	8.2	3.7	0.5	0.0	1.3
Evapotranspiration	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3
Recharge (-) Discharge (+)	-2.4	-5.3	-0.7	0.2	0.6	0.3	1.0	-1.0	0.3	-1.0	0.6	0.8	-0.2
Surface Water Outflows	0.0	-0.8	-33.4	-40.4	-31.7	-10.7	-39.5	-25.0	-19.8	-2.6	-1.7	-0.3	0.0
To Diversion Canal	0.0	0.0	-30.3	-37.2	-28.5	-7.8	-36.7	-21.9	-16.7	0.0	0.0	0.0	0.0
To E. East Edmond (surface)	0.0	-0.8	-3.1	-3.2	-3.2	-2.9	-2.8	-3.1	-3.1	-2.6	-1.7	-0.3	0.0
Subsurface Outflows	-5.4	-6.0	-5.2	-5.5	-5.5	-4.7	-5.9	-5.1	-5.2	-5.1	-4.6	-4.2	-4.0
Change in Storage	13.1	10.2	0.0	0.0	0.0	-2.3	2.3	-0.5	-2.0	-0.1	-8.5	-7.4	-2.0
Predicted WSE in feet													
Bell	217.73	218.58	218.58	218.58	218.58	218.39	218.58	218.54	218.38	218.37	217.66	217.04	216.87
McKay	215.94	216.79	216.79	216.79	216.79	216.60	216.79	216.75	216.59	216.57	215.87	215.25	215.08
Hamer	214.30	215.15	215.15	215.15	215.15	214.96	215.15	215.11	214.95	214.94	214.23	213.61	213.44
Observed WSE ('04) in feet													
Bell													
McKay	214.29	215.23	216.18	216.90	217.01	217.07	217.13						
Hamer	213.60	213.51	214.64	214.45	214.30	214.29	214.28	214.31	214.72	214.68	214.63	214.01	213.35

Table F-16. Water Balance for Bell, McKay, and Hamer Marshes with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water	WY2012												WY2013
Hydrologic Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Precipitation	4.1	6.1	3.2	7.2	3.9	6.8	4.3	3.1	3.3	1.6	0.0	0.1	6.5
Surface Water Inflows	19.5	30.7	12.2	40.0	14.7	36.8	17.5	11.6	11.9	4.3	0.0	0.0	41.1
Runoff from Ft. Lewis - Outfall 002	12.0	18.8	7.5	24.4	9.0	22.5	10.7	7.1	7.3	2.5	0.0	0.0	25.1
Runoff from Ft. Lewis - Outfall 003	7.5	11.9	4.7	15.6	5.7	14.3	6.7	4.5	4.6	1.7	0.0	0.0	16.0
Evapotranspiration	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0
Recharge (-) Discharge (+)	-3.1	-3.0	-2.1	0.6	-0.4	0.9	-0.6	-0.8	-0.2	0.2	0.8	-0.1	-3.3
Surface Water Outflows	0.0	-21.0	-12.4	-38.0	-14.3	-35.7	-16.7	-2.7	-12.1	-1.9	0.0	0.0	-12.2
To Diversion Canal	0.0	-19.4	-9.2	-35.6	-11.3	-32.8	-13.6	0.0	-9.0	0.0	0.0	0.0	-12.2
To E. East Edmond (surface)	0.0	-1.6	-3.2	-2.4	-3.0	-2.9	-3.1	-2.7	-3.1	-1.9	0.0	0.0	0.0
Subsurface Outflows	-5.7	-5.5	-4.7	-5.9	-4.9	-5.8	-4.9	-5.7	-4.5	-4.6	-4.3	-3.6	-7.2
Change in Storage	13.7	6.8	-3.8	3.8	-1.6	1.6	-2.4	2.2	-5.4	-4.9	-7.5	-5.9	23.9
Predicted WSE in feet													
Bell	218.01	218.58	218.26	218.58	218.44	218.58	218.38	218.56	218.12	217.71	217.08	216.59	218.58
McKay	216.22	216.79	216.47	216.79	216.65	216.79	216.59	216.77	216.32	215.91	215.29	214.79	216.79
Hamer	214.58	215.15	214.83	215.15	215.01	215.15	214.95	215.13	214.69	214.28	213.65	213.16	215.15
Observed WSE ('04) in feet													
Bell					219.68	219.77	219.87	219.91	219.77	219.42	219.07	218.23	218.84
McKay	214.03	214.15	214.78	215.42	215.25	215.08	214.91	214.89	215.43	215.18	214.93	213.70	214.59
Hamer	213.44	213.63	214.25	215.05	214.90	215.03	215.15	215.00	214.78	214.40	214.02	213.24	213.96

Table F-16. Water Balance for Bell, McKay, and Hamer Marshes with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water — WY2014

Hydrologic Process	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Precipitation	6.5	7.6	3.5	1.7	3.7	5.5	4.4	1.9	0.0	1.6	6.9	2.6	4.1
Surface Water Inflows	32.3	42.4	13.5	4.2	15.2	25.0	18.6	5.5	0.0	4.8	40.9	8.3	17.3
Runoff from Ft. Lewis - Outfall 002	19.7	25.8	8.3	2.5	9.3	15.3	11.4	3.3	0.0	2.8	25.0	5.0	10.6
Runoff from Ft. Lewis - Outfall 003	12.5	16.5	5.2	1.7	5.9	9.7	7.2	2.2	0.0	1.9	15.9	3.2	6.7
Evapotranspiration	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5
Recharge (-) Discharge (+)	-0.6	2.3	0.7	-0.2	-1.3	-2.6	-1.5	-1.2	-0.3	-2.3	-4.2	-0.9	-1.7
Surface Water Outflows	-32.5	-46.5	-13.5	-5.9	-1.8	-23.8	-17.6	-2.1	0.0	0.0	-8.7	-10.3	-7.2
To Diversion Canal	-29.4	-43.3	-10.2	-3.3	0.0	-20.1	-14.5	0.0	0.0	0.0	-8.7	-6.2	-4.4
To E. East Edmond (surface)	-3.1	-3.2	-3.2	-2.6	-1.8	-3.6	-3.1	-2.1	0.0	0.0	0.0	-4.1	-2.8
Subsurface Outflows	-5.2	-5.7	-5.4	-4.3	-6.2	-4.8	-4.7	-4.4	-4.1	-3.8	-7.1	-4.6	-5.9
Change in Storage	0.0	0.0	-1.2	-5.0	8.3	-2.8	-3.9	-4.1	-8.9	-3.6	25.4	-6.0	6.0
Predicted WSE in feet													
Bell	218.58	218.58	218.48	218.07	218.76	218.53	218.20	217.86	217.12	216.82	218.93	218.43	218.93
McKay	216.79	216.79	216.69	216.27	216.97	216.74	216.41	216.07	215.33	215.02	217.14	216.64	217.14
Hamer	215.15	215.15	215.05	214.64	215.33	215.10	214.77	214.43	213.69	213.39	215.50	215.00	215.50
Observed WSE ('04) in feet													
Bell	219.44	219.62	219.81	219.57	219.35	219.49	219.46	219.25	218.80	218.09	219.27	219.36	219.48
McKay	215.49	215.65	215.47	215.46	215.49	215.57	215.97	216.22	214.67	213.77	214.98	216.08	216.03
Hamer	214.68	214.86	215.05	214.97	215.11	215.07	214.61	214.57	213.93	213.35	214.07	214.78	214.76

Table F-16. Water Balance for Bell, McKay, and Hamer Marshes with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water — WY2015

Hydrologic Process	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation	2.4	4.2	6.9	9.8	4.5	3.3	1.3	1.2	1.6	1.8	5.9	6.1	4.8
Surface Water Inflows	7.4	18.1	31.8	59.6	18.3	12.5	2.7	2.5	4.5	5.8	31.7	28.1	20.8
Runoff from Ft. Lewis - Outfall 002	4.5	11.1	19.5	36.1	11.2	7.7	1.6	1.4	2.6	3.5	19.4	17.2	12.7
Runoff from Ft. Lewis - Outfall 003	2.9	7.0	12.4	23.5	7.1	4.8	1.2	1.1	1.8	2.3	12.3	10.9	8.0
Evapotranspiration	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0
Recharge (-) Discharge (+)	-2.7	-3.1	-1.1	0.5	-0.4	1.6	2.3	2.3	1.1	2.0	-0.9	-1.5	1.1
Surface Water Outflows	-9.7	-6.2	-32.2	-62.9	-18.3	-13.1	-2.6	-1.4	-0.2	0.0	-11.9	-27.1	-20.9
To Diversion Canal	-5.6	-3.5	-28.5	-58.8	-14.3	-9.5	0.0	0.0	0.0	0.0	-11.6	-23.1	-16.8
To E. East Edmond (surface)	-4.1	-2.6	-3.7	-4.1	-4.0	-3.6	-2.6	-1.4	-0.2	0.0	-0.2	-4.0	-4.1
Subsurface Outflows	-4.3	-6.1	-5.0	-5.6	-5.0	-5.2	-4.9	-4.8	-4.8	-5.3	-7.4	-5.2	-5.7
Change in Storage	-7.0	7.0	0.0	0.0	-2.8	-4.0	-5.0	-4.7	-1.9	1.9	16.4	-0.1	0.1
Predicted WSE in feet													
Bell	218.35	218.93	218.93	218.93	218.70	218.36	217.95	217.56	217.40	217.56	218.93	218.92	218.93
McKay	216.56	217.14	217.14	217.14	216.90	216.57	216.16	215.76	215.61	215.77	217.14	217.13	217.14
Hamer	214.92	215.50	215.50	215.50	215.27	214.93	214.52	214.13	213.97	214.13	215.50	215.49	215.50
Observed WSE ('04) in feet													
Bell	218.67	219.27	219.76										
McKay	215.03	215.78	216.09	215.95	216.19	215.94	215.82	215.62	215.27	215.36	215.45	215.97	216.17
Hamer	214.33	214.68	215.58	215.43			215.02	214.50	214.15	214.20	214.25	214.93	215.39

Table F-16. Water Balance for Bell, McKay, and Hamer Marshes with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water — WY2016

Hydrologic Process	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Precipitation	4.1	4.7	4.4	2.1	0.8	0.4	0.2	2.2	1.3	5.0	7.1	12.0	6.9
Surface Water Inflows	16.4	18.0	18.7	6.2	1.0	0.0	0.0	8.2	3.4	31.3	38.6	81.8	34.7
Runoff from Ft. Lewis - Outfall 002	10.1	11.1	11.5	3.8	0.5	0.0	0.0	5.0	1.9	19.2	23.6	49.3	21.2
Runoff from Ft. Lewis - Outfall 003	6.3	7.0	7.2	2.4	0.6	0.0	0.0	3.2	1.4	12.1	15.0	32.5	13.5
Evapotranspiration	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0
Recharge (-) Discharge (+)	0.4	-0.3	1.2	-0.1	1.2	0.5	1.0	-2.1	-1.5	-8.2	-0.2	1.5	0.6
Surface Water Outflows	-16.8	-17.6	-18.4	-8.2	-1.9	-0.4	0.0	0.0	0.0	0.0	-28.0	-89.6	-36.6
To Diversion Canal	-12.7	-14.2	-14.6	-4.7	0.0	0.0	0.0	0.0	0.0	0.0	-26.3	-85.5	-32.5
To E. East Edmond (surface)	-4.1	-3.4	-3.8	-3.4	-1.9	-0.4	0.0	0.0	0.0	0.0	-1.6	-4.1	-4.1
Subsurface Outflows	-5.4	-4.9	-5.6	-4.5	-4.5	-4.0	-3.6	-3.6	-3.2	-6.2	-6.4	-5.7	-5.6
Change in Storage	-1.2	-0.7	-1.0	-6.5	-6.5	-7.1	-6.8	0.8	-2.4	20.9	10.6	0.0	0.0
Predicted WSE in feet													
Bell	218.83	218.77	218.69	218.15	217.60	217.01	216.44	216.50	216.30	218.04	218.93	218.93	218.93
McKay	217.03	216.98	216.89	216.35	215.81	215.22	214.65	214.71	214.51	216.25	217.14	217.14	217.14
Hamer	215.40	215.34	215.26	214.72	214.17	213.58	213.01	213.07	212.87	214.61	215.50	215.50	215.50
Observed WSE ('04) in feet													
Bell					219.23	219.09	218.69	217.87	217.69	217.50	219.85		
McKay	216.10	215.99	215.89	215.65	215.44	214.58	213.88				215.69	216.17	
Hamer	215.29	215.29	215.29	215.26	214.68	213.91	213.36	212.70	212.67	212.64	215.55		

Table F-16. Water Balance for Bell, McKay, and Hamer Marshes with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water — WY2017

Hydrologic Process	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Precipitation	5.8	5.9	1.8	1.0	2.3	1.3	0.2	1.5	9.3	6.9	3.9	3.4	8.6
Surface Water Inflows	25.2	27.7	4.5	1.7	7.3	2.9	0.0	4.1	65.7	33.5	15.5	12.7	45.7
Runoff from Ft. Lewis - Outfall 002	15.4	17.0	2.7	0.9	4.4	1.7	0.0	2.4	39.9	20.5	9.5	7.8	27.8
Runoff from Ft. Lewis - Outfall 003	9.7	10.7	1.8	0.8	2.9	1.2	0.0	1.7	25.8	13.0	6.0	4.9	17.9
Evapotranspiration	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6
Recharge (-) Discharge (+)	0.6	0.6	1.9	3.5	2.3	2.3	1.4	1.1	-5.6	1.3	1.9	1.0	0.5
Surface Water Outflows	-25.6	-27.3	-6.3	-2.7	-1.7	-2.0	-0.2	0.0	-39.7	-35.6	-16.0	-13.6	-46.3
To Diversion Canal	-21.8	-23.2	-3.0	-1.0	0.0	0.0	0.0	0.0	-39.7	-31.7	-11.9	-9.7	-43.0
To E. East Edmond (surface)	-3.8	-4.1	-3.3	-1.7	-1.7	-2.0	-0.2	0.0	0.0	-4.0	-4.1	-4.0	-3.3
Subsurface Outflows	-5.3	-5.6	-5.1	-5.4	-5.4	-4.9	-4.5	-4.5	-7.2	-5.6	-5.7	-5.4	-5.5
Change in Storage	0.0	0.0	-5.2	-5.1	1.0	-4.9	-7.0	-0.2	21.5	0.0	-0.4	-1.9	2.4
Predicted WSE in feet													
Bell	218.93	218.93	218.50	218.07	218.15	217.74	217.15	217.14	218.93	218.93	218.89	218.73	218.93
McKay	217.14	217.14	216.71	216.28	216.36	215.95	215.36	215.35	217.14	217.14	217.10	216.94	217.14
Hamer	215.50	215.50	215.07	214.64	214.72	214.31	213.72	213.71	215.50	215.50	215.46	215.30	215.50
Observed WSE ('04) in feet													
Bell							219.47		218.88				
McKay					215.60	215.55	214.85		214.09	215.95	216.30	216.16	216.16
Hamer					212.25	214.62	213.94		213.45	215.32			

Table F-16. Water Balance for Bell, McKay, and Hamer Marshes with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water — WY2018

Hydrologic Process	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Precipitation	8.7	4.6	2.8	1.8	0.0	0.1	1.0	5.2	7.2	5.8	7.2	3.3	2.3
Surface Water Inflows	49.6	18.8	9.9	5.0	0.0	0.0	1.9	28.0	35.8	27.0	37.6	10.8	7.4
Runoff from Ft. Lewis - Outfall 002	30.1	11.6	6.1	3.0	0.0	0.0	1.0	17.2	21.9	16.6	22.9	6.6	4.5
Runoff from Ft. Lewis - Outfall 003	19.4	7.3	3.8	2.0	0.0	0.0	0.9	10.8	14.0	10.5	14.6	4.2	2.9
Evapotranspiration	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3
Recharge (-) Discharge (+)	3.0	0.9	2.2	2.8	4.0	4.8	2.8	-0.4	-0.4	2.1	1.7	1.6	3.2
Surface Water Outflows	-54.0	-18.8	-11.3	-2.7	0.0	-0.1	0.0	-3.4	-36.7	-29.1	-40.7	-11.9	-9.5
To Diversion Canal	-49.9	-14.8	-7.4	0.0	0.0	0.0	0.0	-3.4	-32.8	-25.0	-36.6	-8.2	-5.6
To E. East Edmond (surface)	-4.1	-4.0	-3.8	-2.7	0.0	-0.1	0.0	0.0	-4.0	-4.1	-4.1	-3.7	-3.8
Subsurface Outflows	-6.0	-5.3	-5.3	-5.4	-5.5	-5.3	-4.9	-7.9	-5.4	-5.8	-5.8	-5.1	-5.6
Change in Storage	0.0	-1.7	-4.8	-2.1	-6.0	-4.4	-1.5	20.5	0.0	0.0	0.0	-1.8	-3.4
Predicted WSE in feet													
Bell	218.93	218.79	218.39	218.21	217.71	217.34	217.22	218.93	218.93	218.93	218.93	218.78	218.50
McKay	217.14	217.00	216.60	216.42	215.92	215.55	215.43	217.14	217.14	217.14	217.14	216.99	216.71
Hamer	215.50	215.36	214.96	214.78	214.28	213.91	213.79	215.50	215.50	215.50	215.50	215.35	215.07
Observed WSE ('04) in feet													
Bell							219.80						
McKay	216.28	216.12		215.96	216.02	215.96	216.12			216.35		216.30	216.35
Hamer				215.45	214.76	213.95	213.83						

Table F-16. Water Balance for Bell, McKay, and Hamer Marshes with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water — WY2019

Hydrologic Process	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Precipitation	6.1	0.7	0.9	0.2	0.3	1.8	4.0	3.8	6.4	3.4	4.8	1.6	3.6
Surface Water Inflows	29.1	0.3	1.3	0.0	0.0	5.8	19.8	15.3	32.5	12.3	19.4	3.9	14.0
Runoff from Ft. Lewis - Outfall 002	17.8	0.0	0.7	0.0	0.0	3.5	12.2	9.4	19.9	7.6	11.9	2.3	8.6
Runoff from Ft. Lewis - Outfall 003	11.3	0.3	0.7	0.0	0.0	2.3	7.6	5.9	12.6	4.8	7.5	1.6	5.4
Evapotranspiration	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0
Recharge (-) Discharge (+)	0.8	1.9	2.1	2.7	1.7	1.3	-3.6	-1.8	1.1	1.0	0.1	0.9	-3.2
Surface Water Outflows	-26.8	-1.0	-1.7	-0.2	0.0	0.0	0.0	-1.2	-31.0	-13.4	-18.7	-5.5	-2.4
To Diversion Canal	-23.9	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	-27.5	-9.4	-15.4	-2.6	0.0
To E. East Edmond (surface)	-2.9	-0.7	-1.7	-0.2	0.0	0.0	0.0	-1.2	-3.6	-4.1	-3.4	-2.9	-2.4
Subsurface Outflows	-5.6	-5.4	-4.5	-4.6	-3.9	-4.3	-5.8	-6.0	-6.1	-5.4	-5.1	-5.2	-5.5
Change in Storage	1.7	-6.7	-5.6	-6.3	-5.9	2.3	13.4	9.6	2.8	-2.1	-0.1	-5.5	4.6
Predicted WSE in feet													
Bell	218.64	218.08	217.61	217.08	216.59	216.78	217.90	218.70	218.93	218.75	218.74	218.29	218.67
McKay	216.85	216.28	215.82	215.29	214.80	214.99	216.11	216.91	217.14	216.96	216.95	216.50	216.88
Hamer	215.21	214.65	214.18	213.65	213.16	213.35	214.47	215.27	215.50	215.32	215.31	214.86	215.24
Observed WSE ('04) in feet													
Bell				219.79	219.20	219.09	218.29					219.89	219.77
McKay	216.38	214.68	214.31	214.30	213.97	213.79		214.25	214.52	214.67	215.96	214.44	214.37
Hamer		215.01	214.47	214.10	213.30	213.11	212.99	213.63	214.85		215.27	214.79	214.64

Table F-16. Water Balance for Bell, McKay, and Hamer Marshes with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water — WY2020

Hydrologic Process	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Precipitation	1.1	0.7	1.0	0.8	3.5	3.9	1.7	6.5	9.6	4.2	3.5	1.5	3.1
Surface Water Inflows	2.1	0.4	2.0	1.3	18.3	18.5	4.6	36.9	57.4	15.9	13.7	3.9	12.7
Runoff from Ft. Lewis - Outfall 002	1.1	0.1	1.1	0.6	11.2	11.4	2.7	22.6	34.8	9.8	8.4	2.3	7.8
Runoff from Ft. Lewis - Outfall 003	0.9	0.3	0.9	0.7	7.1	7.2	1.9	14.3	22.6	6.1	5.3	1.6	4.9
Evapotranspiration	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2
Recharge (-) Discharge (+)	-2.2	-1.5	-2.3	-2.8	-4.2	-2.9	-2.3	-6.4	1.5	-0.8	-3.0	-1.7	-2.7
Surface Water Outflows	-3.2	-1.0	0.0	0.0	0.0	0.0	-1.3	-16.3	-61.6	-16.2	-13.9	-2.0	-0.9
To Diversion Canal	-1.2	0.0	0.0	0.0	0.0	0.0	0.0	-15.5	-57.5	-12.3	-10.4	0.0	0.0
To E. East Edmond (surface)	-2.0	-1.0	0.0	0.0	0.0	0.0	-1.3	-0.8	-4.1	-3.8	-3.5	-2.0	-0.9
Subsurface Outflows	-4.3	-3.6	-3.4	-2.7	-4.2	-5.6	-4.4	-6.5	-6.8	-5.7	-5.2	-4.7	-5.5
Change in Storage	-9.7	-8.8	-7.1	-7.3	11.0	13.0	-2.1	14.2	0.0	-3.0	-6.2	-4.9	3.6
Predicted WSE in feet													
Bell	217.86	217.12	216.53	215.92	216.84	217.92	217.75	218.93	218.93	218.68	218.16	217.75	218.05
McKay	216.07	215.33	214.74	214.13	215.05	216.13	215.95	217.14	217.14	216.89	216.37	215.96	216.26
Hamer	214.43	213.69	213.10	212.49	213.41	214.49	214.32	215.50	215.50	215.25	214.73	214.32	214.62
Observed WSE ('04) in feet													
Bell		218.58	217.47	216.86		218.20				219.71			
McKay		213.99			214.92			213.72	215.28	214.65			
Hamer		213.47	212.68		212.25			213.55	215.55	215.03			

Table F-16. Water Balance for Bell, McKay, and Hamer Marshes with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water WY2021

Hydrologic Process	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Precipitation	2.5	0.3	0.4	2.8	3.0	5.6	5.2	7.3	4.7	2.5	1.2	2.0	2.4
Surface Water Inflows	8.1	0.0	0.0	12.9	13.1	29.6	23.4	39.7	18.2	8.0	2.4	6.4	8.5
Runoff from Ft. Lewis - Outfall 002	4.9	0.0	0.0	7.9	8.0	18.1	14.3	24.3	11.2	4.9	1.3	3.9	5.2
Runoff from Ft. Lewis - Outfall 003	3.2	0.0	0.0	5.0	5.1	11.5	9.0	15.5	7.0	3.1	1.0	2.5	3.3
Evapotranspiration	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7
Recharge (-) Discharge (+)	-2.2	-3.0	-3.6	-3.9	-3.9	-5.1	-2.0	-0.3	0.0	2.0	0.3	0.1	-1.6
Surface Water Outflows	-1.7	-0.3	0.0	0.0	0.0	-1.4	-22.8	-37.7	-18.0	-9.8	-3.5	-1.2	-0.9
To Diversion Canal	0.0	0.0	0.0	0.0	0.0	-1.4	-18.7	-34.0	-14.3	-6.0	-1.6	0.0	0.0
To E. East Edmond (surface)	-1.7	-0.3	0.0	0.0	0.0	0.0	-4.1	-3.7	-3.7	-3.8	-2.0	-1.2	-0.9
Subsurface Outflows	-4.9	-3.6	-2.7	-3.8	-4.4	-7.0	-6.0	-6.8	-5.8	-6.0	-5.1	-5.2	-5.0
Change in Storage	-1.8	-11.1	-10.0	5.6	6.7	21.1	-2.2	2.2	-1.4	-4.5	-6.8	-1.0	-0.3
Predicted WSE in feet													
Bell	217.90	216.98	216.15	216.61	217.17	218.93	218.75	218.93	218.81	218.44	217.87	217.79	217.76
McKay	216.11	215.19	214.36	214.82	215.38	217.14	216.95	217.14	217.02	216.64	216.08	216.00	215.97
Hamer	214.47	213.55	212.72	213.18	213.74	215.50	215.32	215.50	215.38	215.01	214.44	214.36	214.33
Observed WSE ('04) in feet													
Bell					217.23			219.68			219.71	219.41	218.99
McKay						213.87		214.86	214.88	215.59	214.57	214.46	214.38
Hamer						213.15		215.23	215.30	214.89	214.51	214.01	213.58

Table F-16. Water Balance for Bell, McKay, and Hamer Marshes with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water	WY2021		
Hydrologic Process	Jul	Aug	Sep
Precipitation	0.0	0.3	2.6
Surface Water Inflows	0.0	0.0	11.5
Runoff from Ft. Lewis - Outfall 002	0.0	0.0	7.0
Runoff from Ft. Lewis - Outfall 003	0.0	0.0	4.5
Evapotranspiration	-4.5	-4.0	-2.3
Recharge (-) Discharge (+)	-1.8	-2.7	-4.2
Surface Water Outflows	0.0	0.0	0.0
To Diversion Canal	0.0	0.0	0.0
To E. East Edmond (surface)	0.0	0.0	0.0
Subsurface Outflows	-3.8	-2.8	-3.6
Change in Storage	-10.1	-9.2	3.9
Predicted WSE in feet			
Bell	216.92	216.15	216.48
McKay	215.13	214.36	214.69
Hamer	213.49	212.72	213.05
Observed WSE ('04) in feet			
Bell	218.05		
McKay		213.27	
Hamer	212.68	212.25	

Table F-17. Water Balance for East Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water	WY2004						WY2005						
Hydrologic Process	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Precipitation	2.0	1.0	3.8	0.9	0.1	3.6	2.9	4.0	3.2	4.3	4.3	0.6	4.5
Surface Water Inflows	122.8	107.4	68.2	30.6	7.8	4.7	17.0	28.7	62.7	10.4	16.9	21.3	30.4
From Sequalitchew Lake	118.6	103.4	67.1	26.8	7.8	4.4	16.8	28.4	58.9	5.7	11.1	19.9	28.8
From Center Drive	0.1	0.0	0.2	0.0	0.0	0.2	0.2	0.3	0.2	0.3	0.3	0.0	0.3
From Hamer (surface)	4.1	4.0	0.9	3.8	0.0	0.0	0.0	0.0	3.6	4.4	5.5	1.5	1.3
Subsurface Inflows	9.7	6.8	8.7	5.7	4.7	5.7	6.3	8.4	7.6	8.5	8.3	6.4	8.8
Evapotranspiration	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3
Recharge (-) Discharge (+)	*16.4*	*12.9*	*13.9*	*11.2*	*12.1*	*10.2*	*11.5*	*13.6*	*11.1*	*12.8*	*12.9*	*12.4*	*12.3*
Surface Water Outflows	-106.4	-99.8	-75.7	-31.1	-17.6	-14.9	-26.0	-40.8	-64.2	-25.9	-30.9	-32.9	-42.0
To Diversion Canal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
To West Edmond Marsh	-129.8	-116.3	-88.3	-36.3	-20.5	-17.4	-30.4	-47.5	-74.9	-30.2	-36.0	-38.4	-49.0
Change in Storage	19.9	9.8	3.2	8.5	-0.4	2.9	5.0	6.1	9.2	5.8	6.4	1.8	5.7
Predicted WSE in ft													
EM-2S	209.00	209.49	209.68	210.07	210.04	210.28	210.70	211.21	211.67	211.78	211.86	211.89	212.26
East Edmond	209.00	209.33	209.07	209.31	209.00	209.00	209.00	209.00	209.30	209.36	209.46	209.12	209.11
Eastern East Edmond Marsh	209.00	209.33	209.20	209.44	209.20	209.20	209.20	209.20	209.50	209.56	209.66	209.32	209.31
Observed WSE in ft													
EM-2S	210.72	210.74	210.76	210.70	210.40	209.82	209.92	210.33	210.61	210.76	210.86	210.79	210.64
East Edmond (EM-2E)	212.62	212.50	212.35	212.25	211.85	211.43	211.43	211.80	212.12	212.31	212.47	212.40	212.19
East Edmond (EM-2W)	211.15	211.15	211.22	211.20	210.91	210.32	210.41	210.80	211.08	211.20	211.26	211.24	211.09
East Edmond (EM-3E)	212.42	212.29	212.14	212.04	211.69	211.07	211.43	211.70	211.93	212.09	212.15	212.17	211.97
East Edmond (EM-3W)	212.42	212.29	212.15	212.04	211.70	211.10	211.57	211.70	211.94	212.04	212.26	212.20	211.98
Eastern East Edmond (SCM-1)	212.39	212.26	212.09	211.98	211.58	210.96	211.20	211.63	211.84	212.08	212.27	212.17	211.95

Table F-17. Water Balance for East Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water — WY2006

Hydrologic Process	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Precipitation	5.4	3.9	3.8	1.4	0.2	1.6	3.3	6.7	6.5	12.2	3.2	2.6	3.9
Surface Water Inflows	80.4	57.0	55.6	9.9	0.0	0.1	0.2	0.4	24.4	198.6	213.5	191.7	168.6
From Sequalitchew Lake	74.7	52.0	50.1	7.1	0.0	0.0	0.0	0.0	18.5	192.3	208.4	187.5	164.1
From Center Drive	0.4	0.3	0.2	0.1	0.0	0.1	0.2	0.4	0.4	0.9	0.2	0.2	0.2
From Hamer (surface)	5.3	4.7	5.3	2.8	0.0	0.0	0.0	0.0	5.5	5.4	5.0	4.0	4.3
Subsurface Inflows	8.0	8.8	7.0	5.7	2.6	2.1	3.6	9.3	8.4	9.5	7.5	8.6	8.7
Evapotranspiration	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0
Recharge (-) Discharge (+)	*12.8*	*12.9*	*13.4*	*11.2*	*8.3*	*4.4*	*5.2*	*11.3*	*10.1*	*15.6*	*12.3*	*13.6*	*13.4*
Surface Water Outflows	-81.8	-64.0	-60.2	-19.3	-7.2	-4.3	-8.3	-20.0	-33.2	-197.9	-198.1	-180.7	-160.4
To Diversion Canal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
To West Edmond Marsh	-95.3	-74.6	-70.2	-22.5	-8.4	-5.0	-9.7	-23.3	-38.7	-230.6	-231.0	-210.7	-187.0
Change in Storage	9.3	4.8	5.9	1.2	-1.4	0.8	1.6	3.9	10.8	5.2	4.9	4.5	5.7
Predicted WSE in ft													
EM-2S	212.59	212.60	212.65	212.51	212.40	212.47	212.60	212.92	213.36	213.35	213.34	213.38	213.50
East Edmond	209.44	209.39	209.44	209.23	209.00	209.00	209.00	209.00	209.46	209.45	209.41	209.34	209.35
Eastern East Edmond Marsh	209.64	209.59	209.64	209.43	209.20	209.20	209.20	209.20	209.66	209.65	209.61	209.54	209.55
Observed WSE in ft													
EM-2S	210.94	210.90	210.69	210.42	209.82	209.15	209.21	210.48	210.71	210.98	210.88	210.58	210.57
East Edmond (EM-2E)	212.55	212.63	212.47	212.13	211.43	211.43	211.43	211.89	212.22	212.63	212.62	212.51	212.55
East Edmond (EM-2W)	211.28	211.32	211.14	210.88	210.28	209.64	209.67	210.87	211.12	211.31	211.25	210.92	210.89
East Edmond (EM-3E)	212.32	212.40	212.26	211.92	211.13			211.78	212.02	212.42	212.37	212.27	212.30
East Edmond (EM-3W)	212.50	212.41	212.25	211.92	211.15	210.44	210.58	211.75	212.02	212.42	212.38	212.26	212.29
Eastern East Edmond (SCM-1)	212.25	212.43	212.29	211.88	211.08	210.95	210.57	211.69	211.99	212.58	212.47	212.20	212.32

Table F-17. Water Balance for East Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water — WY2007

Hydrologic Process	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Precipitation	2.1	2.2	0.4	0.0	0.8	1.6	14.4	8.6	6.5	4.5	5.7	1.7	1.1
Surface Water Inflows	120.0	110.7	76.7	42.2	14.1	16.7	127.0	203.1	297.3	232.0	365.1	345.6	177.5
From Sequalitchew Lake	114.4	108.1	76.1	42.2	14.1	16.6	126.0	197.0	291.4	226.8	359.2	340.5	174.8
From Center Drive	0.1	0.1	0.0	0.0	0.0	0.1	1.0	0.6	0.4	0.3	0.4	0.1	0.0
From Hamer (surface)	5.5	2.5	0.6	0.0	0.0	0.0	0.0	5.5	5.5	5.0	5.5	4.9	2.7
Subsurface Inflows	7.8	7.5	6.2	4.8	3.8	3.6	10.8	9.9	9.5	8.5	9.5	7.5	7.1
Evapotranspiration	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2
Recharge (-) Discharge (+)	*12.3*	*14.3*	*12.5*	*13.6*	*10.5*	*10.6*	*17.2*	*18.2*	*15.3*	*14.6*	*16.8*	*13.5*	*13.5*
Surface Water Outflows	-113.6	-110.1	-74.9	-43.9	-19.7	-23.2	-139.8	-196.4	-277.4	-218.2	-334.6	-310.2	-165.3
To Diversion Canal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
To West Edmond Marsh	-132.5	-128.3	-87.3	-51.1	-23.0	-27.1	-162.9	-228.9	-323.3	-254.3	-390.1	-361.6	-192.6
Change in Storage	6.5	2.7	4.1	5.5	3.8	4.5	6.1	10.8	5.3	4.8	5.8	4.8	3.4
Predicted WSE in ft													
EM-2S	213.59	213.60	213.90	214.35	214.67	215.04	215.55	215.99	215.97	215.95	215.98	215.97	216.03
East Edmond	209.46	209.21	209.05	209.00	209.00	209.00	209.00	209.46	209.46	209.41	209.46	209.41	209.22
Eastern East Edmond Marsh	209.66	209.41	209.25	209.20	209.20	209.20	209.20	209.66	209.66	209.61	209.66	209.61	209.42
Observed WSE in ft													
EM-2S	210.71	210.85	210.62	210.36	210.21	210.06	211.03	211.01	210.90	210.87	210.83	210.79	210.82
East Edmond (EM-2E)	212.55	212.63	212.53	211.36	211.43	211.65	211.87	211.94	211.78	211.79	211.80	211.65	211.73
East Edmond (EM-2W)	211.08	211.28	211.06	210.74	210.64	210.49	211.37	211.37	211.26	211.26	211.22	211.15	211.24
East Edmond (EM-3E)	212.28	212.39	212.04	211.75	211.51	211.32	212.52	212.61	212.44	212.46	212.43	212.30	212.37
East Edmond (EM-3W)	212.27	212.40	212.03	211.75	211.50	211.31	212.51	212.60	212.42	212.42	212.42	212.29	212.36
Eastern East Edmond (SCM-1)	212.26	212.46	211.97	211.70	211.38	211.33	212.58	212.67	212.49	212.48	212.49	212.29	212.44

Table F-17. Water Balance for East Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water — WY2008

Hydrologic Process	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Precipitation	2.7	1.5	1.0	1.7	5.0	2.8	7.7	4.2	3.6	4.9	1.8	1.3	1.7
Surface Water Inflows	79.0	7.6	110.7	90.8	63.2	81.4	139.0	150.2	137.5	124.1	127.7	86.7	52.3
From Sequalitchew Lake	78.6	6.5	110.6	90.8	62.9	76.3	135.6	144.4	132.4	119.4	122.6	84.2	51.8
From Center Drive	0.2	0.1	0.0	0.1	0.3	0.2	0.5	0.3	0.2	0.3	0.1	0.1	0.1
From Hamer (surface)	0.2	1.0	0.0	0.0	0.0	4.9	2.9	5.5	4.9	4.3	5.0	2.4	0.4
Subsurface Inflows	7.4	6.6	5.6	5.5	9.5	7.1	10.0	9.0	8.1	9.3	7.2	7.3	6.4
Evapotranspiration	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7
Recharge (-) Discharge (+)	*13.9*	*15.3*	*13.6*	*12.4*	*15.0*	*11.9*	*16.4*	*14.6*	*13.2*	*15.2*	*12.7*	*13.0*	*13.6*
Surface Water Outflows	-82.1	-18.9	-104.6	-87.5	-73.5	-79.3	-145.3	-146.0	-134.7	-126.3	-121.3	-87.5	-56.8
To Diversion Canal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
To West Edmond Marsh	-95.7	-22.1	-121.9	-102.0	-85.6	-92.5	-169.4	-170.1	-157.0	-147.3	-141.5	-102.0	-66.2
Change in Storage	3.6	4.5	5.1	6.1	6.1	10.3	3.6	7.9	4.8	4.9	6.0	3.1	4.0
Predicted WSE in ft													
EM-2S	216.31	216.60	217.02	217.52	218.03	218.47	218.53	218.74	218.72	218.77	218.85	218.91	219.21
East Edmond	209.02	209.08	209.00	209.00	209.00	209.41	209.24	209.46	209.41	209.36	209.42	209.20	209.03
Eastern East Edmond Marsh	209.22	209.28	209.20	209.20	209.20	209.61	209.44	209.66	209.61	209.56	209.62	209.40	209.23
Observed WSE in ft													
EM-2S	210.87	210.86	210.68	210.52	210.85	210.93	211.00	210.98	210.95	210.94	210.83	210.79	210.70
East Edmond (EM-2E)	211.66	211.60	211.45	211.27	211.66	211.77	211.92	211.86	211.80	211.86	211.68	211.69	211.63
East Edmond (EM-2W)	211.30	211.28	211.11	210.95	211.29	211.32	211.37	211.35	211.34	211.32	211.28	211.21	211.15
East Edmond (EM-3E)	212.31	212.23	212.09	211.93	212.32	212.40	212.56	212.50	212.44	212.50	212.37	212.33	212.27
East Edmond (EM-3W)	212.29	212.24	212.09	211.91	212.31	212.40	212.54	212.49	212.43	212.49	212.35	212.33	212.25
Eastern East Edmond (SCM-1)	212.35	212.29	212.13	212.06	212.38	212.48	212.63	212.58	212.52	212.55	212.43	212.39	212.32

Table F-17. Water Balance for East Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water WY2009

Hydrologic Process	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Precipitation	0.9	2.1	0.5	2.6	8.3	5.2	7.3	1.6	5.3	3.5	3.4	1.3	0.0
Surface Water Inflows	14.1	31.9	17.2	5.3	56.4	39.0	193.9	90.2	117.1	118.6	106.8	71.7	43.2
From Sequalitchew Lake	14.1	31.7	17.2	5.1	55.8	33.2	188.2	85.8	113.9	113.1	103.0	67.9	43.1
From Center Drive	0.0	0.1	0.0	0.2	0.6	0.3	0.5	0.1	0.4	0.2	0.2	0.1	0.0
From Hamer (surface)	0.0	0.0	0.0	0.0	0.0	5.5	5.2	4.4	2.8	5.3	3.6	3.8	0.0
Subsurface Inflows	5.2	5.0	3.9	4.6	10.0	8.7	9.2	7.0	9.5	7.7	8.9	6.4	5.1
Evapotranspiration	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5
Recharge (-) Discharge (+)	*12.9*	*13.6*	*12.1*	*11.1*	*15.1*	*12.8*	*14.7*	*11.6*	*14.5*	*12.3*	*13.4*	*11.5*	*12.0*
Surface Water Outflows	-21.3	-36.4	-23.1	-16.6	-71.4	-47.1	-188.8	-90.2	-120.9	-113.5	-107.6	-69.9	-45.9
To Diversion Canal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
To West Edmond Marsh	-24.8	-42.5	-26.9	-19.3	-83.3	-54.9	-220.1	-105.2	-141.0	-132.3	-125.5	-81.5	-53.5
Change in Storage	3.7	6.1	4.5	3.2	6.1	10.8	5.0	4.6	4.1	7.8	3.8	5.7	2.3
Predicted WSE in ft													
EM-2S	219.52	220.02	220.39	220.66	221.16	221.60	221.59	221.60	221.71	221.91	221.93	222.09	222.28
East Edmond	209.00	209.00	209.00	209.00	209.00	209.46	209.44	209.37	209.24	209.44	209.30	209.31	209.00
Eastern East Edmond Marsh	209.20	209.20	209.20	209.20	209.20	209.66	209.64	209.57	209.44	209.64	209.50	209.51	209.20
Observed WSE in ft													
EM-2S	210.43	210.28	210.14	210.00	210.90	210.97	210.95	210.92	210.89	210.87	210.93	210.61	210.18
East Edmond (EM-2E)	211.43	211.43	211.43	211.43	211.72	211.81	211.81	211.76	211.54	211.44	211.72	211.43	211.43
East Edmond (EM-2W)	210.88	210.70	210.56	210.41	211.31	211.34	211.33	211.30	211.36	211.36	211.37	211.04	210.58
East Edmond (EM-3E)	211.92	211.63	211.47	211.30	212.41	212.42	212.44	212.39	212.25	212.31	212.38	211.93	211.59
East Edmond (EM-3W)	211.92	211.67	211.50	211.33	212.32	212.40	212.43	212.37	212.25	212.29	212.36	211.94	211.67
Eastern East Edmond (SCM-1)	211.96	211.71	211.54	211.38	212.39	212.48	212.53	212.47	212.33	212.37	212.44	211.94	211.51

Table F-17. Water Balance for East Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water WY2010

Hydrologic Process	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Precipitation	1.9	2.8	5.6	8.9	3.0	8.0	3.3	3.3	3.3	4.6	4.3	0.4	0.2
Surface Water Inflows	33.8	27.4	42.2	103.9	96.9	161.8	140.9	173.0	242.7	176.3	150.9	88.3	50.7
From Sequalitchew Lake	33.7	27.3	41.8	98.0	91.3	157.1	135.7	168.2	237.2	171.8	145.3	87.7	50.7
From Center Drive	0.1	0.2	0.4	0.6	0.2	0.6	0.2	0.2	0.2	0.3	0.3	0.0	0.0
From Hamer (surface)	0.0	0.0	0.0	5.3	5.5	4.1	5.0	4.6	5.3	4.2	5.3	0.6	0.0
Subsurface Inflows	4.7	5.2	9.3	8.9	8.4	9.9	8.0	9.5	8.4	9.4	8.1	6.9	5.3
Evapotranspiration	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0
Recharge (-) Discharge (+)	*11.3*	*11.1*	*13.0*	*13.3*	*13.0*	*15.4*	*11.9*	*13.6*	*13.2*	*13.8*	*12.7*	*13.7*	*12.8*
Surface Water Outflows	-35.7	-32.6	-54.1	-106.3	-99.3	-163.9	-135.0	-165.7	-222.8	-168.6	-142.3	-88.8	-51.0
To Diversion Canal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
To West Edmond Marsh	-41.6	-38.1	-63.0	-123.9	-115.8	-191.0	-157.4	-193.1	-259.7	-196.6	-165.9	-103.5	-59.5
Change in Storage	6.0	6.1	6.1	10.6	5.5	4.1	6.2	5.0	6.0	4.3	6.4	1.3	5.4
Predicted WSE in ft													
EM-2S	222.79	223.29	223.79	224.24	224.23	224.23	224.33	224.37	224.43	224.44	224.53	224.58	225.03
East Edmond	209.00	209.00	209.00	209.44	209.46	209.34	209.41	209.38	209.44	209.35	209.44	209.05	209.00
Eastern East Edmond Marsh	209.20	209.20	209.20	209.64	209.66	209.54	209.61	209.58	209.64	209.55	209.64	209.25	209.20
Observed WSE in ft													
EM-2S	210.12	210.11	210.47	211.06	211.04	211.03	211.03	210.86	211.15	211.13	211.10	210.88	210.61
East Edmond (EM-2E)	211.43	211.43	211.43	211.75	211.52	211.58	211.64	211.90	211.59	212.04	211.93	211.73	211.43
East Edmond (EM-2W)	210.51	210.52	210.90	211.41	211.41	211.39	211.40	211.24	211.58	211.54	211.52	211.36	211.03
East Edmond (EM-3E)	211.49	211.46	211.74	212.41	212.33	212.49	212.38	212.42	212.43	212.55	212.48	212.25	211.93
East Edmond (EM-3W)	211.48	211.46	211.72	212.31	212.25	212.27	212.22	212.39	212.25	212.54	212.44	212.25	211.96
Eastern East Edmond (SCM-1)	211.45	211.46	211.78	212.48	212.40	212.57	212.45	212.49	212.52	212.62	212.55	212.24	211.87

Table F-17. Water Balance for East Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water WY2011

Hydrologic Process	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Precipitation	4.0	4.2	6.6	7.2	6.1	3.1	7.2	5.7	4.8	2.8	0.8	0.3	1.3
Surface Water Inflows	67.0	80.3	116.7	149.7	324.2	289.4	378.5	398.4	313.8	183.8	89.8	42.2	26.7
From Sequalitchew Lake	66.8	78.8	110.9	143.7	318.2	284.3	373.5	392.7	308.2	179.3	87.1	41.8	26.7
From Center Drive	0.2	0.3	0.4	0.5	0.4	0.2	0.5	0.4	0.3	0.2	0.0	0.0	0.1
From Hamer (surface)	0.0	1.2	5.3	5.5	5.5	5.0	4.5	5.3	5.3	4.3	2.8	0.4	0.0
Subsurface Inflows	7.5	9.3	8.9	9.3	9.4	8.1	9.7	8.7	8.8	8.4	7.5	6.5	5.9
Evapotranspiration	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3
Recharge (-) Discharge (+)	*13.7*	*13.5*	*13.1*	*15.0*	*15.1*	*14.1*	*16.1*	*14.9*	*15.2*	*14.0*	*-17.5*	*14.1*	*12.5*
Surface Water Outflows	-71.9	-85.0	-116.1	-150.7	-303.2	-268.7	-351.0	-363.3	-289.9	-175.5	-65.1	-50.8	-36.3
To Diversion Canal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
To West Edmond Marsh	-83.8	-99.1	-135.4	-175.6	-353.4	-313.2	-409.1	-423.5	-337.9	-204.6	-75.9	-59.3	-42.3
Change in Storage	6.1	7.1	9.4	5.5	1.4	1.0	1.1	2.3	1.4	0.6	0.2	-0.2	1.8
Predicted WSE in ft													
EM-2S	225.54	226.03	226.37	226.36	226.02	225.69	225.41	225.15	224.83	224.52	224.31	224.26	224.41
East Edmond	209.00	209.10	209.44	209.46	209.46	209.41	209.38	209.44	209.44	209.36	209.23	209.03	209.00
Eastern East Edmond Marsh	209.20	209.30	209.64	209.66	209.66	209.61	209.58	209.64	209.64	209.56	209.43	209.23	209.20
Observed WSE in ft													
EM-2S	211.01	211.05	211.33	211.43	211.30	211.27	211.25	211.27	211.30	211.22	206.59	211.06	210.85
East Edmond (EM-2E)	211.73	211.75	211.95	212.18	212.13	212.20	212.27	212.30	212.37			212.01	211.69
East Edmond (EM-2W)	211.46	211.48	211.73	211.78	211.68	211.65	211.61	211.58	211.68			211.48	211.33
East Edmond (EM-3E)	212.23	212.37	212.59	212.73	212.73	212.73	212.73	212.76	212.88			212.49	212.06
East Edmond (EM-3W)	212.23	212.25	212.43	212.70	212.63	212.69	212.75	212.77	212.85			212.50	212.18
Eastern East Edmond (SCM-1)	212.28	212.32	212.67	212.81	212.78	212.79	212.80	212.83	212.95			212.58	212.26

Table F-17. Water Balance for East Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water	WY2012												WY2013
Hydrologic Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Precipitation	4.1	6.1	3.2	7.2	3.9	6.8	4.3	3.1	3.3	1.6	0.0	0.1	6.5
Surface Water Inflows	88.0	93.1	97.8	135.3	183.3	253.6	325.7	303.6	150.3	94.5	25.2	2.5	42.1
From Sequalitchew Lake	87.8	90.1	92.1	130.9	177.9	248.3	320.1	299.0	144.9	91.3	25.2	2.5	41.6
From Center Drive	0.3	0.4	0.2	0.5	0.2	0.5	0.3	0.2	0.2	0.1	0.0	0.0	0.5
From Hamer (surface)	0.0	2.6	5.5	3.9	5.1	4.8	5.3	4.5	5.3	3.2	0.0	0.0	0.0
Subsurface Inflows	8.4	9.1	8.0	9.8	8.4	9.6	8.3	9.3	7.7	7.5	6.7	5.3	10.0
Evapotranspiration	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0
Recharge (-) Discharge (+)	*14.0*	*13.2*	*12.6*	*16.8*	*14.1*	*16.3*	*16.2*	*15.3*	*13.7*	*14.6*	*15.4*	*12.6*	*14.8*
Surface Water Outflows	-95.4	-100.0	-100.6	-144.9	-177.0	-243.5	-300.8	-280.8	-145.1	-97.8	-38.0	-13.6	-60.2
To Diversion Canal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
To West Edmond Marsh	-111.3	-116.5	-117.3	-169.0	-206.3	-283.8	-350.6	-327.4	-169.1	-114.0	-44.3	-15.9	-70.2
Change in Storage	2.2	4.4	4.4	0.1	2.7	1.2	2.0	0.7	2.2	-0.3	-0.9	2.2	2.2
Predicted WSE in ft													
EM-2S	224.60	224.75	224.66	224.34	224.14	223.84	223.56	223.24	222.99	222.70	222.62	222.81	222.99
East Edmond	209.00	209.21	209.46	209.33	209.43	209.40	209.44	209.37	209.44	209.26	209.00	209.00	209.00
Eastern East Edmond Marsh	209.20	209.41	209.66	209.53	209.63	209.60	209.64	209.57	209.64	209.46	209.20	209.20	209.20
Observed WSE in ft													
EM-2S	210.97	211.29	211.31	211.37	211.36	211.38	211.40	211.41	211.36	211.25	211.14	210.84	211.08
East Edmond (EM-2E)	211.83	212.03	212.25	212.50	212.52	212.55	212.57	212.63	212.54	212.34	212.13	211.72	212.01
East Edmond (EM-2W)	211.40	211.67	211.71	211.72	211.75	211.76	211.77	211.78	211.75	211.65	211.55	211.31	211.50
East Edmond (EM-3E)	212.19	212.38	212.61	212.85	212.88	212.92	212.95	213.00	212.91	212.70	212.50	212.09	212.37
East Edmond (EM-3W)	212.29	212.50	212.73	212.98	212.99	213.02	213.05	213.11	213.03	212.82	212.61	212.20	212.48
Eastern East Edmond (SCM-1)	212.40	212.59	212.85	213.10	213.12	213.15	213.18	213.35	213.17	212.95	212.74	212.21	212.55

Table F-17. Water Balance for East Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water WY2014

Hydrologic Process	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Precipitation	6.5	7.6	3.5	1.7	3.7	5.5	4.4	1.9	0.0	1.6	6.9	2.6	4.1
Surface Water Inflows	102.5	188.3	229.0	150.9	185.0	180.6	142.3	95.8	43.0	35.1	26.6	88.0	81.6
From Sequalitchew Lake	96.7	182.3	223.3	146.3	181.9	174.0	136.7	92.3	43.0	35.1	26.2	80.6	76.8
From Center Drive	0.4	0.5	0.2	0.1	0.2	0.4	0.3	0.1	0.0	0.1	0.5	0.2	0.3
From Hamer (surface)	5.3	5.5	5.5	4.5	2.9	6.2	5.3	3.5	0.0	0.0	0.0	7.3	4.6
Subsurface Inflows	8.9	9.7	9.1	7.3	10.1	8.1	8.0	7.3	6.6	5.6	10.5	8.2	9.7
Evapotranspiration	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5
Recharge (-) Discharge (+)	*13.4*	*16.8*	*15.6*	*13.9*	*16.7*	*14.3*	*13.9*	*13.6*	*15.6*	*13.8*	*15.7*	*13.1*	*14.0*
Surface Water Outflows	-106.3	-189.5	-219.4	-148.1	-183.6	-173.1	-141.4	-98.6	-53.2	-42.9	-47.3	-87.9	-94.5
To Diversion Canal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
To West Edmond Marsh	-123.9	-220.9	-255.7	-172.7	-214.0	-201.8	-164.8	-115.0	-62.0	-50.0	-55.1	-102.5	-110.1
Change in Storage	6.8	1.6	1.4	0.5	0.3	4.6	0.5	0.0	-1.3	2.2	2.2	8.5	-1.1
Predicted WSE in ft													
EM-2S	223.11	222.79	222.45	222.13	221.90	221.77	221.38	221.08	220.98	221.16	221.34	221.44	220.97
East Edmond	209.44	209.46	209.46	209.37	209.24	209.52	209.44	209.29	209.00	209.00	209.00	209.61	209.38
Eastern East Edmond Marsh	209.64	209.66	209.66	209.57	209.44	209.72	209.64	209.49	209.20	209.20	209.20	209.81	209.58
Observed WSE in ft													
EM-2S	211.31	211.47	211.40	211.40	211.39	211.44	211.43	211.37	211.19	210.88	211.31	211.51	211.47
East Edmond (EM-2E)	212.29	212.69	212.64	212.56	212.59	212.63	212.48	212.39	212.03	211.66	212.05	212.55	212.52
East Edmond (EM-2W)	211.69	211.83	211.78	211.75	211.76	211.81	211.82	211.80	211.64	211.36	211.76	211.89	211.86
East Edmond (EM-3E)	212.65	213.05	212.99	212.91	213.01	212.99	212.86	212.77	212.41	212.03	212.41	212.93	212.88
East Edmond (EM-3W)	212.76	213.17	213.11	213.04	213.06	213.10	212.96	212.88	212.51	212.15	212.53	213.03	212.99
Eastern East Edmond (SCM-1)	212.90	213.32	213.27	213.18	213.21	213.26	213.10	213.03	212.65	212.26	212.66	213.16	213.14

Table F-17. Water Balance for East Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water — WY2015

Hydrologic Process	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation	2.4	4.2	6.9	9.8	4.5	3.3	1.3	1.2	1.6	1.8	5.9	6.1	4.8
Surface Water Inflows	81.5	99.7	160.3	443.9	378.8	308.7	142.5	71.6	37.0	22.2	57.5	117.2	218.4
From Sequalitchew Lake	74.1	95.1	153.3	436.0	371.5	302.4	138.2	69.2	36.6	22.1	56.8	109.7	210.9
From Center Drive	0.1	0.3	0.4	0.7	0.3	0.2	0.1	0.0	0.1	0.1	0.4	0.4	0.3
From Hamer (surface)	7.3	4.3	6.6	7.3	7.0	6.1	4.3	2.3	0.3	0.0	0.4	7.0	7.2
Subsurface Inflows	7.7	9.9	8.8	10.0	8.9	8.9	8.0	7.8	7.5	7.9	11.5	9.2	10.1
Evapotranspiration	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0
Recharge (-) Discharge (+)	*11.9*	*14.8*	*15.2*	*16.4*	*15.2*	*16.2*	*14.4*	*14.2*	*14.2*	*14.6*	*15.6*	*12.6*	*15.5*
Surface Water Outflows	-85.5	-111.5	-160.6	-409.1	-346.9	-286.1	-139.6	-77.5	-48.1	-36.3	-74.5	-117.3	-212.3
To Diversion Canal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
To West Edmond Marsh	-99.6	-129.9	-187.2	-476.9	-404.4	-333.5	-162.7	-90.3	-56.1	-42.3	-86.9	-136.7	-247.5
Change in Storage	3.9	-1.3	3.5	1.9	1.0	0.4	-0.2	-0.1	0.2	1.9	2.5	7.9	1.4
Predicted WSE in ft													
EM-2S	220.68	220.21	219.96	219.51	219.00	218.53	218.16	217.96	217.95	218.10	218.28	218.36	217.87
East Edmond	209.61	209.36	209.55	209.61	209.59	209.51	209.36	209.19	209.03	209.00	209.03	209.59	209.60
Eastern East Edmond Marsh	209.81	209.56	209.75	209.81	209.79	209.71	209.56	209.39	209.23	209.20	209.23	209.79	209.80
Observed WSE in ft													
EM-2S	211.39	211.43	211.51	211.50	211.51	211.54	211.48	211.33	211.22	211.30	211.38	211.49	211.49
East Edmond (EM-2E)	212.33	212.43	212.59	212.59	212.68	212.81	212.73	212.32			212.34	212.53	212.51
East Edmond (EM-2W)	211.80	211.82	211.86	211.87	211.88	211.90	211.87	211.78	211.71	211.76	211.81	211.88	211.89
East Edmond (EM-3E)	212.69	212.80	212.95	212.96	213.04	213.19	213.08	212.66	212.49	212.59	212.69	212.91	212.94
East Edmond (EM-3W)	212.80	212.91	213.06	213.06	213.15	213.29	213.19	212.79	212.61	212.57	212.54	213.02	213.04
Eastern East Edmond (SCM-1)	212.95	213.07	213.21	213.25	213.33	213.46	213.22	212.98	212.76	212.86	212.97	213.20	213.26

Table F-17. Water Balance for East Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water — WY2016

Hydrologic Process	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Precipitation	4.1	4.7	4.4	2.1	0.8	0.4	0.2	2.2	1.3	5.0	7.1	12.0	6.9
Surface Water Inflows	301.6	330.3	310.8	213.3	116.4	31.9	0.2	0.7	8.7	23.5	117.1	282.6	387.3
From Sequalitchew Lake	294.1	324.0	304.1	207.4	113.3	31.4	0.2	0.6	8.6	23.2	113.9	274.4	379.5
From Center Drive	0.3	0.3	0.3	0.1	0.0	0.0	0.0	0.1	0.1	0.3	0.5	0.9	0.5
From Hamer (surface)	7.3	6.1	6.5	5.8	3.1	0.5	0.0	0.0	0.0	0.0	2.7	7.3	7.3
Subsurface Inflows	9.7	8.7	9.6	7.7	7.4	6.2	5.4	5.0	4.5	7.8	10.6	10.2	10.0
Evapotranspiration	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0
Recharge (-) Discharge (+)	*15.1*	*14.3*	*15.6*	*14.0*	*14.0*	*12.6*	*12.4*	*11.4*	*11.4*	*12.2*	*17.0*	*16.7*	*14.4*
Surface Water Outflows	-282.5	-306.5	-289.4	-201.1	-117.1	-41.0	-10.5	-11.2	-18.3	-38.8	-125.9	-270.8	-358.0
To Diversion Canal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
To West Edmond Marsh	-329.3	-357.2	-337.4	-234.4	-136.5	-47.8	-12.2	-13.1	-21.3	-45.3	-146.7	-315.7	-417.3
Change in Storage	1.2	0.2	1.7	0.8	-1.0	-0.4	1.5	2.2	2.2	2.2	4.5	5.7	1.2
Predicted WSE in ft													
EM-2S	217.37	216.87	216.47	216.05	215.71	215.63	215.76	215.94	216.12	216.31	216.46	216.33	215.83
East Edmond	209.61	209.51	209.54	209.49	209.26	209.05	209.00	209.00	209.00	209.00	209.23	209.61	209.61
Eastern East Edmond Marsh	209.81	209.71	209.74	209.69	209.46	209.25	209.20	209.20	209.20	209.20	209.43	209.81	209.81
Observed WSE in ft													
EM-2S	211.46	211.44	211.42	211.33	211.28	211.07	210.67	210.28	210.36	210.44	211.37	211.34	
East Edmond (EM-2E)	212.49	212.47	212.45	212.47	212.38	211.92	211.60	211.43	211.43	211.43	212.50	212.38	
East Edmond (EM-2W)	211.84	211.81	211.78	211.21	211.71	211.53	211.17	210.76	210.81	210.86	211.72	211.68	
East Edmond (EM-3E)	212.85	212.82	212.79	212.83	212.74	212.20	211.92	211.62	211.64	211.65	212.85	212.70	
East Edmond (EM-3W)	212.94	212.92	212.91	212.94	212.83	212.39	212.03	211.71	211.73	211.75	212.95	212.82	
Eastern East Edmond (SCM-1)	213.13	213.11	213.09	213.13	213.03	212.53	212.14	211.79	211.81	211.83	213.11	212.99	

Table F-17. Water Balance for East Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water — WY2017

Hydrologic Process	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Precipitation	5.8	5.9	1.8	1.0	2.3	1.3	0.2	1.5	9.3	6.9	3.9	3.4	8.6
Surface Water Inflows	650.4	646.3	372.9	137.3	92.9	64.0	8.4	12.4	71.2	134.5	212.6	110.5	176.8
From Sequalitchew Lake	643.2	638.6	367.0	134.4	90.0	60.6	8.1	12.3	70.6	127.0	205.1	103.2	170.6
From Center Drive	0.4	0.4	0.1	0.0	0.1	0.1	0.0	0.1	0.7	0.5	0.3	0.2	0.5
From Hamer (surface)	6.8	7.3	5.9	2.9	2.8	3.3	0.3	0.0	0.0	7.0	7.3	7.1	5.7
Subsurface Inflows	9.4	10.0	9.1	9.2	8.9	8.0	7.0	6.7	10.6	9.9	10.2	9.6	9.4
Evapotranspiration	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6
Recharge (-) Discharge (+)	*12.8*	*13.9*	*13.8*	*14.9*	*14.3*	*13.0*	*14.0*	*14.0*	*14.7*	*13.2*	*14.3*	*11.5*	*13.0*
Surface Water Outflows	-580.8	-577.5	-339.4	-137.6	-96.8	-68.2	-22.7	-26.0	-88.0	-133.6	-201.9	-111.3	-174.0
To Diversion Canal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
To West Edmond Marsh	-677.0	-673.2	-395.7	-160.4	-112.9	-79.6	-26.5	-30.3	-102.6	-155.7	-235.3	-129.7	-202.9
Change in Storage	0.8	1.7	0.0	-1.2	1.8	2.2	-0.9	1.9	2.2	8.3	5.7	5.3	4.3
Predicted WSE in ft													
EM-2S	215.32	214.86	214.37	214.03	213.94	213.85	213.75	213.91	214.10	214.20	214.06	213.92	213.80
East Edmond	209.57	209.61	209.49	209.24	209.24	209.28	209.03	209.00	209.00	209.59	209.61	209.59	209.47
Eastern East Edmond Marsh	209.77	209.81	209.69	209.44	209.44	209.48	209.23	209.20	209.20	209.79	209.81	209.79	209.67
Observed WSE in ft													
EM-2S					211.28	211.15	210.81		210.79	211.31	211.32	211.17	211.47
East Edmond (EM-2E)					212.38	212.27	211.76		211.57	212.24	212.22	212.05	212.04
East Edmond (EM-2W)					211.68	211.57	211.27		211.29	211.90	211.78	211.57	211.59
East Edmond (EM-3E)					212.59	212.34	212.05		211.87	212.33	212.35	212.39	213.34
East Edmond (EM-3W)					212.81	212.60	212.19		212.00	212.69	212.66	212.50	212.46
Eastern East Edmond (SCM-1)					212.88	212.65	212.28		212.08	212.60	212.59	212.62	210.24

Table F-17. Water Balance for East Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water — WY 2018

Hydrologic Process	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Precipitation	8.7	4.6	2.8	1.8	0.0	0.1	1.0	5.2	7.2	5.8	7.2	3.3	2.3
Surface Water Inflows	340.8	280.4	199.7	63.0	7.9	0.2	8.0	16.8	20.9	94.9	156.4	215.9	175.7
From Sequalitchew Lake	332.9	273.1	193.0	58.6	7.9	0.0	7.9	16.4	13.4	87.2	148.7	209.1	169.1
From Center Drive	0.6	0.3	0.2	0.1	0.0	0.0	0.0	0.4	0.5	0.4	0.5	0.2	0.1
From Hamer (surface)	7.3	7.0	6.6	4.4	0.0	0.2	0.0	0.0	7.0	7.3	7.3	6.6	6.5
Subsurface Inflows	10.6	9.4	9.0	8.8	9.0	8.2	7.2	11.7	9.5	10.4	10.3	9.1	9.5
Evapotranspiration	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3
Recharge (-) Discharge (+)	*15.2*	*13.7*	*12.2*	*10.6*	*13.1*	*11.8*	*10.9*	*13.9*	*11.9*	*12.8*	*13.4*	*13.0*	*12.3*
Surface Water Outflows	-314.8	-258.2	-184.8	-66.0	-22.0	-11.9	-18.3	-34.4	-31.4	-101.4	-156.1	-202.3	-165.7
To Diversion Canal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
To West Edmond Marsh	-366.9	-301.0	-215.5	-76.9	-25.6	-13.9	-21.4	-40.1	-36.6	-118.2	-181.9	-235.8	-193.2
Change in Storage	7.0	5.2	5.1	3.7	-0.1	2.4	3.4	6.5	12.5	5.7	5.4	4.8	5.5
Predicted WSE in ft													
EM-2S	213.78	213.63	213.51	213.45	213.44	213.63	213.91	214.45	214.90	214.77	214.62	214.48	214.39
East Edmond	209.61	209.59	209.55	209.37	209.00	209.01	209.00	209.00	209.59	209.61	209.61	209.55	209.54
Eastern East Edmond Marsh	209.81	209.79	209.75	209.57	209.20	209.21	209.20	209.20	209.79	209.81	209.81	209.75	209.74
Observed WSE in ft													
EM-2S	211.31	211.27		211.18	211.05	211.24	210.72			211.95		211.29	211.12
East Edmond (EM-2E)	212.14	212.21		212.34	212.18	211.95	211.82			212.59		212.35	212.14
East Edmond (EM-2W)	210.67	211.63		211.55	211.44	210.47	211.09			211.69		211.60	211.48
East Edmond (EM-3E)	212.37	212.47		212.67	212.88	212.52	212.03			212.56		212.51	212.40
East Edmond (EM-3W)	212.54	212.62		212.78	212.62	212.37	212.27			213.07		212.79	212.58
Eastern East Edmond (SCM-1)	212.62	212.68		212.95	212.65	212.56	212.64			212.89		212.76	212.65

Table F-17. Water Balance for East Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water — WY2019

Hydrologic Process	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Precipitation	6.1	0.7	0.9	0.2	0.3	1.8	4.0	3.8	6.4	3.4	4.8	1.6	3.6
Surface Water Inflows	110.3	49.0	24.9	3.7	3.1	21.0	22.0	25.2	114.7	87.3	139.5	17.2	126.8
From Sequalitchew Lake	104.9	47.7	22.0	3.4	3.1	20.9	21.7	22.9	108.2	79.8	133.4	12.1	122.7
From Center Drive	0.4	0.0	0.0	0.0	0.0	0.1	0.3	0.2	0.4	0.2	0.3	0.1	0.2
From Hamer (surface)	4.9	1.3	2.9	0.3	0.0	0.0	0.0	2.0	6.1	7.3	5.8	5.0	3.9
Subsurface Inflows	9.5	9.3	7.4	7.1	5.8	6.0	8.0	9.8	10.4	9.6	8.8	8.8	9.0
Evapotranspiration	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0
Recharge (-) Discharge (+)	*14.3*	*13.1*	*10.3*	*11.1*	*10.1*	*10.3*	*7.8*	*11.4*	*11.8*	*11.1*	*10.9*	*11.1*	*11.3*
Surface Water Outflows	-114.9	-56.8	-28.1	-14.8	-11.5	-27.1	-30.0	-35.6	-114.6	-89.8	-136.6	-28.1	-123.4
To Diversion Canal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
To West Edmond Marsh	-133.9	-66.2	-32.8	-17.3	-13.4	-31.5	-35.0	-41.5	-133.6	-104.7	-159.2	-32.7	-143.9
Change in Storage	4.2	2.6	7.0	0.3	1.9	5.2	5.8	8.2	9.7	6.6	4.2	4.7	4.8
Predicted WSE in ft													
EM-2S	214.33	214.45	214.79	214.79	214.95	215.39	215.87	216.39	216.69	216.64	216.50	216.47	216.55
East Edmond	209.41	209.11	209.24	209.02	209.00	209.00	209.00	209.17	209.51	209.61	209.48	209.42	209.32
Eastern East Edmond Marsh	209.61	209.31	209.44	209.22	209.20	209.20	209.20	209.37	209.71	209.81	209.68	209.62	209.52
Observed WSE in ft													
EM-2S	211.17	211.08	211.17	211.01	210.61	210.70	210.71	211.07	211.35	211.39	211.14	211.24	211.37
East Edmond (EM-2E)	212.37	212.41	212.23	212.05	211.65	211.73	211.78	212.21	212.63		212.55	212.37	212.63
East Edmond (EM-2W)	211.51	211.24	211.59	211.44	211.01	211.12	211.07	211.66	211.70		211.48	211.66	211.89
East Edmond (EM-3E)	212.48						212.06	212.42	212.65	212.71	212.83	212.69	212.67
East Edmond (EM-3W)	212.81	212.81	212.50	212.50	212.14	212.19	212.19	212.64	212.98	212.50	213.00	212.81	213.06
Eastern East Edmond (SCM-1)	212.77	212.59	212.85	212.01	211.75	211.84	212.57					212.88	212.90

Table F-17. Water Balance for East Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water — WY2020

Hydrologic Process	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Precipitation	1.1	0.7	1.0	0.8	3.5	3.9	1.7	6.5	9.6	4.2	3.5	1.5	3.1
Surface Water Inflows	77.2	21.9	2.7	2.2	2.0	7.6	12.5	43.8	12.9	155.9	243.6	221.4	150.0
From Sequalitchew Lake	73.8	20.2	2.6	2.2	1.8	7.4	10.3	42.1	5.0	148.8	237.4	218.1	148.5
From Center Drive	0.0	0.0	0.0	0.0	0.2	0.3	0.1	0.5	0.7	0.3	0.2	0.1	0.2
From Hamer (surface)	3.4	1.7	0.0	0.0	0.0	0.0	2.1	1.3	7.3	6.8	6.0	3.3	1.3
Subsurface Inflows	7.4	5.9	5.0	3.7	5.1	8.2	7.1	10.1	12.1	10.0	8.8	7.7	8.6
Evapotranspiration	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2
Recharge (-) Discharge (+)	*10.8*	*9.9*	*10.0*	*8.2*	*5.9*	*13.0*	*14.2*	*12.7*	*17.9*	*13.2*	*17.2*	*16.3*	*15.9*
Surface Water Outflows	-75.4	-26.7	-11.7	-8.2	-10.5	-23.3	-24.2	-58.0	-40.6	-151.2	-227.6	-204.6	-144.1
To Diversion Canal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
To West Edmond Marsh	-87.8	-31.1	-13.6	-9.5	-12.2	-27.1	-28.2	-67.6	-47.3	-176.3	-265.4	-238.5	-168.0
Change in Storage	5.5	3.5	0.6	1.6	2.0	4.5	6.8	5.5	5.2	6.5	6.5	6.5	6.5
Predicted WSE in ft													
EM-2S	216.73	216.87	216.92	217.05	217.22	217.60	217.99	218.33	218.16	218.13	218.17	218.44	218.87
East Edmond	209.28	209.14	209.00	209.00	209.00	209.00	209.18	209.11	209.00	209.00	209.00	209.00	209.00
Eastern East Edmond Marsh	209.48	209.34	209.20	209.20	209.20	209.20	209.38	209.31	209.20	209.20	209.20	209.20	209.20
Observed WSE in ft													
EM-2S		210.80	210.49	210.07	210.20	210.34		210.30	211.41	210.49			
East Edmond (EM-2E)		211.91	211.55	211.43	211.43	211.44		211.43	212.60	212.45			
East Edmond (EM-2W)		211.58	210.92	210.54		210.77		211.58	211.69	211.66			
East Edmond (EM-3E)						211.90		211.74	212.80	212.80			
East Edmond (EM-3W)		212.37	212.00	211.54	212.27	211.89		212.16	213.03	212.89			
Eastern East Edmond (SCM-1)													

Table F-17. Water Balance for East Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water WY 2021

Hydrologic Process	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Precipitation	2.5	0.3	0.4	2.8	3.0	5.6	5.2	7.3	4.7	2.5	1.2	2.0	2.4
Surface Water Inflows	84.5	38.4	26.6	22.8	40.2	74.5	126.4	151.6	127.1	168.1	134.1	82.9	68.9
From Sequalitchew Lake	81.6	38.0	26.6	22.6	40.0	74.2	118.8	144.7	120.2	161.3	130.8	80.9	67.3
From Center Drive	0.1	0.0	0.0	0.2	0.2	0.4	0.4	0.5	0.3	0.1	0.0	0.1	0.1
From Hamer (surface)	2.8	0.4	0.0	0.0	0.0	0.0	7.3	6.3	6.6	6.7	3.2	1.9	1.5
Subsurface Inflows	8.0	5.8	4.0	4.8	6.1	10.3	10.7	11.6	10.3	10.7	8.4	8.4	7.7
Evapotranspiration	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7
Recharge (-) Discharge (+)	*14.8*	*9.9*	*7.6*	*7.7*	*8.6*	*12.8*	*14.7*	*16.1*	*14.2*	*14.3*	*11.8*	*13.1*	*11.3*
Surface Water Outflows	-85.4	-37.3	-25.5	-26.3	-43.2	-82.6	-129.2	-154.5	-128.0	-161.2	-126.1	-83.0	-68.8
To Diversion Canal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
To West Edmond Marsh	-99.5	-43.4	-29.7	-30.6	-50.4	-96.3	-150.6	-180.1	-149.2	-187.9	-147.0	-96.8	-80.2
Change in Storage	6.5	6.5	4.9	5.1	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
Predicted WSE in ft													
EM-2S	219.18	219.68	220.09	220.52	221.06	221.60	221.53	221.54	221.54	221.52	221.79	222.17	222.59
East Edmond	209.00	209.00	209.00	209.00	209.00	209.00	209.00	209.00	209.00	209.00	209.00	209.00	209.00
Eastern East Edmond Marsh	209.20	209.20	209.20	209.20	209.20	209.20	209.20	209.20	209.20	209.20	209.20	209.20	209.20
Observed WSE in ft													
EM-2S		210.83	210.33		210.25			211.47			211.31	211.27	211.13
East Edmond (EM-2E)		211.43	211.43		211.43	212.93		212.54			212.27	212.16	212.04
East Edmond (EM-2W)			210.76		210.69			211.77	212.14	212.14	211.70	211.69	211.51
East Edmond (EM-3E)					211.47	212.18		212.88	213.54	212.83	212.43		
East Edmond (EM-3W)			211.69		211.56	212.50		212.99	212.50	212.50	212.73	212.60	212.50
Eastern East Edmond (SCM-1)													

Table F-17. Water Balance for East Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water WY 2021

Hydrologic Process	Jul	Aug	Sep
Precipitation	0.0	0.3	2.6
Surface Water Inflows	21.7	26.6	22.8
From Sequalitchew Lake	21.7	26.6	22.6
From Center Drive	0.0	0.0	0.1
From Hamer (surface)	0.0	0.0	0.0
Subsurface Inflows	5.9	4.2	4.5
Evapotranspiration	-4.5	-4.0	-2.3
Recharge (-) Discharge (+)	*8.9*	*6.3*	*5.9*
Surface Water Outflows	-23.6	-24.6	-24.6
To Diversion Canal	0.0	0.0	0.0
To West Edmond Marsh	-27.5	-28.6	-28.6
Change in Storage	4.5	4.7	4.7
Predicted WSE in ft			
EM-2S	222.97	223.36	223.76
East Edmond	209.00	209.00	209.00
Eastern East Edmond Marsh	209.20	209.20	209.20
Observed WSE in ft			
EM-2S	210.73		
East Edmond (EM-2E)	211.69	211.43	
East Edmond (EM-2W)	211.14		
East Edmond (EM-3E)			
East Edmond (EM-3W)	212.23	211.56	
Eastern East Edmond (SCM-1)		210.20	

Table F-18. Water Balance for West Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water	WY2004						WY2005						
Hydrologic Process	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Precipitation	2.0	1.0	3.8	0.9	0.1	3.6	2.9	4.0	3.2	4.3	4.3	0.6	4.5
Surface Water Inflows	441.8	378.0	286.8	117.9	66.7	56.4	98.7	154.5	243.4	98.3	117.0	124.8	159.2
From East Edmond	441.8	378.0	286.8	117.9	66.7	56.4	98.7	154.5	243.4	98.3	117.0	124.8	159.2
Evapotranspiration	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3
Recharge (-) Discharge (+)	-33.3	-35.2	-35.4	-37.7	-43.3	-39.9	-37.5	-36.3	-34.9	-33.2	-30.2	-32.6	-32.4
Surface Water Outflows	-409.3	-342.0	-252.1	-77.4	-19.0	-16.2	-61.7	-121.1	-211.1	-69.4	-91.1	-92.3	-130.1
To Center Drive	-409.3	-342.0	-252.1	-77.4	-19.0	-16.2	-61.7	-121.1	-211.1	-69.4	-91.1	-92.3	-130.1
Change in Storage	0.0	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Predicted WSE in ft	206.50	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49
Observed WSE EM-1/EM-1A	209.10	208.59	207.26	206.55	205.27	205.27	205.27	205.86	206.15	207.67	209.18	207.97	206.63

Table F-18. Water Balance for West Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water — WY2006

Hydrologic Process	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Precipitation	5.4	3.9	3.8	1.4	0.2	1.6	3.3	6.7	6.5	12.2	3.2	2.6	3.9
Surface Water Inflows	309.8	242.5	228.1	73.2	27.4	68.4	31.5	75.8	125.6	749.5	750.5	684.7	607.6
From East Edmond	309.8	242.5	228.1	73.2	27.4	68.4	31.5	75.8	125.6	749.5	750.5	684.7	607.6
Evapotranspiration	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0
Recharge (-) Discharge (+)	-29.2	-29.7	-31.7	-36.5	-36.9	-42.8	-38.6	-32.4	-27.3	-13.9	-19.1	-25.8	-27.5
Surface Water Outflows	-284.1	-213.5	-196.6	-33.5	-0.2	-11.3	-0.2	-44.6	-104.8	-747.7	-734.0	-660.2	-582.1
To Center Drive	-284.1	-213.5	-196.6	-33.5	-0.2	-11.3	-0.2	-44.6	-104.8	-747.7	-734.0	-660.2	-582.1
Change in Storage	0.0	0.0	0.0	0.0	-13.4	13.6	-5.1	5.0	-0.1	0.0	0.0	0.0	0.0
Predicted WSE in ft	206.49	206.49	206.49	206.49	205.37	206.50	206.07	206.49	206.49	206.49	206.49	206.49	206.49
Observed WSE EM-1/EM-1A	209.29	209.08	207.09	205.79	205.27	205.27	205.27	206.05	208.15	208.82	208.53	208.69	208.78

Table F-18. Water Balance for West Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water WY2007

Hydrologic Process	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Precipitation	2.1	2.2	0.4	0.0	0.8	1.6	14.4	8.6	6.5	4.5	5.7	1.7	1.1
Surface Water Inflows	430.5	417.0	283.6	166.1	74.6	87.9	529.4	743.9	1050.7	826.4	1267.5	1175.0	626.0
From East Edmond	430.5	417.0	283.6	166.1	74.6	87.9	529.4	743.9	1050.7	826.4	1267.5	1175.0	626.0
Evapotranspiration	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2
Recharge (-) Discharge (+)	-31.2	-32.1	-38.4	-42.3	-43.4	-45.3	-16.4	-15.4	-16.8	-18.3	-18.8	-24.6	-31.6
Surface Water Outflows	-398.2	-383.4	-241.1	-119.8	-29.6	-43.3	-527.0	-737.0	-1040.4	-812.1	-1253.2	-1150.1	-592.3
To Center Drive	-398.2	-383.4	-241.1	-119.8	-29.6	-43.3	-527.0	-737.0	-1040.4	-812.1	-1253.2	-1150.1	-592.3
Change in Storage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Predicted WSE in ft	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49
Observed WSE EM-1/EM-1A	207.56	207.10	205.67	205.27	205.27	205.27	208.74	208.94	208.71	208.75	208.84	208.70	207.84

Table F-18. Water Balance for West Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water WY2008

Hydrologic Process	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Precipitation	2.7	1.5	1.0	1.7	5.0	2.8	7.7	4.2	3.6	4.9	1.8	1.3	1.7
Surface Water Inflows	311.0	71.7	396.2	331.6	278.3	300.5	550.5	552.9	510.3	478.6	459.7	331.6	215.0
From East Edmond	311.0	71.7	396.2	331.6	278.3	300.5	550.5	552.9	510.3	478.6	459.7	331.6	215.0
Evapotranspiration	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7
Recharge (-) Discharge (+)	-33.0	-36.2	-39.2	-38.1	-34.7	-33.7	-22.7	-23.5	-23.9	-25.9	-29.2	-34.7	-36.0
Surface Water Outflows	-277.0	-32.6	-354.1	-292.8	-247.5	-269.1	-535.5	-533.7	-489.5	-456.4	-430.3	-295.0	-177.0
To Center Drive	-277.0	-32.6	-354.1	-292.8	-247.5	-269.1	-535.5	-533.7	-489.5	-456.4	-430.3	-295.0	-177.0
Change in Storage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Predicted WSE in ft	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49
Observed WSE EM-1/EM-1A	206.92	205.84	205.63	205.62	207.09	207.82	209.17	209.07	209.02	209.23	209.03	206.96	206.38

Table F-18. Water Balance for West Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water WY2009

Hydrologic Process	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Precipitation	0.9	2.1	0.5	2.6	8.3	5.2	7.3	1.6	5.3	3.5	3.4	1.3	0.0
Surface Water Inflows	80.7	138.0	87.4	62.8	270.6	178.3	715.1	341.9	458.2	429.9	407.7	264.9	173.7
From East Edmond	80.7	138.0	87.4	62.8	270.6	178.3	715.1	341.9	458.2	429.9	407.7	264.9	173.7
Evapotranspiration	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5
Recharge (-) Discharge (+)	-40.6	-40.7	-42.7	-42.8	-27.7	-26.7	-21.2	-26.4	-26.0	-27.7	-29.2	-32.6	-40.6
Surface Water Outflows	-36.6	-95.4	-42.9	-21.5	-250.8	-156.8	-701.3	-316.5	-436.1	-403.7	-378.7	-229.9	-128.6
To Center Drive	-36.6	-95.4	-42.9	-21.5	-250.8	-156.8	-701.3	-316.5	-436.1	-403.7	-378.7	-229.9	-128.6
Change in Storage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Predicted WSE in ft	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49
Observed WSE EM-1/EM-1A	205.27	205.27		205.27	208.19	208.61	208.52	208.60	209.22	209.09	208.22	206.01	205.27

Table F-18. Water Balance for West Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water WY2010

Hydrologic Process	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Precipitation	1.9	2.8	5.6	8.9	3.0	8.0	3.3	3.3	3.3	4.6	4.3	0.4	0.2
Surface Water Inflows	135.2	123.7	204.8	402.7	376.2	620.7	511.4	627.5	843.9	638.8	539.0	336.3	193.2
From East Edmond	135.2	123.7	204.8	402.7	376.2	620.7	511.4	627.5	843.9	638.8	539.0	336.3	193.2
Evapotranspiration	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0
Recharge (-) Discharge (+)	-40.4	-38.3	-33.6	-22.3	-26.6	-18.3	-20.8	-21.0	-20.8	-22.6	-23.8	-33.2	-38.1
Surface Water Outflows	-92.7	-85.8	-175.8	-388.9	-352.6	-610.4	-493.3	-608.6	-824.5	-617.6	-515.8	-299.0	-151.3
To Center Drive	-92.7	-85.8	-175.8	-388.9	-352.6	-610.4	-493.3	-608.6	-824.5	-617.6	-515.8	-299.0	-151.3
Change in Storage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Predicted WSE in ft	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49
Observed WSE EM-1/EM-1A	205.27	205.27	205.98	209.21	209.55	208.68	208.58	208.34	209.17	207.87	207.82	206.07	206.07

Table F-18. Water Balance for West Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water WY2011

Hydrologic Process	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Precipitation	4.0	4.2	6.6	7.2	6.1	3.1	7.2	5.7	4.8	2.8	0.8	0.3	1.3
Surface Water Inflows	272.3	321.9	440.0	570.8	1148.3	1017.8	1329.5	1376.1	1098.1	664.9	246.6	192.6	137.4
From East Edmond	272.3	321.9	440.0	570.8	1148.3	1017.8	1329.5	1376.1	1098.1	664.9	246.6	192.6	137.4
Evapotranspiration	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3
Recharge (-) Discharge (+)	-33.1	-33.1	-25.0	-21.1	-22.0	-23.0	-25.7	-25.8	-18.1	-21.9	-27.1	-32.1	-35.5
Surface Water Outflows	-240.9	-292.0	-421.1	-556.8	-1132.4	-997.3	-1309.8	-1354.1	-1081.6	-642.0	-215.8	-156.8	-100.9
To Center Drive	-240.9	-292.0	-421.1	-556.8	-1132.4	-997.3	-1309.8	-1354.1	-1081.6	-642.0	-215.8	-156.8	-100.9
Change in Storage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Predicted WSE in ft	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49
Observed WSE EM-1/EM-1A	206.07	206.05	208.98	209.46	207.57		208.99	209.34	209.95		207.28	206.60	206.03

Table F-18. Water Balance for West Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water	WY2012												WY2013
Hydrologic Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Precipitation	4.1	6.1	3.2	7.2	3.9	6.8	4.3	3.1	3.3	1.6	0.0	0.1	6.5
Surface Water Inflows	361.5	378.7	381.1	549.0	670.4	922.3	1139.3	1063.8	549.5	370.5	143.8	51.7	228.0
From East Edmond	361.5	378.7	381.1	549.0	670.4	922.3	1139.3	1063.8	549.5	370.5	143.8	51.7	228.0
Evapotranspiration	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0
Recharge (-) Discharge (+)	-34.6	-33.3	-29.2	-23.2	-21.3	-24.0	-26.7	-25.7	-24.9	-28.8	-32.4	-36.5	-35.9
Surface Water Outflows	-330.0	-351.1	-355.1	-533.0	-652.4	-903.8	-1114.8	-1038.0	-524.2	-338.8	-107.4	-13.0	-197.6
To Center Drive	-330.0	-351.1	-355.1	-533.0	-652.4	-903.8	-1114.8	-1038.0	-524.2	-338.8	-107.4	-13.0	-197.6
Change in Storage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Predicted WSE in ft	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49
Observed WSE EM-1/EM-1A	206.28	206.94	207.83	209.23	209.32	209.55	209.78	209.52	209.14		206.36	205.73	206.56

Table F-18. Water Balance for West Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water | WY2014

Hydrologic Process	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Precipitation	6.5	7.6	3.5	1.7	3.7	5.5	4.4	1.9	0.0	1.6	6.9	2.6	4.1
Surface Water Inflows	402.7	717.8	831.0	561.1	695.3	655.8	535.6	373.6	201.5	162.4	179.1	333.0	357.8
From East Edmond	402.7	717.8	831.0	561.1	695.3	655.8	535.6	373.6	201.5	162.4	179.1	333.0	357.8
Evapotranspiration	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5
Recharge (-) Discharge (+)	-31.0	-27.6	-22.4	-21.3	-23.8	-21.1	-29.6	-29.6	-36.8	-39.1	-28.7	-20.3	-25.4
Surface Water Outflows	-377.7	-697.8	-812.1	-540.9	-674.0	-638.2	-507.2	-342.2	-160.2	-121.0	-154.9	-314.2	-336.0
To Center Drive	-377.7	-697.8	-812.1	-540.9	-674.0	-638.2	-507.2	-342.2	-160.2	-121.0	-154.9	-314.2	-336.0
Change in Storage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Predicted WSE in ft	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49
Observed WSE EM-1/EM-1A	208.21	209.83	209.07	209.27	209.37	209.44	208.41	207.37	205.95	206.06	206.17	208.73	208.72

Table F-18. Water Balance for West Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water WY2015

Hydrologic Process	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation	2.4	4.2	6.9	9.8	4.5	3.3	1.3	1.2	1.6	1.8	5.9	6.1	4.8
Surface Water Inflows	323.7	422.2	608.4	1549.7	1314.1	1083.7	528.8	293.5	182.4	137.5	282.3	444.2	804.1
From East Edmond	323.7	422.2	608.4	1549.7	1314.1	1083.7	528.8	293.5	182.4	137.5	282.3	444.2	804.1
Evapotranspiration	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0
Recharge (-) Discharge (+)	-24.4	-19.5	-19.0	-21.1	-24.1	-23.5	-25.1	-32.8	-34.2	-28.5	-24.8	-20.8	-21.9
Surface Water Outflows	-301.6	-406.9	-595.8	-1537.1	-1292.6	-1060.4	-501.2	-257.5	-145.8	-108.5	-262.4	-429.0	-787.0
To Center Drive	-301.6	-406.9	-595.8	-1537.1	-1292.6	-1060.4	-501.2	-257.5	-145.8	-108.5	-262.4	-429.0	-787.0
Change in Storage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Predicted WSE in ft	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49
Observed WSE EM-1/EM-1A	207.55	208.55	209.72	209.98	210.01	209.99	209.05	205.30	205.87	206.07	208.63	208.73	209.84

Table F-18. Water Balance for West Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water — WY2016

Hydrologic Process	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Precipitation	4.1	4.7	4.4	2.1	0.8	0.4	0.2	2.2	1.3	5.0	7.1	12.0	6.9
Surface Water Inflows	1070.1	1160.8	1096.4	761.7	443.5	155.5	39.7	42.6	69.3	147.0	476.9	1025.9	1356.1
From East Edmond	1070.1	1160.8	1096.4	761.7	443.5	155.5	39.7	42.6	69.3	147.0	476.9	1025.9	1356.1
Evapotranspiration	0.0	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0
Recharge (-) Discharge (+)	-19.3	-20.7	-23.4	-27.1	-33.6	-38.8	-39.4	-40.6	-41.0	-42.7	-23.7	-21.4	-23.2
Surface Water Outflows	-1054.9	-1144.2	-1076.2	-734.7	-407.5	-113.3	-0.2	-0.1	-27.2	-108.4	-459.8	-1016.5	-1339.8
To Center Drive	-1054.9	-1144.2	-1076.2	-734.7	-407.5	-113.3	-0.2	-0.1	-27.2	-108.4	-459.8	-1016.5	-1339.8
Change in Storage	0.0	0.0	0.0	0.0	0.0	0.0	-4.0	0.1	0.0	0.0	0.0	0.0	0.0
Predicted WSE in ft	206.49	206.49	206.49	206.49	206.49	206.49	206.15	206.16	206.49	206.49	206.49	206.49	206.49
Observed WSE EM-1/EM-1A	209.79	209.76	209.74	209.48	207.29	205.54	205.27	205.27	205.27	205.27	209.37	210.02	

Table F-18. Water Balance for West Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water — WY2017

Hydrologic Process	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Precipitation	5.8	5.9	1.8	1.0	2.3	1.3	0.2	1.5	9.3	6.9	3.9	3.4	8.6
Surface Water Inflows	2200.1	2187.6	1285.8	521.3	366.8	258.5	86.0	98.5	333.4	506.0	764.8	421.6	659.3
From East Edmond	2200.1	2187.6	1285.8	521.3	366.8	258.5	86.0	98.5	333.4	506.0	764.8	421.6	659.3
Evapotranspiration	-0.6	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6
Recharge (-) Discharge (+)	-21.7	-25.0	-24.6	-25.4	-25.0	-32.5	-35.9	-35.4	-37.2	-24.3	-22.9	-20.7	-14.8
Surface Water Outflows	-2183.6	-2167.2	-1260.9	-493.7	-340.4	-222.9	-46.3	-62.3	-304.4	-488.0	-745.9	-404.3	-652.5
To Center Drive	-2183.6	-2167.2	-1260.9	-493.7	-340.4	-222.9	-46.3	-62.3	-304.4	-488.0	-745.9	-404.3	-652.5
Change in Storage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Predicted WSE in ft	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49
Observed WSE EM-1/EM-1A					208.90	206.26	205.31		206.87	208.72	209.45	209.29	209.86

Table F-18. Water Balance for West Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water — WY2018

Hydrologic Process	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Precipitation	8.7	4.6	2.8	1.8	0.0	0.1	1.0	5.2	7.2	5.8	7.2	3.3	2.3
Surface Water Inflows	1192.4	978.0	700.1	249.8	83.3	45.0	69.5	130.2	118.8	384.0	591.2	766.2	627.7
From East Edmond	1192.4	978.0	700.1	249.8	83.3	45.0	69.5	130.2	118.8	384.0	591.2	766.2	627.7
Evapotranspiration	-1.3	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3
Recharge (-) Discharge (+)	-17.6	-18.3	-21.6	-23.6	-29.1	-32.6	-34.8	-27.0	-26.1	-17.9	-20.2	-20.2	-24.0
Surface Water Outflows	-1182.2	-962.3	-678.1	-224.4	-49.7	-8.6	-33.3	-107.5	-99.4	-371.9	-578.2	-748.7	-604.8
To Center Drive	-1182.2	-962.3	-678.1	-224.4	-49.7	-8.6	-33.3	-107.5	-99.4	-371.9	-578.2	-748.7	-604.8
Change in Storage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Predicted WSE in ft	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49
Observed WSE EM-1/EM-1A	210.22	208.64		209.58	207.22	206.67	205.31			209.98		209.98	209.67

Table F-18. Water Balance for West Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water — WY2019

Hydrologic Process	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Precipitation	6.1	0.7	0.9	0.2	0.3	1.8	4.0	3.8	6.4	3.4	4.8	1.6	3.6
Surface Water Inflows	435.1	215.1	106.6	56.2	43.4	102.5	113.6	134.7	434.1	340.3	517.4	106.4	467.5
From East Edmond	435.1	215.1	106.6	56.2	43.4	102.5	113.6	134.7	434.1	340.3	517.4	106.4	467.5
Evapotranspiration	-2.0	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0
Recharge (-) Discharge (+)	-24.9	-30.5	-34.1	-36.8	-39.3	-38.4	-39.5	-33.6	-23.3	-17.4	-16.1	-28.1	-29.5
Surface Water Outflows	-414.2	-182.1	-69.7	-15.1	-0.4	-63.5	-77.0	-104.4	-417.2	-326.3	-505.5	-78.5	-439.6
To Center Drive	-414.2	-182.1	-69.7	-15.1	-0.4	-63.5	-77.0	-104.4	-417.2	-326.3	-505.5	-78.5	-439.6
Change in Storage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Predicted WSE in ft	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49
Observed WSE EM-1/EM-1A	209.97	208.18	205.31	205.31	205.31	205.31	205.31	206.55	209.32	209.38	209.41	208.53	208.79

Table F-18. Water Balance for West Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water WY2020

Hydrologic Process	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Precipitation	1.1	0.7	1.0	0.8	3.5	3.9	1.7	6.5	9.6	4.2	3.5	1.5	3.1
Surface Water Inflows	285.4	101.2	44.2	30.9	166.5	88.2	91.6	219.6	153.6	572.9	862.3	775.1	545.9
From East Edmond	285.4	101.2	44.2	30.9	166.5	88.2	91.6	219.6	153.6	572.9	862.3	775.1	545.9
Evapotranspiration	-3.2	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2
Recharge (-) Discharge (+)	-35.3	-38.9	-42.3	-40.0	-40.0	-38.6	-35.6	-35.0	-16.7	-18.4	-30.2	-29.2	-30.2
Surface Water Outflows	-248.1	-59.2	-0.2	-0.2	-128.1	-52.5	-57.2	-191.2	-146.4	-558.1	-834.4	-745.4	-515.7
To Center Drive	-248.1	-59.2	-0.2	-0.2	-128.1	-52.5	-57.2	-191.2	-146.4	-558.1	-834.4	-745.4	-515.7
Change in Storage	0.0	0.0	-1.7	-12.3	-0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Predicted WSE in ft	206.49	206.49	206.34	205.46	206.44	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49
Observed WSE EM-1/EM-1A		205.31	205.31	205.31	205.31	205.31		206.97	209.81	209.35			

Table F-18. Water Balance for West Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water WY2021

Hydrologic Process	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Precipitation	2.5	0.3	0.4	2.8	3.0	5.6	5.2	7.3	4.7	2.5	1.2	2.0	2.4
Surface Water Inflows	323.4	141.2	96.4	99.6	163.8	312.9	489.3	585.3	485.0	610.6	477.7	314.5	260.6
From East Edmond	323.4	141.2	96.4	99.6	163.8	312.9	489.3	585.3	485.0	610.6	477.7	314.5	260.6
Evapotranspiration	-3.7	-4.5	-4.0	-2.3	-1.0	-0.5	0.0	0.0	-0.6	-1.3	-2.0	-3.2	-3.7
Recharge (-) Discharge (+)	-29.2	-40.7	-42.5	-41.4	-43.1	-30.1	-31.1	-19.1	-22.0	-24.4	-28.7	-38.0	-37.7
Surface Water Outflows	-292.9	-96.3	-50.4	-58.6	-122.7	-287.9	-463.5	-573.4	-467.1	-587.5	-448.2	-275.3	-221.6
To Center Drive	-292.9	-96.3	-50.4	-58.6	-122.7	-287.9	-463.5	-573.4	-467.1	-587.5	-448.2	-275.3	-221.6
Change in Storage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Predicted WSE in ft	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49	206.49
Observed WSE EM-1/EM-1A			205.31		205.31	206.87		209.40	209.72	209.15	208.13	205.31	205.31

Table F-18. Water Balance for West Edmond Marsh with Mining Restoration - Low Groundwater

Monthly Average in Inches of Water WY2021

Hydrologic Process	Jul	Aug	Sep
Precipitation	0.0	0.3	2.6
Surface Water Inflows	89.2	93.0	93.0
From East Edmond	89.2	93.0	93.0
Evapotranspiration	-4.5	-4.0	-2.3
Recharge (-) Discharge (+)	-41.6	-41.6	-40.3
Surface Water Outflows	-43.1	-43.6	-49.0
To Center Drive	-43.1	-43.6	-49.0
Change in Storage	0.0	4.1	4.0
Predicted WSE in ft	206.49	206.49	206.49
Observed WSE EM-1/EM-1A	205.31	206.87	

Appendix C

Air Quality Assessment

Prepared for

CalPortland

Prepared by

Ramboll US Corporation
Lynnwood, Washington

Date

September 27, 2022

PIONEER AGGREGATES SOUTH PARCEL EXPANSION PROJECT

AIR QUALITY ASSESSMENT

RAMBOLL Bright ideas. Sustainable change.

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1. INTRODUCTION

The Pioneer Aggregates South Parcel Project ("South Parcel Project") includes horizontal expansion of mining into approximately 188 acres previously undisturbed by mining and vertical expansion of approximately 125 acres where mining will deepen a portion of the existing mine. The South Parcel Project would extend mining at the current rate for approximately 14 additional years but would not increase current throughput. As under current conditions, all the material from the expansion will be processed in the already permissible processing facilities.

Mining under the South Parcel Project will proceed slowly from the north to the south over a period of five to eight years. The method of mining will be identical to that currently used in the permitted mine area. A dozer would push excavated material from the top of the mine face to two front-end loaders working on the mine floor. The front-end loaders would scoop-up the sand and gravel and dump it into portable hoppers that feed conveyors leading to the processing area.

A conveyor will start at the north end of the Expansion Area and will be extended south as mining progresses. The conveyor is comprised of a 48-inch-wide rubberized belt that is supported by a series of rollers, called idlers, mounted on steel framed segments that support the conveyor about five feet off the ground.

As excavation of the South Parcel proceeds, water wells will be installed to create a "curtain" that intercepts groundwater along the future pit edge. Water that intercepts these wells will be pumped. At its peak, when the pit edge is at the greatest extent, approximately 50 pumps may be working simultaneously.

Ramboll US Consulting (Ramboll) evaluated the air quality implications of the above mining activities associated with the expansion. For sand and gravel excavation, particulate matter (dust) is typically the only pollutant emitted in sufficient quantities to be a potential concern and is the focus of this air quality analysis. In addition, we are providing an assessment of potential greenhouse gas (GHG) emissions associated with the Project. The following information is based on a qualitative analysis of particulate matter (i.e., no air quality monitoring or modeling) and simple GHG calculations.

2. AFFECTED ENVIRONMENT

2.1 Regulatory Overview

Air quality is generally assessed in terms of whether concentrations of air pollutants are higher or lower than ambient air quality standards established to protect human health and welfare. Three agencies have jurisdiction over ambient air quality in the project area: the U.S. Environmental Protection Agency (EPA), the Washington Department of Ecology (Ecology), and the Puget Sound Clean Air Agency (PSCAA). These agencies establish regulations that govern both the concentrations of pollutants in the outdoor air and contaminant emissions from air pollution sources. Although their regulations are similar in stringency, each agency has established its own standards. Unless the state or local jurisdiction has adopted more stringent standards, the EPA standards pertain.

To track air quality conditions over time, Ecology and PSCAA maintain a network of monitoring stations throughout the Puget Sound region. These stations are typically located where air quality problems may be expected to occur, and so are usually in or near urban areas or close to specific large air pollution sources. Other stations are used to indicate regional air pollution levels. Based on monitoring information collected over a period of years, the EPA and Ecology designate regions as being "attainment" or "nonattainment" for particular air pollutants. Attainment status is therefore a benchmark of whether air quality in an area complies with the National Ambient Air Quality Standard (NAAQS) for one or more "criteria" air pollutants.[1] Regions once designated nonattainment that have since attained the standard are considered air quality "maintenance" areas through two 10-year cycles of review, after which the area achieves "attainment" if the ambient standards have been maintained.

The project area is considered in attainment for all monitored air pollutants. This suggests air quality in the project vicinity is generally good. Pertinent air pollutants are discussed in greater detail below. A complete list of local, state, and federal ambient air quality standards is displayed in **Table 1**.

Table 1. Applicable Ambient Air Quality Standards for Criteria Pollutants

Pollutant	Terms of Compliance [(a)]	Concentration
Inhalable Particulate Matter (PM_{10})		
Annual Average ($\mu g/m^{3)}$	Arithmetic mean not to be exceeded	50 $\mu g/m^3$
24-Hour Average ($\mu g/m^3$)	The 3-year average of the 98th percentile of the daily concentrations must not exceed	150 $\mu g/m^3$
Fine Particulate Matter ($PM_{2.5}$)		
Annual Average ($\mu g/m^3$)	The 3-year average of the annual mean must not exceed	12 $\mu g/m^3$
24-Hour Average ($\mu g/m^3$)	The 3-year average of the 98th percentile of daily concentrations must not exceed	35 $\mu g/m^3$
Carbon Monoxide (CO)		
8-Hour Average (ppm)	The 8-hour average must not exceed more than once per year	9 ppm
1-Hour Average (ppm)	The 1-hour average must not exceed more than once per year	35 ppm
Ozone (O_3)		
8-Hour Average (ppm)	The 3-year average of the 4th highest daily maximum 8-hour average must not exceed	0.070 ppm

[1] The criteria air pollutants are particulate matter, CO, SO_2, NO_2, ozone, and lead.

Pollutant	Terms of Compliance [a]	Concentration
Sulfur Dioxide (SO_2) [b]		
Annual Average (ppm)	Annual arithmetic mean of 1-hour averages must not exceed	0.02 ppm [b]
24-Hour Average (ppm)	24-hour average must not exceed	0.10 ppm [b]
1-Hour Average (ppm)	1-hour average must not exceed	0.40 ppm [b]
1-Hour Average (ppm)	The 3-year average of the 99th percentile of daily max 1-hour conc. must not exceed	0.075 ppm
1-Hour Average (ppm)	No more than twice in 7 consecutive days may 1-hour average exceed	0.25 ppm [b]
Nitrogen Dioxide (NO_2)		
Annual Average (ppm)	The annual mean of 1-hour averages must not exceed	0.053 ppm
1-Hour Average (ppm)	3-year average of 98th percentile of daily max 1 hour averages must not exceed	0.1 ppm
Lead (Pb)		
Quarterly Average ($\mu g/m^3$)	3-month average must not exceed	0.15 $\mu g/m^3$

Note: $\mu g/m^3$ = micrograms per cubic meter; ppm = parts per million; note that some standards also are sometimes expressed as parts per billion (ppb)

[a] All limits are federal and state air quality standards except as noted. All indicated limits represent "primary" air quality standards intended to protect human health.

[b] Washington State standards; Washington applies more stringent annual and 24-hour limits for SO_2 than in federal rules. There is also a federal 0.5 ppm 3-hour average "secondary" standard for SO_2 to protect welfare.

2.2 Existing Air Quality

2.2.1 Carbon Monoxide

Carbon monoxide (CO) is a by-product of incomplete combustion. CO is generated by vehicular traffic and other fuel-burning activities, such as residential space heating, especially space heating using solid fuels such as coal or wood. There are two short-term air quality standards for CO: a 1-hour average standard of 35 ppm and an 8-hour average standard of 9 ppm.

The impacts of CO are usually localized near the source(s), with the highest ambient concentrations typically occurring near congested roadways and intersections during periods of cold temperatures (autumn and winter months), light winds, and stable atmospheric conditions. Such weather conditions reduce the atmospheric mechanisms that disperse and dilute pollutants.

The project site is located next to a past CO maintenance area where the 20-year maintenance period ended in 2016. Due to violations of the federal 1-hour CO standard, the Puget Sound region was designated as nonattainment for CO. In 1996, EPA determined that the Puget Sound ozone nonattainment area had attained the health-based CO standard in effect at that time. EPA then reclassified the Puget Sound region as attainment for CO and approved the associated air quality maintenance plan. Under present plans and policies, the CO attainment/nonattainment status of the area would have no direct effects on the proposed project.

2.2.2 Ozone

Ozone is a reactive form of oxygen created by sunlight-activated chemical transformations of nitrogen oxides and volatile organic compounds (hydrocarbons) in the atmosphere. Ozone problems tend to be regional in nature because the atmospheric chemical reactions that produce ozone occur over a period of time, during which ozone precursors can be transported far from their sources. Transportation sources like automobiles and trucks are among the sources that produce ozone precursors.

The project site is located next to a past ozone maintenance area within the Puget Sound region where the 20-year maintenance period ended in 2016. In the past, due to violations of the federal 1-hour ozone standard, the Puget Sound region was designated as nonattainment for ozone. In 1997, EPA determined that the Puget Sound ozone nonattainment area had attained the health-based ozone standard in effect at that time. EPA then reclassified the Puget Sound region as attainment for ozone and approved the associated air quality maintenance plan. In 2005, EPA revoked the 1-hour ozone standard in most areas of the US including the Puget Sound region, which ended the ozone maintenance status of this region. In March of 2008, the EPA adopted a new more stringent 8-hour average ozone standard of 75 parts per billion (ppb). The 8-hour standard was later strengthened to 70 ppb for most areas, effective December 2015.[(2)] Under present plans and policies, the ozone attainment/nonattainment status of the area would have no direct effects on the proposed project.

2.2.3 Inhalable Particulate Matter – PM_{10} and $PM_{2.5}$

Particulate matter air pollution is comprised of particles either emitted directly into the air (e.g., dust) or formed when hot gases cool and condense. Such air pollution is generated primarily by industrial activities and operations involving fuel combustion and material handling, and by other fuel combustion sources like motor vehicle engines, vessel engines, and residential wood burning. Federal, state, and local regulations set limits for particle concentrations in the air (i.e., weight per unit volume) based on the size of the particles and the related potential threat to health. When first regulated, particle pollution limits were based on "total suspended particulate," which included all size fractions. As sampling technology improved and the importance of particle size and chemical composition became more apparent, ambient standards were revised to focus on the size fractions thought to be most dangerous to human health. Based on the most recent studies, EPA has redefined the size fractions and set new, more stringent standards for particulate matter based on fine and coarse inhalable particulate matter to focus control efforts on the smaller size fractions.

The previous PM_{10} maintenance area for health-based ambient air quality standards for PM_{10}, or particles less than or equal to about 10 micrometers (microns) in diameter, was for all of Pierce County. The 20-year maintenance period ended in 2021 and is now classified as an attainment area for PM_{10}. This site is close to a current maintenance area for $PM_{2.5}$, or particulate matter less than or equal to 2.5 microns in diameter, which was designated in 2015. The latter size fraction and even smaller (ultra-fine) particles are now considered the most dangerous size fractions of airborne particulate matter because such small particles (e.g. a typical human hair is about 100 microns in diameter) can be breathed deeply into lungs. In addition, such particles are often associated with toxic

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(2) 80 Fed. Reg. 65,292 (Oct. 26, 2015).

substances that are deleterious in their own right and that adsorb to the particles and be carried into respiratory system.

The nearest PM2.5 maintenance area encompasses Tacoma and surrounding lowland areas in Pierce County.(3) The project site is south of Tacoma in the lowlands of Pierce County and is considered part of this maintenance area.

In gravel excavation and processing operations, particulate matter (dust) is typically the only pollutant emitted in sufficient quantities to be a potential concern. Therefore, particulate emissions, inhalable and fine particulate matter (PM10/PM2.5), are a focus of this analysis.

PSCAA states that reasonable precautions must be in place to control fugitive dust if visible emissions are present. PSCAA must respond to any emission of fugitive dust that is or can be damaging to human health, plant or animal life, property, or the enjoyment of life. The Agency can respond to complaints and will take enforcement action if necessary.

2.2.4 Greenhouse Gases and Global Climate Change

The phenomena of natural and human-caused effects on the atmosphere that cause changes in long-term meteorological patterns is known as climate change. Due to the importance of the greenhouse effect and related atmospheric warming to climate change, the gases that affect such warming are called greenhouse gasses (GHGs). The GHGs of primary importance are CO_2, methane, and nitrous oxide. Because CO_2 is the most abundant of these gases, GHGs are usually quantified in terms of CO_2e (carbon dioxide equivalent), based on their relative longevity in the atmosphere and the related "global warming potential" of these constituents. CO_2 is not considered an air "pollutant" that causes direct health-related effects, so it is not subject to ambient air quality standards used to gauge pollutant concentrations in the air.

Fuel combustion used for transportation is a significant source of GHG emissions, primarily through the burning of gasoline and diesel fuels. National estimates indicate the transportation sector (including on-road, construction, airplanes, and vessels) accounts for about 29 percent of total domestic CO_2e emissions from fossil fuels in 2017.[4] In a tabulation of 2017 emissions within Washington, Ecology estimated transportation accounted for about 45 percent of statewide GHG emissions;[5] the higher percentage is due to lower GHG emissions from electrical generation because the state relies heavily on hydropower for electricity.

No specific federal, state, or local emission reduction requirements or targets are applicable to the proposed Project, and there are no generally accepted emission level thresholds against which to assess potential localized or global consequences of GHG emissions. Therefore, this assessment

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(3) The maintenance area is called the Tacoma – Pierce County area. See information and maps at: https://ecology.wa.gov/Regulations-Permits/Plans-policies/State-implementation-plans/Maintenance-SIPs.

4 *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2017*, February 2020, https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks

5 *2017 Greenhouse Gas Data,* https://ecology.wa.gov/Air-Climate/Climate-change/Greenhouse-gases/2017-greenhouse-gas-data

includes a qualitative consideration of GHG emissions that may be associated with emissions related to operations at the facility.

2.3 Local Climate and Terrain

Weather is one of several variables that influence air quality, with wind (speed and direction) and atmospheric stability being two major factors that affect dispersion. Periods with stable high-pressure systems and periods that include nighttime thermal inversions due to the low solar heating of the land in winter create stable atmospheric conditions. It is during these very stable atmospheric conditions when little vertical dispersion occurs high concentrations of air pollutants emitted at ground level typically occur. Ground-level emitted pollutants include CO from motor vehicles and particulate matter from vehicles and wood stoves.

In the Puget Sound region, summers are cool and comparatively dry, and winters are mild, wet, and cloudy. The winter months are dominated by a stronger south wind and frequent precipitation. Annual average precipitation in the region is approximately 50.82 inches. Annual mean temperature in the urban areas of Olympia is about 50°F. The annual mean wind speed is about 4.5 mph, with a predominately southerly wind direction (i.e., from the south). Ecology maintains records of wind data, and wind roses which are available on their website at: (https://enviwa.ecology.wa.gov/home/map).

In some instances, terrain can also influence air quality. The proposed area is in the south Puget Sound area and is characterized as relatively flat terrain.

3. IMPACTS

3.1 Operational Impacts

The proposal would enable the Dupont site to expand its mining operations to a neighboring parcel. The proposed site would operate much like the existing site. A new loader will be purchased to operate in the area and will feed material onto conveyor belts to be transported to the processing plant. Their existing dozer will be used to maintain the high wall. Water pumps will be used to pump groundwater that intercepts the edge of the pit. The processing plant and other operations in the current site will continue unchanged.

Fugitive dust emissions could continue to be emitted in the current and new pit, in the processing areas, and on the transport roads from a number of sources; with the potential effects discussed below.

- **Wind erosion.** Wind erosion over exposed surfaces and stockpiles generates fugitive dust. Emissions of wind-blown dust are directly related to the number of exposed areas and are affected by a number of other factors such as moisture content and soil type. Groundwater is expected to come in contact with the material during mining operations. Therefore, there is little potential for wind erosion associated with the mining pit. The potential for wind erosion and wind-blown dust would continue for the current mining areas and for stockpiles and transport of materials.

- **Automobiles and off-site haul trucks.** Employee vehicles and haul trucks traveling on area roadways could be sources of fugitive dust and exhaust particulate. Haul trucks may be used to

export mined materials from the site. With the proposal, these sources would not notably differ from the current activities.

- **Heavy equipment.** Mobile heavy equipment (such as a front-end loader) would continue excavating and dropping material into hoppers feeding conveyors transporting material to the existing processing area.

- **On-site haul trucks.** On-site haul trucks typically generate the greatest fugitive dust emissions compared with other air pollution sources at a mining site. However, material at the site is transported from active mining areas to the processing areas via conveyors, and the use of on-site haul trucks is limited.

Fugitive dust emissions from the sources listed above are likely to be greatest in the dry summer months. It is not likely that gravel extraction would significantly affect particulate matter concentrations during the winter months (when existing concentrations are typically higher due to residential wood burning and other factors) because greater precipitation keeps the material wet.

Heavy equipment and trucks generate diesel engine exhaust pollutants, but engine emissions from these existing sources are inconsequential considering the limited number of these vehicles.

3.1.1 Fugitive Dust Deposition

Due to the nature of the process, excavation of the proposed mine may cause dust deposition in the surrounding area. Although fugitive dust deposition is not a health issue, excess dust deposition is considered a nuisance as it can increase the soiling of surfaces, such as parked cars or the exterior of buildings.

The State of Washington does not have any quantitative standards pertaining to dust deposition. However, Section 9.11 of PSCAA Regulations states that "It shall be unlawful for any person to cause or allow the emission of any air contaminant in sufficient quantities and of such characteristics and duration as is, or is likely to be, injurious to human health, plant or animal life, or property, or which unreasonably interferes with enjoyment of life and property." Members of the public can contact PSCAA if they feel the project is interfering with the use and enjoyment of their property due to a dust deposition issue. The Agency will respond to complaints and potentially issue a Notice of Violation to the facility if the concern is determined to be valid. In that event the facility will likely have to pay a fine and provide assurances to PSCAA that measures to resolve the dust problem have been implemented and impacts will not continue. In the event of repeated violations, PSCAA may levy an enforcement action against the facility. This scenario could result in a shutdown of the facility, criminal penalties for the operators and firm requirements for changes at the facility.

3.1.2 Greenhouse Gas Emissions

When a Greenhouse Gas (GHG) emissions inventory is prepared for a facility or other entity, associated GHG emissions are separated into three categories, or "scopes":

- Scope 1 GHG emissions are direct emissions from sources that are owned or controlled by the facility, such as on-site fossil fuel combustion and industrial processes;

- Scope 2 GHG emissions are indirect emissions from the generation of electricity, heat or steam purchased by the facility from a utility provider; and

- Scope 3 GHG emissions are all indirect emissions linked to facility operations and production that are not included in Scope 2.

The GHGs emitted by the loaders and dozer are classified as Scope 1 emissions. GHGs emitted by off-site sources that generate electricity used by the conveyor drives and water pumps are Scope 2 emissions. Because the facility's annual production and operating time will not change, Scope 3 emissions are not expected to change as a result of the project.

Annual Scope 1 emissions were estimated using CO_2-equivalent (CO_2e) emission factors, expected annual operating hours for the South parcel, and the estimated fuel usage for each piece of equipment. The loaders and dozer fuel consumption ranges were estimated using hourly fuel consumption rates from tables found in the 29th edition of Caterpillar's performance handbook.[6&7]

CalPortland estimates that the South Parcel will be operated 2,080 hours per year and is expected to be the area of highest production at the facility. Total Scope 1 GHG emissions are expected to be 1,497 metric tons per year (mtpy) of CO_2e. It should be noted that the expansion of mining into the South Parcel will not require the addition of new equipment to the site but will instead redirect use of existing equipment into the expansion area. In this way, the overall annual hours of operation of the dozer and loaders are not expected to increase over current active mining operations. In this way, the emission calculations can be considered a very conservative estimation of the GHG emissions due to the South Parcel Expansion Project. The calculations are summarized below.

Table 2. Scope 1 Estimated Greenhouse Gas Emissions (mtpy CO_2e)

Equipment	Annual Operation (hr/yr)	Maximum Fuel Use (gal/hr)[3]	Emission Factor (lb CO_2e/gal)	Annual Scope 1 GHG Emissions (mtpy CO_2e)[1&2]
Caterpillar 992K Loader (2)	2,080	26	22.58	1,090
Caterpillar D10T Dozer	2,080	19.4	22.58	407
Total Annual GHG Emissions				1,497

Notes:
[1] Calculated using default emission factors from 40 CFR Part 98 Subpart C Tables C-1 and C-2 and assuming two loaders each operate 2,080 hours per year.
[2] Calculated using global warming potentials from 40 CFR Part 98 Subpart A Table A-1.
[3] Calculated using fuel consumption range on page 21-18 of, pages 25-9 and 25-39 of edition 46, the equipment is estimated to be used at medium load on average.

[6] Caterpillar Performance Handbook: Edition 29, Prepared by Caterpillar: http://nees.ucsd.edu/facilities/docs/Performance_Handbook_416C.pdf
[7] Caterpillar Performance Handbook: Edition 48, Prepared by Caterpillar: https://wheelercat.com/wp-content/uploads/2018/07/SEBD0351_ED48.pdf

Scope 2 emissions were estimated using CO_2e emission factors, expected annual South Parcel operating hours, and the quantity of electricity required to operate the conveyor belt and water pumps.

The facility purchases electricity from Puget Sound Energy (PSE). The Total Firm & Total Non-Firm Contracts, Purchases, and PSE Generated Electricity from Table 7 (Detailed Emissions Calculations) of PSE's 2020 Greenhouse Inventory document were combined to calculate a supplier-specific emission factor of 874 pounds of CO_2e per megawatt-hour (CO_2e/MWh). [8] This emission factor was combined with the estimated annual megawatt (MW) usage for conveyor drive motors and water pumps to be used in the South Phase to calculate annual Scope 2 GHG emissions.

The conveyor belt currently operated in the North Parcel of the facility is approximately 1,200 feet (ft) long and requires drive motors that total approximately 400 HP. A similar conveyor belt would be used in the South Parcel, so it is assumed that electric drive motors totaling 400 HP will be needed for every 1,200 ft of conveyor belt length. The South Parcel is expected to require approximately 1,200 feet of conveyors when operations begin, and approximately 5,000 feet of conveyors when operations are at their maximum expected extent (i.e., driver motors totaling approximately 1,667 HP). It was assumed that the conveyor belts will be operated the same number of hours per year as the loaders (i.e., 2,080) because they will be operated jointly with the loaders.

There are expected to be a total of approximately 50 water pumps used at the South Parcel to intercept water at the edge of the pit, and each pump will be driven by a 10 HP electric motor. While all 50 pump motors will typically not be operated simultaneously, we assumed continuous operation of all 50 pumps throughout the year (i.e., 8,760 hours per year) as a worst-case GHG emission scenario.

The water pumps will be operated as needed and continuous operation is not anticipated. To provide a conservative estimate of potential emissions attributable to the pumps, the GHG emissions summarized in the table below assume that all 50 pumps will be operated continuously throughout the year (i.e., 8,760 hr/yr); actual emissions are expected to be less than the values shown. Total Scope 2 emissions attributable to planned operations at the South Parcel are expected to range from 2,034 to 3,062 mtpy of CO_2e as the extent of the conveyor system increases from an initial 1,200 ft to a maximum of 5,000 ft.

Table 3. Scope 2 Estimated Greenhouse Gas Emissions (mtpy CO_2e)

Operating Scenario	Equipment	Annual Operation (hr/yr)	Annual Power Consumption (MW/yr)[2]	Annual Scope 2 GHG Emissions (mtpy CO_2e)[1]
Initial Extent	1,200 ft Conveyor System	2,080	832	325
	50 Water Pumps	8,760	4,380	1,709
	Total		**5,212**	**2,034**

[8] 2020 Greenhouse Inventory, prepared by Puget Sound Energy and published online in June 2021: https://www.pse.com/-/media/PDFs/GHG_Inventory_2020.pdf

Maximum Extent	5,000 ft Conveyor System	2,080	3,467	1,353
	50 Water Pumps	8,760	4,380	1,709
	Total		**7,847**	**3,062**

Notes:
[1] Calculated using a 2020 PSE-specific emission factor of 873.9 lb/MWh.
[2] A 1 horsepower (HP) motor is assumed to use 0.001 megawatt-hour (MWh) of electricity.

Adding the worst-case potential Scope 1 and Scope 2 emissions at the maximum extent of mining results in overall annual GHG emissions of 4,559 mtpy of CO_2e.

There are no well-established nor well-recognized thresholds for determining whether GHG emission rates from a project would be considered significant, although there are reporting thresholds established by the USEPA and by Ecology for stationary sources. Furthermore, GHG emission rates are reported by Ecology for the State of Washington, by USEPA for the United States, and by the World Resources Institute (and others) for the entire globe. The large-scale (United States and global) emission inventories are relevant since the impacts due to GHG emissions are considered to be global in scale.

Even these maximum potential worst-case GHG emissions from the proposed sources are less than half of the reporting thresholds identified by Washington State (10,000 mtpy CO_2e) and federal agencies (25,000 mtpy CO_2e). The three-year average GHG emissions (2013 to 2015) for all sources in Washington State was 97.4 million mtpy CO_2e. The GHG emissions from the proposed project would represent a very small percentage of the total state-wide inventory.

3.2 Construction Impacts

Construction related to the project will include site preparation activities such as logging and clearing, topsoil removal, and construction of perimeter berms using diesel-powered, heavy equipment (e.g., dozers and loaders). During construction, fugitive dust from site preparation may temporarily cause a localized ambient concentration increase of particulate matter (PM_{10} and $PM_{2.5}$). In addition, heavy machinery will emit diesel engine exhaust pollutants that could slightly degrade local air quality in the immediate vicinity of the activity. However, these emissions will be temporary and localized and are expected to be minimal in comparison to regional emissions considering the limited amount of this equipment.

In addition to emissions from diesel-powered equipment, logging of the site in preparation of mining may result in GHG emissions due to the removal of the trees. The extent of the GHG emissions will ultimately depend on the final use of the logs. For example, use of the trees to produce wood products used in construction would result in the storage of some of the GHG emissions. Regardless of the ultimate use of the trees, GHG emissions resulting from the logging of the site would be minimal in comparison with other local sources, such as truck and vehicular traffic.

4. MITIGATION

By virtue of the process, gravel extraction releases fugitive dust. Because of the local climate, much of the material excavated as part of this proposal would be wet much of the year, thereby reducing the potential for fugitive dust emissions. Regardless, the existing mine and the expansion due to the proposal is subject to local and federal air pollution regulations that require precautions to minimize impacts on air quality. PSCAA, the local air pollution agency with jurisdiction over this area, regulates sources of fugitive dust under Section 9.15 of PSCAA Regulations. Section 9.15(c) states that reasonable precautions must be employed to prevent visible fugitive particulate material from becoming airborne. Reasonable precautions include, but are not limited to:

- The use of control equipment, enclosures, and wet (or chemical) suppression techniques, as practical, and curtailment during high winds;
- Surfacing roadways and parking areas with asphalt, concrete, or gravel;
- Treating temporary, low-traffic areas (e.g., construction sites) with water or chemical stabilizers, reducing vehicle speeds, constructing pavement or rip rap exit aprons, and cleaning vehicle undercarriages before they exit to prevent the track-out of mud or dirt onto paved public roadways; or
- Covering or wetting truck loads or allowing adequate freeboard to prevent the escape of dust-bearing materials

Although not specifically identified as mitigation with regards to GHG emissions, CalPortland is the only industrial company in the United States that has reduced energy consumption and been recognized by EPA as an Energy Star Partner for 17 consecutive years. Specific actions taken at the overall Pioneer Aggregates operation that reduce energy consumption and associated greenhouse gas emissions include the following:

- Converting incandescent lighting systems to LED and implementing motion-activated lighting,
- Regenerating electricity from the conveyor belt leading downhill to the barge loadout facility, and
- Participating in PSE's Schedule 258 electricity energy efficiency program.

5. CONCLUSION

With the appropriate application of some or all the mitigation measures described above and consistent use of best management practices, no significant air quality impacts are expected from the South Parcel Expansion Project.

Appendix D

Stormwater Management Report

STORMWATER MANAGEMENT REPORT

South Parcel Project

Prepared for: CalPortland

Project No. 040001-016-02 • February 23, 2021

Aspect CONSULTING

earth + water

STORMWATER MANAGEMENT REPORT

South Parcel Project

Prepared for: CalPortland

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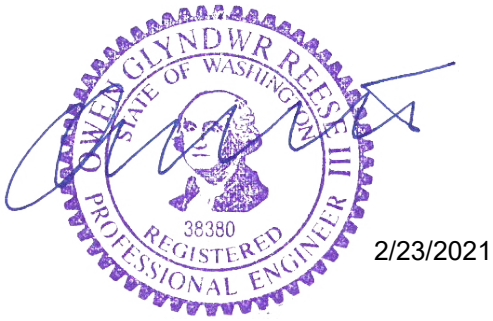
Aspect Consulting, LLC



2/23/2021

Breeyn Greer, PE
Project Engineer
bgreer@aspectconsulting.com

Owen G. Reese, PE
Sr. Associate Water Resources Engineer
oreese@aspectconsulting.com

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Acronyms

Aspect	Aspect Consulting, LLC
BMP	best management practice
cf	cubic feet
cfs	cubic feet per second
DMC	City of DuPont Municipal Code
DNR	Washington State Department of Natural Resources
Ecology	Washington State Department of Ecology
ft/day	feet per day
H:V	horizontal to vertical
NCRS	Natural Resources Conservation Service
NGVD 29	National Geodetic Vertical Datum of 1929
NPDES	National Pollution Discharge Elimination System
O&M	operation and maintenance
PGHS	pollution-generating hard surfaces
PGPS	pollution-generating pervious surfaces
SCS	Soil Conservation Service
sf	square feet
SWMMWW	Stormwater Management Manual for Western Washington
SWPPP	stormwater pollution prevention plan
WWHM2012	Western Washington Hydrology Model 2012

1 Project Overview

The Pioneer Aggregates South Parcel Project (hereinafter referred to as the "project") is an expansion of the existing mine operated by Glacier Northwest, Inc., doing business as CalPortland, in DuPont, Washington. The project includes horizontal expansion of mining into approximately 188 acres previously undisturbed by mining, and vertical expansion of approximately 125 acres where re-mining will deepen a portion of the existing mine. The project would extend mining at the current rate for approximately 14 additional years. This document describes the proposed stormwater management system for the project.

CalPortland is currently permitted to extract sand and gravel from a 497-acre area that includes the original mine permitted in 1997 (355 acres) and the North Parcel Expansion (142 acres), permitted in 2014. Activities on the existing site include extraction of sand and gravel, aggregate processing, concrete manufacture, and loading for transportation by barge and truck. Mining began in 1997, and the current mine has an estimated remaining life of 6 to 10 years. Mining is currently limited to 10 feet above groundwater.

The project would expand the mine area by 175 acres and allow deeper mining within portions of the existing mine. No changes are proposed to the processing area. The mine expansion would also include:

- Creation of a mitigation berm along a portion of the southern boundary to reduce noise and visual impacts.
- Creation of a wetland in the existing mine to mitigate for impacts to the Kettle Wetland.

Groundwater is present at shallow depths in the expansion area and the portion of the existing mine underlain by the Olympia beds (a lower permeability geologic unit below the glacial sand and gravels being mined). Mining in these areas requires constructing a temporary dewatering system consisting of a series of wells to draw down groundwater and allow mining to advance along the eastern perimeter of the expansion area. After removing the overlying sand and gravel, a drainage swale would be constructed in the underlying low permeability soils to intercept groundwater seepage and discharge it to a new mitigation wetland to be constructed on the bottom of the existing mine. Overflow from the mitigation wetland would flow to a new infiltration facility complete in the Steilacoom gravels on the bottom of the existing mine. Infiltrated water will join the sea level aquifer and ultimately flow into Puget Sound.

This report describes the proposed stormwater management system at completion of mining. These facilities would be constructed as mining advances and would also be used as the primary components of temporary stormwater management.

2 Summary of Minimum Requirements

The minimum requirements for stormwater management for new development and redevelopment are established in Chapters 22.01.200 and 22.01.090 of the City of DuPont Municipal Code (DMC), which collectively adopt the minimum requirements of the 2012 Washington State Department of Ecology's (Ecology) Stormwater Management Manual for Western Washington, as amended in 2014 (2014 SWMMWW; Ecology, 2014a) and as further amended by Appendix 1 of the National Pollution Discharge Elimination System (NPDES) Phase II general permit (Ecology, 2014b), which specifically addresses minimum requirements. This section describes how the proposed project complies with the nine minimum requirements identified in Appendix 1 of the Phase II NPDES permit.

As the project would disturb more than 7,000 square feet and would convert greater than 2.5 acres of native vegetation, all nine minimum requirements apply.

2.1 Minimum Requirement #1 – Preparation of Stormwater Site Plan

CalPortland will prepare a Stormwater Site Plan in accordance with Section 4.1 of Appendix 1 of the Phase II NPDES permit.

2.2 Minimum Requirement #2 – Construction Stormwater Pollution Prevention Plan

A Construction Stormwater Pollution Prevention Plan has been developed and is included as Appendix A. Much of the site will drain internally. Erosion and sediment control for the internally draining areas will generally be governed by the Sand and Gravel NPDES General Permit and the Reclamation Plan.

2.3 Minimum Requirement #3 – Source Control of Pollution

Source control best management practices (BMPs) will be implemented to prevent contamination of surface or ground waters.

2.4 Minimum Requirement #4 – Preservation of Natural Drainage Systems and Outfalls

The natural drainage pattern would be preserved with site development. Precipitation falling on the project site would be collected and infiltrated. From there it would join the sea-level aquifer and flow through subsurface to Puget Sound, as it does currently. There are no outfalls or other discharges of stormwater to surface water.

2.5 Minimum Requirement #5 – On-site Stormwater Management

All stormwater falling within the closed depression of the mine will be infiltrated, preserving the natural drainage pattern and retaining runoff on-site. The specific on-site stormwater management BMPs identified in List #2 of Section 4.5 of Appendix 1 of the Phase II NPDES permit are generally not applicable to the project as no hard surfaces will be created. Soil quality and depth will be managed in accordance with a Washington State Department of Natural Resources (DNR)-approved Reclamation Plan.

2.6 Minimum Requirement #6 – Runoff Treatment

Runoff treatment is required for sites that exceed minimum thresholds for pollution-generating pervious or hard surface areas as stated in Section 4.6 of Appendix 1 of the Phase II NPDES permit.

The proposed project exceeds the thresholds requiring treatment for pollution-generating surfaces. The type of treatment required is Basic Treatment as the project discharges to ground and the groundwater flows to a marine water. The site does not require Oil Control as the heavy vehicle and traffic loading does not meet the threshold for a "high-use" site.

Runoff treatment BMPs (two-celled wet ponds) are included upstream of proposed infiltration facilities. Treatment facility types were selected based on guidance in the 2014 SWMMWW. The facilities were sized to treat 91 percent of site runoff using the Western Washington Hydrology Model 2012 (WWHM2012).

2.7 Minimum Requirement #7 – Flow Control

Section 4.7 of Appendix 1 of the Phase II NPDES permit requires all projects that do not discharge to a flow control-exempt surface water to provide flow control to reduce the impacts of stormwater runoff. The proposed project meets this requirement by draining internally to infiltration ponds. Thus, the proposed surface flow leaving the site would be 0 cubic feet per second (cfs) for all storms; with sufficient infiltration capacity to infiltrate 100 percent of runoff simulated with WWHM2012.

2.8 Minimum Requirement #8 – Wetlands Protection

Additional water quality and flow control protections are required for stormwater discharges to wetlands. No stormwater will be discharged to any natural wetlands. Once reclaimed, stormwater from the eastern slope of the proposed mine expansion will be collected along with groundwater inflows and drain to a mitigation wetland to be constructed on the floor of the existing mine. There are no pollution generating hard surfaces (PGHS) or pervious surfaces (PGPS) within the drainage area tributary to the wetland.

2.9 Minimum Requirement #9 – Operation and Maintenance

An operation and maintenance (O&M) manual, consistent with Volume V of the 2014 SWMMWW will be provided for the proposed stormwater facilities and BMPs.

3 Existing Site Conditions

This section describes the existing site conditions within the active mine site and proposed project area. The existing site features and adjacent streams and wetlands are shown on Figure 1.

3.1 Site Geology

The geologic unit being mined is the Quaternary Vashon recessional outwash, predominantly comprised of sand and gravel. The first detailed study of the outwash sequence in the mine was conducted by CalPortland in 1988 and 1989 to evaluate the resource (Lonestar Northwest, 1989). At that time, borings were drilled through the sand and gravel and into the underlying silts on approximately 500-foot centers. Numerous subsequent studies were conducted for the specific area being proposed for mining in these plans, beginning largely in 1999 (CH2M Hill, 2000 and 2003; Aspect, 2004 and 2005a).

The sand and gravel outwash includes two generalized units in the area of the mine: the Steilacoom gravel, and an older Vashon outwash unit. The Steilacoom gravel is a highly permeable flood deposit that occurs at ground surface throughout the Sequalitchew Creek basin. Steilacoom gravel is the deposit that is currently being mined by CalPortland. It is estimated to be roughly 40 to 50 feet thick in the eastern expansion area.

Below the Steilacoom gravel is an older outwash deposit indicated by greater density, more silty layers, and lower hydraulic conductivity. This lower section of sand and gravel occurs in the eastern expansion area (Figure 2). It is approximately 30 to 40 feet thick.

Underlying the sand and gravel outwash are the Olympia Beds—a glacially overridden sequence of nonglacial, low-permeability silts and sands. This unit has been called the Kitsap Formation in geologic reports older than 1999 (Troost, 1999). The Olympia Beds occur at an elevation ranging from approximately 90 to 140 feet[1] in the planned mining area. This unit is estimated to be at least 40 feet thick in the project area and to occur to an elevation of 50 feet or lower (URS, Inc. and Pioneer Technologies Corporation, 2003).

Figure 2 presents a hydrogeologic cross section through the existing mine and the proposed expansion area. Depositional processes of the Steilacoom gravel eroded away the western end of the Olympia Beds and older outwash creating a discontinuity between the existing mine and the expansion area. In the eastern expansion area, the Olympia Beds hold groundwater elevations high by its relatively low permeability compared to the Steilacoom gravel to the west. The absence of Olympia Beds to the west creates a groundwater fall into the existing mine area. In this area, the

[1] All elevations presented in this report reference the National Geodetic Vertical Datum of 1929 (NGVD 29).

groundwater levels drop by over 100 feet in less than 500 feet (gradient between 0.1 and 0.2 feet/feet).

Appendix B provides more detailed descriptions of the expansion area geology and groundwater conditions.

3.1.1 Surficial Soils

According to the Natural Resource Conservation Service (NRCS) 2004 soil study for Pierce County, two surficial soil types are present in the planned mine area: Alderwood sandy gravelly loam and Spanaway sandy gravelly loam (NRCS, 2004). Both are typical of outwash gravels. The extent of these soils is shown on Figure 1. Both soils allow rapid infiltration of stormwater and their easy drainage encourages the establishment of plant communities that tolerate dry conditions.

3.2 Groundwater Conditions

Groundwater occurs at an average depth of approximately 10 to 15 feet below ground surface within the Steilacoom gravel. Groundwater levels fluctuate annually with precipitation and precipitation readily infiltrates the area soils. In the expansion area, groundwater levels are typically 7 feet higher in the winter/spring months than in summer/fall, ranging from approximately 197 to 190 feet elevation.

The aquifer is differentiated into an upper zone in the Steilacoom gravel, and a lower zone in the older outwash. The upper aquifer zone is more permeable with an estimated average hydraulic conductivity of 850 feet per day (ft/day). The lower zone is estimated to have an average hydraulic conductivity of 31 ft/day.

Four pumping tests were conducted in the aquifers beneath the site, with monitoring in both the upper and lower zones. Wells TW-1, TW-2, TW-3, and TW-4 (see Figure 1) were located and tested around the eastern boundary of the proposed expansion area. The 1- to 3-day tests provide good information on expected groundwater conditions during mining. These data, together with groundwater flow modeling and area-wide hydrology monitoring (Aspect, 2004, 2005b, 2007, and 2017b) have been used evaluate the groundwater system, and groundwater control during mining. The South Parcel Monitoring Plan (Appendix B) provides additional information on the predicted groundwater conditions during and following mining.

3.2.1 Sensitive Areas

Sensitive areas are present within the project site and would be impacted by the proposal. The following sections describe the wetlands, stream, and steep-slope sensitive areas present on-site and summarize any project activities within them.

3.2.2 Wetlands

One wetland, known as the Kettle wetland, is present within the proposed project area. It was delineated by Anchor QEA and is more thoroughly described and evaluated in their Kettle Wetland Delineation Report (Anchor QEA, 2020a).

The Kettle wetland is 1.78 acres of Category III wetland located near the eastern boundary of the existing lease area (Figure 1). The Kettle wetland would be dewatered shortly after the dewatering system is brought on line and subsequently removed by

mining. The dewatering and subsequent removal would be mitigated via the construction of a mitigation wetland within the existing mine.

3.2.3 Stream

Sequalitchew Creek forms the southern boundary of the project area. In accordance with DMC 25.105.070 (4)(a), a 100-foot buffer measured from the stream bank is maintained along the stream corridor throughout the project area.

3.2.4 Steep Slopes

Steep slopes (greater than 40 percent) are present along the Sequalitchew Creek ravine and western slope facing Puget Sound. The boundary of steep slope areas was defined using ArcGIS and light detection and ranging (LiDAR) topographic data (which provides better resolution than aerial mapping in areas of dense vegetation).

In accordance with DMC 25.105.070(2), the project Geotechnical Report (Aspect, 2020) recommends maintaining at least a 50-foot buffer from the top of steep slopes. Consistent with the 2012 Settlement Agreement, the project includes a 100-foot buffer along the top of the slope along the Sequalitchew Creek ravine. The 100-foot buffer provides ample protection for steep slopes.

3.3 Site Hydrology

The existing site hydrology is dominated by evapotranspiration and infiltration. Surface soils are coarse, so precipitation falling on the site infiltrates and either is ultimately transpired by vegetation or flows in the subsurface to Puget Sound or to a lesser extent to Sequalitchew Creek (e.g., through the seeps in the ravine, such as the Seep wetland located near the proposed confluence).

The expansion area is generally flat and vegetated, with some cleared areas and gravel roads. Conifer forest, dominated by Douglas fir, covers 90 percent of the expansion area. A smaller clearing, approximately 13 acres in size in the northern portion of the expansion area, was once considered a prairie-type habitat, but is now dominated by Scot's broom. Surficial soils, shown on Figure 1, are classified by the NRCS Soil Survey (2004) as Spanaway gravelly sandy loam, which are characterized as "deep somewhat excessively drained soils formed in glacial outwash."

The Kettle wetland is the only surface water body within the existing mine or expansion area. The Kettle wetland is hydrologically connected to the Vashon aquifer. The Kettle wetland receives water primarily from groundwater inflows, but also from direct precipitation and any runoff generated within the kettle that surrounds it. The Kettle wetland does not have a surface discharge.

The active mine forms a closed depression so all stormwater generated within the mine either infiltrates or evaporates. Exposed soils within the existing mine consist of bare sand and gravel side slopes, where active mining is occurring, and compacted roads and equipment operating areas. Within the reclaimed portions of the mine the side slopes have been covered with topsoil and revegetated, and fine soil resulting from gravel washing (i.e., belt press fines) has been placed on the mine bottom. There have been no

water quality or flooding problems associated with stormwater management within the active mine. There are no surface water discharges from the mine.

Several industrial warehouses, including Industrial Place and the Amazon Fulfillment Center, are located east of the project. These warehouses manage stormwater through infiltration, preceded by water quality treatment. There is no off-site run-on to the proposed project site.

Existing site stormwater conditions were not analyzed with a hydrologic model because there is no runoff currently occurring. As stormwater management for the mine will largely use infiltration, hydrologic model results for the existing condition are not important for correctly designing the water quality treatment and infiltration facilities.

4 Developed Site Conditions

The project would allow for the extraction of approximately 25 million cubic yards of sand and gravel from the expansion area and newly dewatered areas of the existing mine. Postmining conditions are shown on Figure 3. The project includes multiple two-cell stormwater treatment ponds and infiltration basins. The project also includes the following additional elements:

- A constructed wetland to mitigate impacts to the Kettle wetland. Groundwater emanating from the toe of the eastern mine slope of the South Parcel will be collected and conveyed to the wetland to be constructed within the existing mine.
- A berm along the southern boundary to mitigate noise and visual impacts.
- Grading for two future roads descending into the mine from the southwest corner. The road beds would be graded, but would not be paved as a component of this project.

4.1 Dewatering Plan

Dewatering will be required for control of groundwater during mining as outlined in the South Parcel Monitoring Plan (Monitoring Plan; Aspect, 2017a).

Mining of the South Parcel will proceed slowly from the north to the south over a period of 5 to 8 years, extracting gravel to create a broad trough along the eastern property boundary. Wells will be installed and pumped in advance of mining to intercept groundwater and dry out the gravels for mining. The purpose of mining a trough is to minimize the amount of time that active dewatering by pumping wells is required. Once mining of each section of trough is completed, the adjacent wells can be turned off, allowing groundwater to passively seep from the stable mine slope and flow by gravity to an infiltration facility on floor of the existing mine. After mining the trough along the perimeter, gravel will be extracted from the interior area.

The dewatering plan consists of four steps:

Step 1 – Initial Pumping Test. The initial step is a 60-day pumping test that is completely reversible (i.e., no gravel will be extracted during the test). The results of that test will be analyzed and evaluated, and plans adjusted as necessary prior to commencing the next phase.

Step 2 – Preparation for Mining/Dewatering Test. The second step involves installing and pumping additional dewatering wells to lower water levels in the first mine segment in preparation for mining. This step would last about 6 months and functions as a greatly expanded pumping test. As with the first step, it is also completely reversible.

Step 3 – Active Dewatering during Mining. This step involves mining the trough described above. Additional dewatering wells will be installed and pumped as mining

progresses. Mining would begin at the location farthest from the Edmond Marsh and Sequalitchew Creek and proceed slowly south. Completing the trough would require 5 to 8 years depending on market conditions and the success in meeting predicted groundwater levels. The potential impact on groundwater levels builds slowly over time as wells are added and mining progresses south. This allows ample opportunity to monitor and adapt to the conditions observed before mining proceeds into each dewatered segment.

Step 4 – Cessation of Active Dewatering. The final step begins when mining of the trough is complete and the last dewatering well is turned off. Groundwater, no longer intercepted by wells, would form seeps at the toe of the eastern mine slope. It would flow by gravity through newly created wetlands and a vegetated swale to an infiltration pond located at the bottom of the existing mine. Groundwater discharge from the toe of the slope would continue in perpetuity. Once this step has begun, further mining activities in the interior of the South Parcel would not affect groundwater.

4.2 Mine Phasing

Mining activity has been divided into four segments, each consisting of two to four sequence areas. Sequence areas generally represent 1 to 2 years of mining, but the actual rate of mining will vary based on market conditions unforeseeable at this time. The mining sequence is shown on Sheet C3 of the Conditional Use Permit plan set.

Segment 1. Mining would begin from the bottom of the existing conveyor in the northeast corner of the existing permit area. Mining in Segment 1 involves excavating a deep, relatively narrow trough going south along the eastern property boundary. The trough would have a bottom width of about 200 feet, allowing room for a conveyor with access roads on each side, and toe ditches to convey stormwater and any intercepted groundwater.

The trough would begin in the existing mine area and would proceed to advance to the southeast, parallel to the conveyor, until reaching the eastern boundary of the expansion area. Mining would then turn to the south, advancing the trough along lease boundary for approximately 2,500 feet. From there, the trough would turn to the southwest and would be advanced about 2,000 feet and widened out

Segment 1 would be graded to drain to the north to a new water quality treatment pond and infiltration pond (Pond C) located in the existing mine.

Segment 2. Mining in Segment 2 would proceed to the northwest, ultimately connecting to the existing mine excavation. As the last sequence of Segment 2, mining would return to excavate the benches in the southeast corner of the expansion area.

Segments 3 and 4. Segments 3 and 4 involve extracting material from the center of the expansion area and existing mine. Mining would start at the southern portion of the trench and proceed west toward the existing mine. On reaching the existing mine, mining would start again from the trench in the next Segment to the north. The conveyor would be retracted as mining proceeds to the north.

4.3 Developed Site Hydrology

Site hydrology for developed conditions was evaluated using guidance provided in the 2014 SWMMWW. The WWHM2012 was used for sizing of the infiltration and water quality facilities per Ecology standards. Model input and out for WWHM2012 is included in Appendix C.

4.3.1 Basins

The site was divided into five drainage basins, labeled C, D, E1, E2, and E3[2]. These drainage basins were based on the proposed topography (Figure 4). A brief description of drainage patterns of each basin follows.

Basins C and D drain internally to infiltration ponds located in the existing mine and include about 390 acres of the existing mine and expansion area. When mining is completed, each basin will include mine side slopes, large areas of rolling terrain where sand and gravel will be excavated exposing the lower-permeability Olympia Beds, and a relatively flat area at elevation 25 to 50 feet in the bottom of the existing mine.

Basins E1, E2 and E3 consists of 92.6 acres of the mine side slopes and mitigation wetland which drain to the ditches designed to capture and convey groundwater emanating from the toe of the mined slope once active dewatering has ceased. Basin E1 consists of the slopes on the southern and southwestern corner of the mine as well as the mitigation wetland itself. Basin E1 drains to the mitigation wetland, then eventually infiltration pond E. . Basin E2 includes the western slopes that will drain to the ditch that conveys outflow from the wetland to the infiltration pond; it also includes infiltration pond E. Basin E3 consists of the eastern slopes that drain to the groundwater capture trench running along the toe of those slopes.

4.3.2 Land Types

Each basin was subdivided into smaller areas based on soil types, vegetative cover, and slope (Figure 4). The total areas calculated for each resulting land classification are presented in Table 1.

Table 1. Land Types by Basin in Acres

	Till Lawn			Outwash Lawn				Imperv.	
Basin	Flat	Mod.	Steep	Flat	Mod.	Steep	Wetland	Steep	Total
C	57.5	49.3	20.7	19.2	0.0	14.4	0.0	1.0	162.1
D	11.9	144.1	26.3	4.0	41.5	0.0	0.0	0.0	227.8
E1	2.2	0.0	0.0	0.0	0.0	34.1	4.3	0.0	40.6
E2	10.5	0.0	0.0	3.5	0.0	20.1	0.0	0.0	34.2
E3	0.0	0.0	0.0	0.0	0.0	17.9	0.0	0.0	17.9
Total	82.1	193.5	47.0	26.6	41.5	86.5	4.3	1.0	482.5

[2] Basins A and B are part of the North Parcel Mine Expansion (Aspect, 2012).

After the final phase of mining is complete, the developed site will be primarily composed of two types of pervious soils:

- Advance outwash and/or Steilacoom gravel deposits, which were modeled as outwash (Soil Conservation Service [SCS] soil type A/B), and
- Olympia Beds, which will be still covered by about 10 feet of gravel left in place after mining, but were conservatively modeled as till (SCS soil type C).

WWHM2012 uses three slope classifications: flat (0 to 5 percent slope), moderate (5 to 15 percent slope) and steep (greater than 15 percent slope). Vegetation categories are lawn, pasture, or forest, of which lawn generates the most runoff and is typically used to represent developed landscapes even if actual plantings will eventually more closely resemble a pasture or forest. As such, lawn was used as the vegetation for all land uses in the model.

The WWHM2012 categories were applied to different areas of the mine as follows:

- Till Lawn – Used for the Olympia Beds (even though overlain by 10 feet of gravel), areas of the existing mine where belt press fines have been placed (assumed to be 75 percent of the mine floor west of the edge of the Olympia Beds), and the mitigation berm.
- Outwash Lawn – Surfaces comprised of advance outwash and/or Steilacoom gravel, including mine side slopes, and the terraces in the southwest corner of the South Parcel. Twenty-five percent of the mine floor west of the edge of the Olympia Beds was assumed to be outwash lawn.
- Impervious – The surface of the compacted gravel access road in Basin C.

4.3.3 Incorporating Groundwater Inflow

Groundwater discharges were added to the WWHM2012 model for Basin E to ensure the infiltration pond has adequate capacity to infiltrate captured groundwater in the long-term.

A three-dimensional groundwater model was used to predict groundwater discharge at the toe of the mined slope after the cessation of active dewatering (i.e., in Step 4). The model results are documented in the Groundwater Model Update (Aspect, 2017b).

Groundwater discharge at the toe of the mine slope will vary from year to year and month to month. The maximum, average, and minimum groundwater discharges predicted by the model over the 12-year period simulated are shown on Figure 5. The maximum predicted groundwater discharge was 13.7 cfs, occurring in November, and the minimum was 4 cfs.

For design of infiltration pond E, groundwater inflow was conservatively assumed to be the maximum predicted by the model for each month (i.e., the blue line shown on Figure 5). A time series of the maximum monthly values was created and added as an inflow to the infiltration pond in WWHM2012. The maximum monthly values were used for all years in WWHM2012, regardless of the precipitation occurring in that year.

4.3.4 Peak Flows

Model-predicted peak flows for each basin are shown in Table 2. These flows represent the inflow to the infiltration ponds. The 15-minute time-step peak flows for the 100-year event ranged from 14.1 cfs for Basin E to 68.9 cfs for Basin C (Table 2).

Table 2. 15-Minute Peak Flows in cfs

Basin	Return Interval		
	2-year	25-year	100-year
C	7.2	31.8	55.9
D	9.5	42.8	75.7
E	14.2	16.3	17.1

5 Proposed Drainage System

This section describes the permanent drainage system that would be constructed as mining advances and would continue to operate after completion of mining and dewatering. The permanent system consists of water quality treatment facilities, infiltration ponds, and a network of open ditches to convey stormwater.

5.1 Water Quality Facilities

There are two water quality treatment facilities proposed for the project. The infiltration ponds in Basins C and D are preceded by two-cell wet ponds for solids settlement.

The volume of the water quality design storm for each basin was calculated using WWHM2012 (Table 3). Each water quality wet pond was designed to hold the BMP water quality volume determined by the model.

Table 3. Water Quality Design Volumes

Basin	Volume of Water Quality Storm in cf	Type of Settling Pond	Size Factor	Volume Required in cf
C	264,845	Basic Wet Pond	1	264,845
D	372,438	Basic Wet Pond	1	372,438

Notes: cf = cubic feet

The resulting wet-pond designs are summarized in Table 4. The ponds range in depth from 6 to 7 feet deep and each have 3:1 horizontal to vertical (H:V) side slopes. Two-celled ponds were designed to provide 30 percent of required storage in the first cell. Pond geometry was shaped to provide a flow path length to width ratio at least 3:1 at mid-depth. Each pond is equipped with 1 foot of freeboard and the upstream cell of each two-cell facility is designed to hold 1 foot of silt. The first cell of each wet pond would be lined with a compacted till layer a minimum 18 inches thick and compacted to 95 percent to retain water at all times, improving wet-pond function. The second cell would be unlined to promote infiltration.

Table 4. Wet Pond Dimensions

Pond	Cell	Depth in feet	Volume Provided in cf	Volume Required in cf
C	1	6	79,704	79,453
	2	7	187,614	185,391
D	1	6	111,816	111,731
	2	7	263,739	260,707

Notes: cf = cubic feet

5.2 Constructed Mitigation Wetland

As described in Section 3.2.1, above, the 1.78-acre Kettle wetland will be dewatered and ultimately removed by the proposed mining activities. To mitigate these wetland impacts, a constructed mitigation wetland is included in the proposed drainage system.

Groundwater discharges from the southern and southeastern mine slope and stormwater runoff from Basin E1 will provide the water source for the mitigation wetland. The groundwater source will provide a continuous inflow to the wetland throughout the year. Upon the completion of mining and revegetation, Basin E1 would not contain any PGPS and thus does not require water quality treatment.

5.3 Infiltration Studies

The three proposed infiltration ponds (C, D and E) will receive runoff from approximately 162, 228, and 93 acres, respectively. The ponds would be located on native outwash soils on the floor of the existing mine, as shown on Figure 3. These locations were evaluated and found suitable for the proposed facilities.

The infiltration ponds were designed to infiltrate all stormwater and groundwater generated within the mine. Key dimensions of the infiltration ponds are summarized in Table 5. The ponds were assumed to be rectangular with 3H:1V slopes, and a total depth of 6 feet (5 feet of active depth with 1 foot of freeboard).

The infiltration properties of soils in the pond areas were estimated using the methodology provided in Volume III, Chapter 3.3.6, Section 3 of the 2014 SWMMWW. This methodology relates infiltration rates to the grain-size characteristics of the soil. Grain-size information was obtained from CalPortland's gridded borings at the location and depth closest to the proposed pond locations (Lonestar Northwest, 1989). Data from the two borings closest to each infiltration pond, in the 168- to 188-foot depth range (which corresponds to the soils below the bottom of the infiltration ponds) were used to estimate infiltration rates. Conservative correction factors of CF_v = 0.33, CF_t = 0.40, and CF_m = 0.9 were applied.

The long-term infiltration rates corresponding with these grain-size results are 8.2, 8.1, and 8.2 inches per hour for Ponds C, D, and E, respectively. Calculations for the estimation of infiltration rates are presented in Appendix D.

The 'size infiltration pond' function in WWHM2012 was then used to determine the appropriate size of the infiltration pond, with preliminary dimensions being based on the amount of storage needed to fit the design volume simultaneously, and reducing it to account for infiltration, evaporation, and design storm hydrograph (Table 5). Infiltration Pond E also received groundwater inputs, as described above.

Table 5. Infiltration Pond Dimensions

Pond	Depth in feet (without freeboard)	Bottom Area in sf	Top Area at Max Water Level in sf	Side Slopes
C	5	50,762	66,748	3H:1V
D	5	37,655	68,755	3H:1V
E	6	57,807	82,120	3H:1V

Notes: sf = square feet

5.4 Conveyance

The conveyance system will consist of a network of open ditches that collect and route stormwater to the water quality facilities described above. In places where the slope is less than 2.5 percent, the ditches would be vegetated. Steeper ditches would require lining with cobbles for slopes up to 5 percent, or rip rap for steeper. The conveyance system was designed to convey the 25-year peak flow.

5.5 Dewatering System Flows and Discharges

The proposed dewatering system consists of two lines of wells located east and west of Segment 1 of mine excavation (Sheet C3 of Construction Plan Set). Groundwater pumped from these wells would be discharged to an infiltration pond on the floor of the existing mine.

The dewatering system would be constructed in phases ahead of the advancing mine excavation along the new creek corridor. Three phases are planned with each phase adding new pumping wells. As mining advances beyond the dewatering wells, the wells will be turned off, allowing groundwater to naturally discharge at the toe of the mined slope. The groundwater discharges will be collected in ditches and ponds and conveyed with the stormwater system into Pond E in the existing mine.

5.5.1 Groundwater Discharges to Stormwater System

Discharges to the infiltration ponds constructed for the stormwater system would include dewatering water from the wells located along the northern (DW-1 through DW-5) and west side of the Segment 1 mining area, and groundwater inflows to the base of the mine as mine sequences are completed and dewatering wells are turned off. Dewatering modeling results (Appendix A) indicate permanent discharges to the stormwater system, ultimately reaching Pond E, would reach a potential maximum of 13.7 cfs (Table 6).

Dewatering model results were incorporated into the WWHM2012 model by building a 15-minute time-step time-series flow file with the maximum monthly average groundwater inflow (in cfs) for each month. This time series uses the maximum average flow to produce a conservatively sized pond. The time series was inputted into infiltration Pond E along with stormwater runoff from watershed E, and the pond was sized based on those two inputs.

Table 6. Groundwater Discharges to Infiltration Pond E in cfs

	Dewatering Step	Average Annual Pumping Rate	Average Wet Season Pumping Rate	Groundwater Inflow to Base of Mine
1	Initial Pumping Test	3.6	5.5	-
2	Preparation for Mining/Expanded Pumping Test	5.2	8.8	-
3	Active Dewatering during Mining	6.9	12.2	-
4	Cessation of Active Dewatering	-	-	6.6 - 13.7

Notes: cfs = cubic feet per second

Dewatering discharges would be conveyed to internal infiltration Pond E through a pipeline system. The pipeline would parallel the well alignment, starting along the expansion area lease boundary and running north, then curving in and downslope near the existing access road from the processing plant.

6 Off-site Analysis

A qualitative downstream analysis was conducted in accordance with Option Guidance #2 of the 2014 SWMMWW.

Relevant and available information on the study area was reviewed, including boring logs from on-site resource evaluation, WRIA 14 basin planning efforts, DNR Forest Practices Activity Map, wetland inventories, and groundwater studies from adjacent sites (Fort Lewis Landfill 5). The Kettle wetland is the only surface water body present on the site. No streams or drainage channels were identified on the project site on the DNR Forest Practice Activity Map for the area. There were no existing drainage problems identified.

The off-site analysis indicated that there would be no potential impacts from the proposed stormwater management approach of infiltrating all stormwater within the closed depression of the proposed mine.

6.1 Spills and Discharges of Priority Pollutants

Mining equipment primarily would operate within the closed depression of the mine, which reduces the potential for discharges to surface water. A stormwater pollution prevention plan (SWPPP) has been developed for mine as a component of complying with the Sand and Gravel General NPDES permit. The SWPPP BMPs for mobile fueling, vehicle and equipment maintenance, and spill prevention and response. However, due to the internally draining nature of the project, discharges to surface water are not expected.

6.2 Discharges to Groundwater Recharge Zones

The infiltration ponds would discharge to the unconfined aquifer that in turn flows to Puget Sound. The stormwater discharges would be treated to remove suspended sediments prior to discharge. As infiltrated stormwater is treated and vehicle activity is generally limited to a few pieces of equipment, there is little risk of contamination of the shallow aquifer. There are no water supply wells downgradient of the site, so the proposed activities will not affect local drinking water supplies.

7 Special Reports and Studies

The following special reports and studies have been prepared as a component of the South Parcel Mine Expansion:

- Groundwater Model Update (Aspect, 2017b)
- Geotechnical Report (Aspect, 2020)
- Kettle Wetland Delineation Report (Anchor QEA, 2020a)
- Critical Areas Report (Anchor QEA, 2020b)

8 Other Permits

This section provides a list of other permits and approvals required for the project that would include conditions that affect the drainage plan. Those permits and approvals are:

- Sand and Gravel General NPDES Permit, issued by Ecology.
- Surface Mine Reclamation Permit, issued by DNR.

9 References

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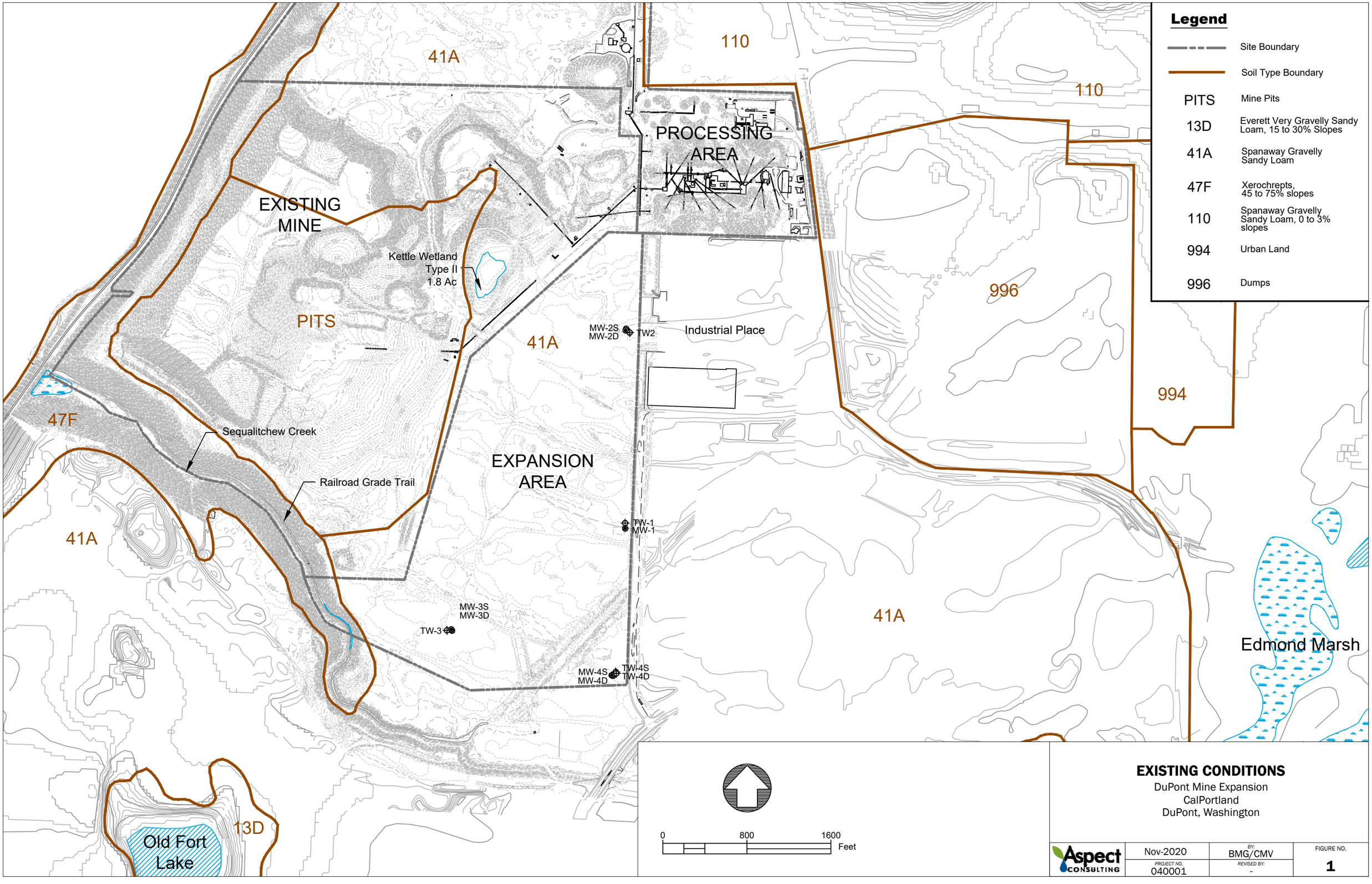
Washington State, Department of Ecology (Ecology), 2014b, Western Washington Phase II Municipal Stormwater Permit, Appendix 1 – Minimum Technical Requirements for New Development and Redevelopment. Accessed at: https://ecology.wa.gov/DOE/files/7a/7a6940d4-db41-4e00-85fe-7d0497102dfd.pdf. Modification Date: January 16, 2014.

10 Limitations

Work for this project was performed and this report prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. It is intended for the exclusive use of CalPortland for specific application to the referenced property. This report does not represent a legal opinion. No other warranty, expressed or implied, is made.

FIGURES



EXISTING CONDITIONS

DuPont Mine Expansion
CalPortland
DuPont, Washington

Aspect CONSULTING	Nov-2020	BY: BMG/CMV	FIGURE NO. 1
	PROJECT NO. 040001	REVISED BY: -	

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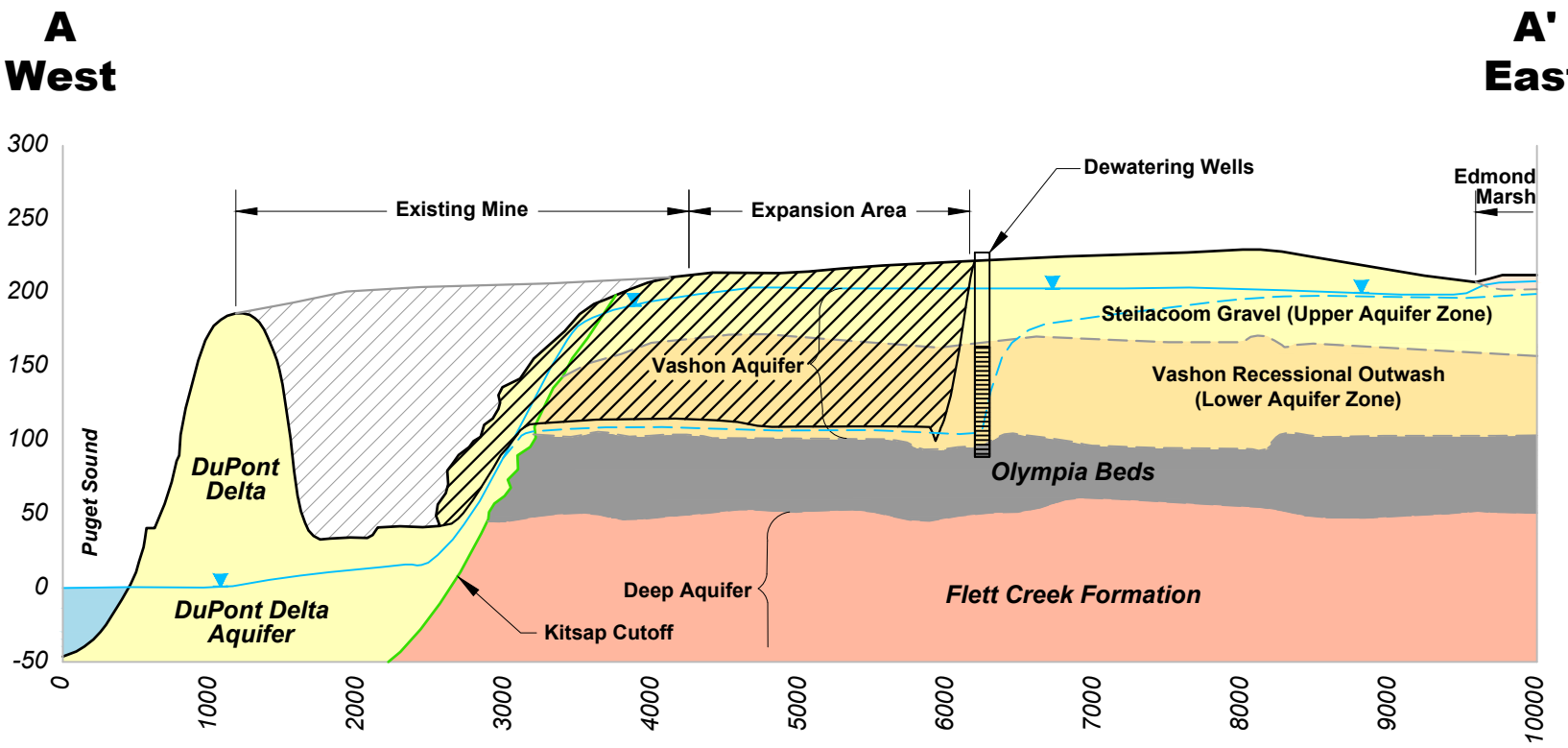

Note: Cross-Section from CH2M Hill, 2003, Figures 1-2 and 1-3.

Legend

- Existing Water Table
- Future Water Table
- Area to be Mined

0 125 250 Feet

0 1250 2500 Feet

Horizontal Scale: 1" = 1250'
Vertical Scale: 1" = 125'
Vertical Exaggeration 10x

GENERALIZED GEOLOGIC CROSS-SECTION

DuPont Mine Expansion
CalPortland
DuPont, Washington

Aspect Consulting	Nov-2020	BY: BMG/CMV	FIGURE NO. 2
	PROJECT NO. 040001	REVISED BY: -	

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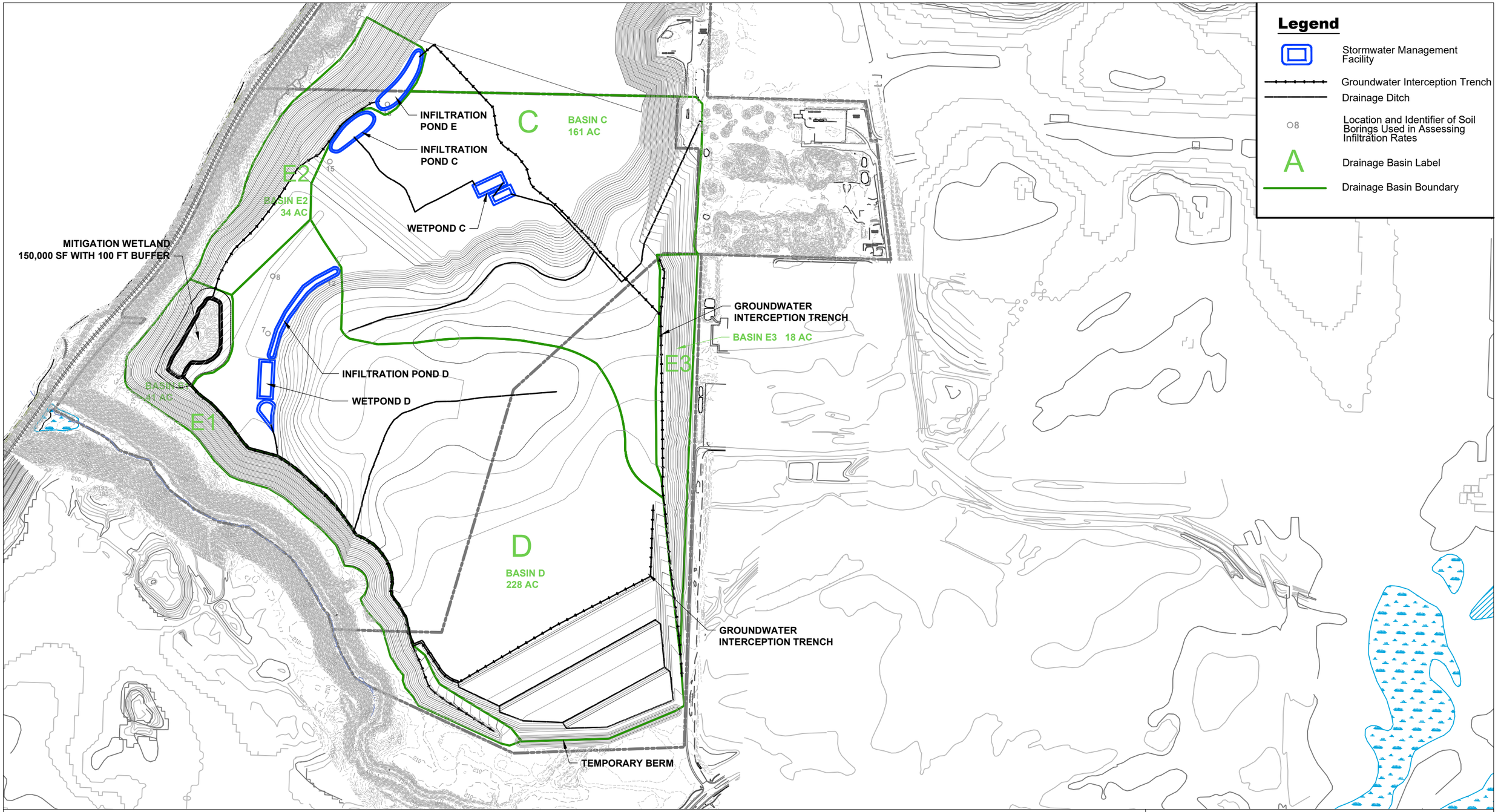

PROPOSED CONDITIONS

CalPortland
Dupont, Washington

Aspect CONSULTING	Nov-2020	BY: BMG/CMV	FIGURE NO. 3
	PROJECT NO. 040001	REVISED BY: -	

CAD Path: Q:\CalPortland\040001 DuPont Hydrologic Study\2020-11 SW Mgmt Report Figures\040001-03.dwg Figure 3 || Date Saved: Nov 25, 2020 4:17pm || User: cvanslyke

Legend

- OUTWASH LAWN
- 25% OUTWASH LAWN 75% TILL LAWN
- TILL LAWN
- IMPERVIOUS
- WETLAND
- SITE BOUNDARY

0 800 1600 Feet

STORMWATER MODEL INPUT

DuPont Mine Expansion
CalPortland
DuPont, Washington

Aspect CONSULTING	Nov-2020	BY: BMG/CMV	FIGURE NO. 4
	PROJECT NO. 040001	REVISED BY: -	

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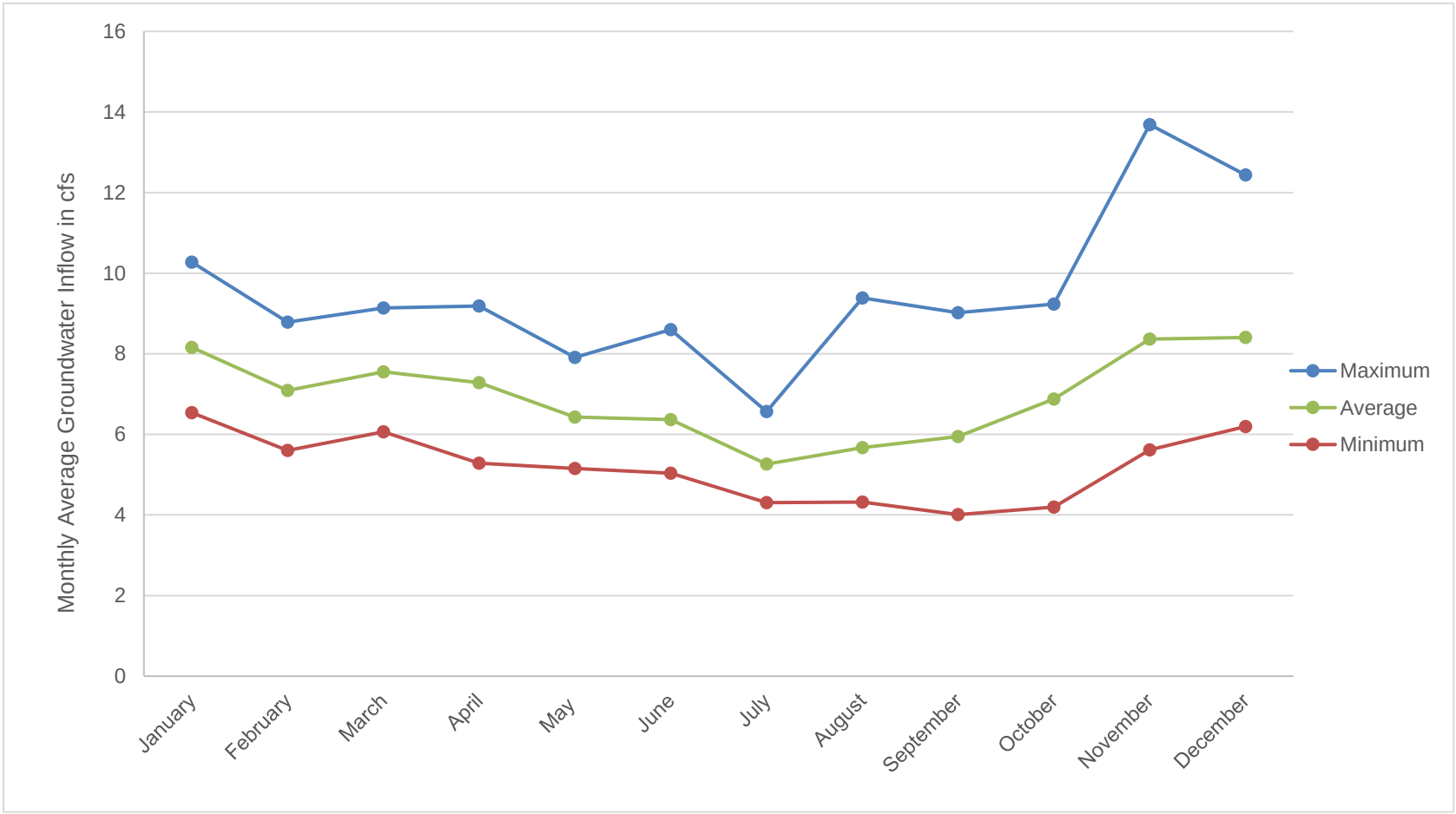

Figure 5
Monthly Variation in Groundwater Inflows
Preliminary Stormwater Management Report
DuPont WA

Aspect Consulting
02/23/2021
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APPENDIX A

Construction Stormwater Pollution Prevention Plan

CONSTRUCTION STORMWATER POLLUTION PREVENTION PLAN

Pioneer Aggregates South Parcel Project

Prepared for: CalPortland

Project No. 040001-016 • February 23, 2021

Aspect CONSULTING

earth + water

CONSTRUCTION STORMWATER POLLUTION PREVENTION PLAN

Pioneer Aggregates South Parcel Project

Prepared for: CalPortland

Project No. 040001-016 • February 23, 2021

Aspect Consulting, LLC

02/23/2021

Owen G. Reese, PE
Sr. Associate Water Resource Engineer
oreese@aspectconsulting.com

Breeyn Greer, PE
Project Engineer
bgreer@aspectconsulting.com

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Introduction

This document describes the Construction Stormwater Pollution Prevention Plan (CSWPPP) for CalPortland's Pioneer Aggregates South Parcel Project (hereafter referred to as the project) in DuPont, Washington. The project includes a 188-acre expansion of the existing mine.

Throughout the project, the following basic principles will form the core of the approach to preventing erosion at the site:

- Design the project to drain internally.
- Emphasize erosion control rather than sediment control.
- Minimize the extent and duration of area exposed.
- Keep runoff velocities low by encouraging infiltration where possible.
- Retain sediment on the site.
- Thoroughly monitor the site and maintain erosion and sediment control (ESC) measures.

The site will drain internally, eliminating the risk of off-site sediment delivery from erosion. ESC measures will be governed by the Sand and Gravel NPDES Permit requirements and Reclamation Plan.

Minimum Requirements

City of DuPont Municipal Code 22.01.200 requires that all projects comply with the *2012 Stormwater Management Manual for Western Washington* as Amended in December 2014 (2014 SMMWW; Ecology, 2014). Minimum Requirement #2 states that all projects disturbing 7,000 square feet or more prepare a Construction Stormwater Pollution Prevention Plan (SWPPP). The SWPPP contains 15 erosion and sediment control element requirements. The requirements are described individually below, with the code requirement in italic bullets followed by a description of how that requirement has been addressed in the proposed project. The summary of code requirements is omitted for elements that are not applicable.

Element #1: Preserve Vegetation/Mark Clearing Limits

- *Before beginning land disturbing activities, including clearing and grading, clearly mark all clearing limits, sensitive areas and their buffers, and trees that are to be preserved within the construction area.*
- *Retain the duff layer, native top soil, and natural vegetation in an undisturbed state to the maximum degree practical.*

Clearing limits for the mine will be marked with frequent and brightly colored flagging or posts. Given the size of the site, use of continuous clearing limit fencing would be economically and environmentally wasteful. The topsoil layer will be temporarily removed to facilitate mining, but those soils will be stockpiled on-site and used in mine reclamation in accordance with a Surface Mine Reclamation Permit from the Washington State Department of Natural Resources (DNR).

Element #2: Establish Construction Entrance

- *Limit construction vehicle access and exit to one route, if possible.*
- *Stabilize access points with a pad of quarry spalls, crushed rock, or other equivalent Best Management Plans (BMPs), to minimize tracking sediment onto roads.*
- *Locate wheel wash or tire baths on site, if the stabilized construction entrance is not effective in preventing tracking sediment onto roads.*
- *If sediment is tracked off site, clean the affected roadway thoroughly at the end of each day, or more frequently as necessary (for example, during wet weather). Remove sediment from roads by shoveling, sweeping, or pick up and transport the sediment to a controlled sediment disposal area.*
- *Conduct street washing only after sediment is removed in accordance with the above bullet.*

- *Control street wash wastewater by pumping back on site or otherwise preventing it from discharging into systems tributary to waters of the State.*

All equipment and trucks, if leaving the property, will use the existing wheel wash in the Processing Area. No new construction entrances will be created.

Element #3: Control Flow Rates

- *Protect properties and waterways downstream of development sites from erosion and the associated discharge of turbid waters due to increases in the velocity and peak volumetric flow rate of stormwater runoff from the project site, as required by local plan approval authority.*
- *Where necessary to comply with the bullet above, construct stormwater retention or detention facilities as one of the first steps in grading. Assure that detention facilities function properly before constructing site improvements (e.g. impervious surfaces).*
- *If permanent infiltration ponds are used for flow control during construction, protect these facilities from siltation during the construction phase.*

The proposed site drains internally into the mine depression and, therefore, poses little risk of discharging sediment past project boundaries. Construction of infiltration ponds will be sequenced to avoid siltation from active mining.

Element #4: Install Sediment Controls

- *Construct sediment control BMPs (sediment ponds, traps, filters, etc.) as one of the first steps in grading. These BMPs shall be functional before other land disturbing activities take place.*
- *Minimize sediment discharges from the site. The design, installation and maintenance of erosion and sediment controls must address factors such as the amount, frequency, intensity and duration of precipitation, the nature of resulting stormwater runoff, and soil characteristics, including the range of soil particle sizes expected to be present on the site.*
- *Direct stormwater runoff from disturbed areas through a sediment pond or other appropriate sediment removal BMP, before the runoff leaves a construction site or before discharge to an infiltration facility. Runoff from fully stabilized areas may be discharged without a sediment removal BMP, but must meet the flow control performance standard in Element #3, bullet #1.*
- *Locate BMPs intended to trap sediment on site in a manner to avoid interference with the movement of juvenile salmonids attempting to enter off-channel areas or drainages.*
- *Provide and maintain natural buffers around surface waters, direct stormwater to vegetated areas to increase sediment removal, and maximize stormwater infiltration, unless infeasible.*

- *Where feasible, design outlet structures that withdraw impounded stormwater from the surface to avoid discharging sediment that is still suspended lower in the water column.*

The proposed site drains internally and, therefore, poses little risk of discharging sediment from the construction site. All permanent infiltration ponds are preceded by water quality treatment BMPs to prevent clogging or reduction in long-term infiltration performance.

Element #5: Stabilize Soils

- *Stabilize exposed and unworked soils by application of effective BMPs that prevent erosion. Applicable BMPs include, but are not limited to: temporary and permanent seeding, sodding, mulching, plastic covering, erosion control fabrics and matting, soil application of polyacrylamide (PAM), the early application of gravel base early on areas to be paved, and dust control.*
- *Control stormwater volume and velocity within the site to minimize soil erosion.*
- *Control stormwater discharges, including both peak flow rates and total stormwater volume, to minimize erosion at outlets and to minimize downstream channel and stream bank erosion.*
- *Soils must not remain exposed and unworked for more than the time periods set forth below to prevent erosion.*
  - *During the dry season (May 1 – Sept. 30): 7 days.*
  - *During the wet season (October 1 – April 30): 2 days.*
- *Stabilize soils at the end of the shift before a holiday or weekend if needed based on the weather forecast.*
- *Stabilize soil stockpiles from erosion, protect with sediment trapping measures, and where possible, be located away from storm drain inlets, waterways, and drainage channels.*
- *Minimize the amount of soil exposed during construction activity.*
- *Minimize the disturbance of steep slopes.*
- *Minimize soil compaction and, unless infeasible, preserve topsoil.*

As the mine is internally draining, CalPortland proposes to comply with Element 5 by implementing the erosion control and reclamation requirements of their DNR Surface Mine Reclamation Permit.

Element #6: Protect Slopes

- *Design and construct cut-and-fill slopes in a manner to minimize erosion. Applicable practices include, but are not limited to, reducing continuous length of slope with terracing and diversions, reducing slope steepness, and roughening slope surfaces (for example, track walking).*

- *Divert off-site stormwater (run-on) or ground water away from slopes and disturbed areas with interceptor dikes, pipes, and/or swales. Off-site stormwater should be managed separately from stormwater generated on the site.*
- *At the top of slopes, collect drainage in pipe slope drains or protected channels to prevent erosion.*
    - *Temporary pipe slope drains must handle the peak volumetric flow rate calculated using a 10-minute time step from a Type 1A, 10-year, 24-hour frequency storm for the developed condition. Alternatively, the 10-year, 1-hour flow rate predicted by an approved continuous runoff model, increased by a factor of 1.6, may be used. The hydrologic analysis must use the existing land cover condition for predicting flow rates from tributary areas outside the project limits. For tributary areas on the project site, the analysis must use the temporary or permanent project land cover condition, whichever will produce the highest flow rates. If using the Western Washington Hydrology Model (WWHM) to predict flows, bare soil areas should be modeled as "landscaped" area.*
- *Place excavated material on the uphill side of trenches, consistent with safety and space considerations.*
- *Place check dams at regular intervals within constructed channels that are cut down a slope.*

Mine cut slopes will be constructed by cutting to final grade, followed by topsoil, surface roughening, and reclamation planting according to established reclamation practices currently used in the existing mine. CalPortland's mining technique leaves a series of ridges on the slope that helps prevent erosion prior to reclamation, by encouraging infiltration on the mine slopes.

Element #7: Protect Drain Inlets

Not applicable, no storm drain inlets are proposed.

Element #8: Stabilize Channels and Outfalls

- *Design, construct, and stabilize all on-site conveyance channels to prevent erosion from the following expected peak flows:*
    - *Channels must handle the peak volumetric flow rate calculated using a 10-minute time step from a Type 1A, 10-year, 24-hour frequency storm for the developed condition. Alternatively, the 10-year, 1-hour flow rate indicated by an approved continuous runoff model, increased by a factor of 1.6, may be used. The hydrologic analysis must use the existing land cover condition for predicting flow rates from tributary areas outside the project limits. For tributary areas on the project site, the analysis must use the temporary or permanent project land cover condition, whichever will produce the highest flow rates. If using the Western Washington Hydrology Model (WWHM) to predict flows, bare soil areas should be modeled as "landscaped area.*

- *Provide stabilization, including armoring material, adequate to prevent erosion of outlets, adjacent streambanks, slopes, and downstream reaches at the outlets of all conveyance systems.*

No temporary conveyance channels are proposed in areas with the potential to discharge off-site. CalPortland requests that the sizing and armoring requirements not apply within the internally draining portions of the mine. Current erosion control and mine reclamation practices within the existing mine have prevented erosion without requiring the use of armored drainage channels.

Element #9: Control Pollutants

- *Design, install, implement and maintain effective pollution prevention measures to minimize the discharge of pollutants.*
- *Handle and dispose of all pollutants, including waste materials and demolition debris that occur on-site in a manner that does not cause contamination of stormwater.*
- *Provide cover, containment, and protection from vandalism for all chemicals, liquid products, petroleum products, and other materials that have the potential to pose a threat to human health or the environment. On-site fueling tanks must include secondary containment. Secondary containment means placing tanks or containers within an impervious structure capable of containing 110% of the volume contained in the largest tank within the containment structure. Double-walled tanks do not require additional secondary containment.*
- *Conduct maintenance, fueling, and repair of heavy equipment and vehicles using spill prevention and control measures. Clean contaminated surfaces immediately following any spill incident.*
- *Discharge wheel wash or tire bath wastewater to a separate on-site treatment system that prevents discharge to surface water, such as closed loop recirculation or upland land application, or to the sanitary sewer, with local sewer district approval.*

CalPortland manages other potential pollutants at the existing mine under the requirements of the Sand and Gravel General Permit. The site is managed under a SWPPP that includes BMPs for mobile fueling, vehicle maintenance, and the loading, unloading, storage, and containment for potential pollutants. The SWPPP also includes a Spill Control Plan.

With the proposed project, CalPortland would continue to manage potential pollutants using the existing established BMPs. No new potential pollutant sources would be created.

Element #10: Control Dewatering

- *Discharge foundation, vault, and trench dewatering water, which have characteristics similar to stormwater runoff at the site, into a controlled conveyance system before discharge to a sediment trap or sediment pond.*
- *Discharge clean, non-turbid de-watering water, such as well-point ground water, to systems tributary to, or directly into surface waters of the State, as specified in Element #8, provided the de-watering flow does not cause erosion or flooding of receiving waters or interfere with the operation of the system. Do not route clean dewatering water through stormwater sediment ponds. Note that "surface waters of the State" may exist on a construction site as well as off site; for example, a creek running through a site.*
- *Handle highly turbid or contaminated dewatering water separately from stormwater.*
- *Other treatment or disposal options may include:*
    1) *Infiltration.*
    2) *Transport off-site in a vehicle, such as a vacuum flush truck, for legal disposal in a manner that does not pollute state waters.*
    3) *Ecology-approved on-site chemical treatment or other suitable treatment technologies.*
    4) *Sanitary or combined sewer discharge with local sewer district approval, if there is no other option.*
    5) *Use of a sedimentation bag with outfall to a ditch or swale for small volumes of localized dewatering.*

Dewatering is a significant component of the proposed project. CalPortland intends to manage dewatering via the Groundwater Model Update (Aspect, 2017). This comprehensive plan includes a cyclical process of dewatering, disposal, and monitoring that requires design modifications should the requirements not be met. Further, all dewatering discharge will be disposed of internally into an infiltration basin that will return the water to the deep aquifer than flows to the Puget Sound. No dewatering water will flow off-site.

Element #11: Maintain BMPs

- *Maintain and repair all temporary and permanent erosion and sediment control BMPs as needed to assure continued performance of their intended function in accordance with BMP specifications.*
- *Remove all temporary erosion and sediment control BMPs within 30 days after achieving final site stabilization or after the temporary BMPs are no longer needed.*

Maintenance would be performed according to the requirements of Ecology's 2014 SMMWW. Most of the ESC BMPs included in this plan are components of final site stabilization and would remain in place. However, if any Temporary Erosion and Sediment Control (TESC) measures are installed, they will be removed when no longer necessary.

Element #12: Manage the Project

- *Phase development projects to the maximum degree practicable and take into account seasonal work limits.*
- *Inspection and monitoring – Inspect, maintain, and repair all BMPs as needed to assure continued performance of their intended function. Conduct site inspections and monitoring in accordance with the Construction Stormwater General Permit or local plan approval authority.*
- *Maintaining an updated construction SWPPP – Maintain, update, and implement the SWPPP in accordance with the Construction Stormwater General Permit.*

CalPortland will manage the proposed mining project in compliance with Element #12, the Sand and Gravel General Permit, and DNR Surface Mine Reclamation Permit. Routine inspections and maintenance of the SWPPP would be performed as required by the Sand and Gravel General Permit.

Financial Liability

Per City of Dupont Municipal Code 22.01.295:

> *Performance bonding, or other appropriate financial instruments shall be required as determined necessary by the City to ensure compliance with these standards.*

Under the Washington State Surface Mining Act, CalPortland is required to obtain a Reclamation Permit and provide the DNR sufficient performance security to reclaim the permitted mine. Because DNR will hold the performance security and exclusive authority to regulate reclamation under Chapter 78.44 Revised Code of Washington (RCW), CalPortland respectfully requests that the City of DuPont waive their performance bond requirement for the area covered by the Surface Mine Reclamation Permit.

ESC Measures

The mine area will be graded to drain internally to three infiltration facilities located on the floor of the mine. Two of the infiltration facilities would be preceded by water quality treatment to remove suspended sediments, enhancing long-term performance of the infiltration ponds. The third infiltration facility has no Pollution Generating Pervious or impervious surfaces draining to it.

ESC in the internally draining areas is generally governed by the Sand and Gravel NPDES Permit, and the Reclamation Plan, which establishes the plan for permanently stabilizing the site for the postmining condition. As portions of the site are mined, slopes will be stabilized and replanted using methods and practices prescribed in the Reclamation Plan approved by DNR.

Construction Sequence

Because this project includes ongoing operation and removal of materials, the CSWPPP is flexible to allow for adjustments in operation. In addition, a phased approach will be adopted. Some erosion control measures apply regardless of the phase of the project, while other measures are specific to certain phases as described in the previous section.

The following describes the general sequence of project actions as they pertain to erosion control measures.

1. Initial site preparation of the Expansion Area (clearing and removal of overburden).
2. Excavation of Sequence Areas 1–4.
    a. Grade and plant slopes as mining progresses.
    b. Clear and grub next mine area concurrently with mining.
3. Continued excavation of overburden, mining, and sequential reclamation of remaining phases of the mine development (Segments 1, 2, 3, and 4).
4. Removal of equipment from mine area and conveyor route.
5. Final stabilization of site.

References

Aspect Consulting, LLC (Aspect), 2017, Groundwater Model Update, DuPont Mine South Parcel Expansion Area, Prepared for CalPortland, June 29, 2017.

Washington State Department of Ecology (Ecology), 2014, Stormwater Management Manual for Western Washington. Publication No. 04-10-076. Water Quality Program, Washington State Department of Ecology, Olympia, WA.

Limitations

Work for this project was performed and this report prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. It is intended for the exclusive use of CalPortland for specific application to the referenced property. This report does not represent a legal opinion. No other warranty, expressed or implied, is made.

APPENDIX B

South Parcel Monitoring Plan

SOUTH PARCEL MONITORING PLAN

DuPont Mine South Parcel Expansion Area

Project No. 040001-014-02 • November 22, 2017

CONFIDENTIAL
This document is confidential, and is intended for the sole use of CalPortland and the Environmental Caucus (and their designated attorneys and consultants) for the purpose of effectuating the provisions of the 2012 Settlement Agreement. Any distribution of this document to any other party, or use of this document for any other purpose, is prohibited.

Aspect CONSULTING

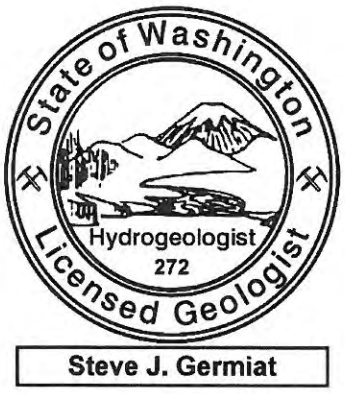
earth + water

SOUTH PARCEL MONITORING PLAN

DuPont Mine South Parcel Expansion Area

Project No. 040001-014-02 • November 22, 2017

Aspect Consulting, LLC



Steve Germiat, LHG
Principal Hydrogeologist
sgermiat@aspectconsulting.com

Owen Reese, PE
Senior Associate Water Resources Engineer
oreese@aspectconsulting.com

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1 Introduction

This document presents the Monitoring Plan for dewatering of the South Parcel of CalPortland's DuPont Mine. The South Parcel is a 177-acre property located southeast of the existing mine, shown on Figure 1. CalPortland proposes to expand the existing mine by extracting sand and gravel from the South Parcel. Groundwater saturates the lower level of gravels that are proposed for extraction. For mining to occur, these gravels of the South Parcel would need to be dewatered by installing a series of pumping wells to capture groundwater. The dewatering activity would affect groundwater levels in the surrounding area.

In 2011, CalPortland, the City of DuPont, Washington State Department of Ecology (Ecology), and a group of seven environmental organizations collectively known as the Environmental Caucus entered into a Settlement Agreement to define the conditions under which mining of the South Parcel could occur. The Settlement Agreement requires the development and permitting of a Restoration Plan for the Sequalitchew Creek watershed. It also requires the development of a Monitoring Plan for ensuring that changes in groundwater levels resulting from dewatering are within expected (and agreed-upon) limits.

Section 7.3 of the 2011 Settlement Agreement specifies that the Monitoring Plan will *"…include a series of monitoring actions to allow a comparison of predicted and actual changes in groundwater draw-down levels, and a process for the Parties to meet and confer if groundwater monitoring results do not meet the criteria provided in the Monitoring Plan."* This document was developed to meet that requirement.

The aim of the Restoration Plan is to increase available habitat for aquatic species through the restoration and enhancement of creek flow from Sequalitchew Lake to the Puget Sound. The Restoration Plan includes the following restoration actions, among others: comprehensive beaver management to restore flow from Sequalitchew Lake to West Edmond Marsh, improvements to the outlet of Sequalitchew Lake to reduce barriers to flow down the creek system, rehabilitating fish passage through the DuPont Railroad Trail by replacing a section of trail that is built on fill with a pedestrian bridge, culvert evaluation and replacement, and habitat restoration in Sequalitchew Creek downstream of Edmond Marsh. Implementing these actions will involve changes to marsh water levels and increases in Sequalitchew Creek flows.

The Restoration Plan actions are intended to occur concurrently with South Parcel mining activities. Under the terms of the Settlement Agreement, mining of the South Parcel cannot commence until all necessary permits for the Restoration Plan have been obtained. The Restoration Plan will include a monitoring component aimed at measuring the success of restoration actions and adaptively responding if goals are not met.

As specified in the Settlement Agreement, this Monitoring Plan focuses on observing and responding to changes in groundwater levels. Marsh water levels and streamflows will

also be monitored (as required by Section 7.2 of the Settlement Agreement), but they are not the focus of the adaptive management actions identified in the Monitoring Plan.

This Monitoring Plan consists of three components:

1) The main text, which outlines the framework for monitoring and decision making at a conceptual level.

2) A set of figures illustrating the performance thresholds for each month at each well in each dewatering step (Appendix A).

3) A sampling and analysis plan (SAP; Appendix B), which provides the specific details of monitoring, such as identification of monitoring locations, parameters, and frequency, as well as monitoring methods.

The parties acknowledge that the Monitoring Plan may be updated or amended by mutual agreement of the parties.

2 Goals and Objectives

This Monitoring Plan strives to monitor and respond to maintain groundwater at or above predicted levels beneath the marshes and Sequalitchew Creek, and manage groundwater to maintain conditions conducive to safe and efficient mining in the South Parcel.

Articulating the specific goals, objectives, and performance thresholds of a plan provides clarity in measuring the success of the actions taken and guidance for managing unanticipated circumstances. Goals are the overarching principles behind the Monitoring Plan. Objectives identify specific, measurable elements that are undertaken to meet the goal(s) of a project. They provide more detail on how the goals will be achieved, and criteria for determining when their achievement has occurred.

For each objective, a performance threshold is identified to measure success in meeting that objective. Failure to meet the performance threshold will trigger the adaptive management process and require iterative additional actions until it is met. If monitoring indicates that a performance threshold is not being met, additional action will be necessary and the adaptive management process (described in Section 4) will be used iteratively to identify and implement actions intended to improve conditions until the performance threshold has been met.

The goals, objectives, and thresholds of the Monitoring Plan are:

Goal 1. Maintain groundwater at or above predicted levels beneath Edmond Marsh and Sequalitchew Creek.

> **Objective 1A**. Groundwater levels at monitoring wells near Edmond Marsh and Sequalitchew Creek are at or above predicted levels.
>
> **Performance Threshold**: Monthly groundwater level measurements are at or above target levels established for each step of the dewatering process at each well and for each month of the year, based on statistical analysis of groundwater model predictions over a range of historical climate conditions. Initial target levels are included in Tables 4, 6, 8, and 10.

Goal 2. Maintain groundwater conditions conducive to safe and efficient mining and processing of the South Parcel aggregates.

> **Objective 2A**. Moisture content of mined aggregate is at appropriately low levels for safe and efficient mining and processing.

3 Dewatering Plan Overview

The entire mining process will take many years and is designed to proceed slowly from areas of least potential impact toward areas of increasing potential impact, allowing time and opportunity to confirm predictions and adaptively manage the mining and dewatering effort before irreversible changes occur.

Mining of the South Parcel will proceed slowly from the north to the south over a period of 5 to 8 years, extracting gravel to create a broad trough along the eastern property boundary. Wells will be installed and pumped in advance of mining to intercept groundwater and dry out the gravels for mining. The purpose of mining a trough is to minimize the amount of time that active dewatering by pumping wells is required. Once mining of each section of trough is completed, the adjacent wells can be turned off, allowing groundwater to passively seep from the stable mine slope and flow by gravity to an infiltration facility on floor of the existing mine. After mining the trough along the perimeter, gravel will be extracted from the interior area.

The following section describes four steps of the dewatering plan, but it is important to recognize that these steps occur on very different time scales. Figure 2 provides an overview of the timeline for the four steps of dewatering, assuming that mining proceeds rapidly during the period of active dewatering (Step 3).

The initial step is a 60-day pumping test that is completely reversible (i.e., no gravel will be extracted during the test). The results of that test will be analyzed and evaluated, and plans adjusted as necessary prior to commencing the next phase.

The second step involves installing and pumping additional dewatering wells to lower water levels in the first mine segment in preparation for mining. This step would last about six months and functions as a greatly expanded pumping test. As with the first step, it is also completely reversible.

The third step—active dewatering during mining—involves mining the trough described above. Additional dewatering wells will be installed and pumped as mining progresses. Mining will begin at the location farthest from the Edmond Marsh and Sequalitchew Creek and proceed slowly south. Completing the trough would require 5 to 8 years depending on market conditions and the success in meeting predicted groundwater levels. The potential impact on groundwater levels builds slowly over time as wells are added and mining progresses south. This allows ample opportunity to monitor and adapt to the conditions observed before mining proceeds into each dewatered segment.

The final step—passive dewatering—begins when mining of the trough described above is complete and the last dewatering well is turned off. Passive dewatering represents the groundwater condition that will continue in perpetuity. Groundwater, no longer intercepted by wells, would form seeps at the toe of the eastern mine slope. It would flow by gravity through newly created wetlands and a vegetated swale to an infiltration pond located at the bottom of the existing mine. Once this step has begun, further mining activities in the interior of the South Parcel would not affect groundwater.

Additional detail about each of these steps is described in the following section.

3.1 Four Steps of Dewatering Plan

The dewatering necessary to accomplish the mine expansion will occur in four steps as outlined below to address the needs of the mining operations and to provide an opportunity for adaptive management, as described in Section 4. Figure 3 depicts locations of the wells planned for installation in each step. All water generated during dewatering will be infiltrated within the footprint of the current mine, west of the expansion area. Infiltrated water will travel vertically into the ground to the aquifer then flow westward and discharge as seeps to Puget Sound

Step 1. Initial Pumping Test: The first step is a 10-well pumping test, conducted for a minimum of 60 days, to validate model predictions of dewatering effectiveness in the local vicinity of the test wells and make any necessary changes to the model parameters and/or plans for subsequent dewatering and mining activities. The 10 wells will be located in the northeastern portion of the South Parcel as shown on Figure 3. Monitoring will be conducted throughout the test in the pumping wells and existing monitoring wells. The combined pumping rate during Step 1 is predicted to be approximately 3.5 cubic feet per second (cfs) on average, and up to approximately 5 cfs if pumping during the wet season. The model predicts that groundwater level changes will stabilize within approximately 60 days of the start of pumping. No mining will occur in the South Parcel during this step. Step 1 could occur at any time prior to mining; it is not anticipated that all permits for mining would need to be obtained before Step 1 could occur.

Step 2. Preparation for Mining/ Dewatering Test: Following completion of the initial pumping test, the next step of the dewatering plan involves expanding the dewatering well network along the eastern edge of the mine area with two purposes: 1) to evaluate model predictions across a wider extent (making any necessary changes to model parameters and/or to subsequent dewatering/mining activities); and 2) to dewater gravels for the first segment of mining. No mining will occur in the South Parcel before this step is completed.

During Step 2, an expected 14 additional dewatering wells will be installed along the South Parcel mine boundary, including wells located interior to the mine, as shown on Figure 3. The dewatering wells will be arranged in two lines on either side of the initial mine trough, including 19 boundary wells and 5 interior wells. Two additional monitoring wells will also be installed to measure drawdown within the mine interior. Step 2 is expected to last for up to 6 months,with the first two months being a second pumping test again lasting a minimum of 60 days, followed by an estimated four additional months of pumping to dry gravels in the Segment 1A in preparation for mining. The results from the first 60 days would be used to evaluate the model; this evaluation would occur concurrently with the continued dewatering in preparation for mining. The predicted total system pumping rate of approximately 5.1 cfs on average and up to approximately 8 cfs during the wet season.

Since a key component of Step 2 is preparation of the site for mining, pumping during Step 2 would only occur once mining and restoration permits have been obtained.

Step 3. Active Dewatering during Mining: Step 3 is active dewatering as mining begins to form a broad trough in the northeastern corner of the site. Over the next 5 to 8 years,

mining will then proceed from north to south along eastern boundary of site. Step 3 dewatering is predicted to use 66 dewatering wells arranged in two lines on either side of the initial mine trough, with 54 boundary wells and 12 inner wells, as shown on Figure 3. The wells are installed and pumped ahead of the trough's southern progression; as mining of an area is completed, wells along that portion of the trough are shut off, allowing groundwater to begin seeping from the newly mined slope. Groundwater seeping into the mine will be collected in a vegetated swale and conveyed to the infiltration pond located at the bottom of the existing mine.

If all 66 dewatering wells were operating, the combined pumping rate is predicted to be approximately 6.8 cfs on average and up to approximately 11 cfs during the wet season. However, it is unlikely that all dewatering wells would need to be operated at any one time as wells will be phased off as mining progresses.

Step 4. Cessation of Active Dewatering: During Step 4, pumping from the dewatering well network will cease, and the post-mining groundwater flow condition will be established consistent with reclamation objectives. Once all dewatering wells are off, mining above the water table will continue in the interior of the South Parcel. Groundwater will flow from the toe of the newly mined slope on the eastern boundary of the property and be collected and conveyed to an infiltration pond in the bottom of the existing mine, from where it will continue its westward flow, ultimately entering Puget Sound. Groundwater levels will increase slightly following the cessation of active dewatering as they adjust to long-term equilibrium with the new spring locations that will form along the toe of the mined slope. Step 4 lasts through mining of the remaining interior areas and through the post-mining period.

3.2 Dewatering Well Construction

The dewatering wells are designed to accommodate large drawdowns (up to 70 feet), and operate under a wide range of flow rates against a wide range of heads. All dewatering wells will be screened to the depth of the Olympia Beds, with nominal 10-foot sumps installed into the top of the Olympia Beds. Expected well depths will range from about 75 to 115 feet to accommodate the variation in aquifer thickness (between ground surface and the Olympia Beds contact) and the 10-foot sump into the Olympia Beds. The dewatering wells will be screened across the lower zone and a portion of the upper aquifer zone (generally 40- to 50-foot screen lengths). Continuous slot, v-wire wrapped stainless-steel well screens will be used for maximum dewatering efficiency (low head loss). Anticipated well flows range from approximately 400 gallons per minute (gpm) initially to an average of approximately 50 to 200 gpm to maintain drawdown once storage is depleted.

3.3 Predicted Effects of Dewatering on Groundwater Levels

The effects of the four-step dewatering plan on groundwater levels have been evaluated using a numerical, three-dimensional, groundwater model developed specifically for the project (DuPont model). The model is transient, meaning that it simulates changes in groundwater levels over time, and runs on a monthly time step for a roughly 12-year period from March 2004 to December 2015 that includes wet and dry climate conditions.

This allows the model to be used to analyze the effects of the proposed dewatering plan over a range of weather conditions.

The model was developed using data from 2004 to 2010 and calibrated to observed water levels at 19 wells. The calibrated model achieved a "good fit" with a mean residual (difference between predicted and observed) of 1.7 feet or about 6 percent of the difference in minimum and maximum groundwater levels at the calibration targets. The model was validated over 2004 to 2015 (after a change in the precipitation data source) and the validation statistics were similar to the calibration with a mean residual of 1.87 feet providing confidence in its use to simulate groundwater conditions. Additional detail on groundwater model development, calibration, validation and predictive results is available in the Groundwater Model Update (Aspect, 2017).

The DuPont model was used to predict changes in groundwater conditions during the four sequential steps of proposed dewatering and mining activity in the South Parcel. These predictive runs used the same weather and boundary conditions as model calibration with the only change being the addition of pumping wells and changes in surface topography with mining. Dewatering Steps 1, 2, and 3 simulated 10, 24, and 66 active dewatering wells, respectively. Step 4 simulated the post-mining condition with pumping terminated and groundwater passively discharging at the toe of the newly mined slope.

Results of the predictive models are discussed below by dewatering step, in terms of predicted changes in groundwater levels. Baseline groundwater levels are sensitive to seasonal and longer-term precipitation patterns, and the model indicates that groundwater levels during the four dewatering steps will likewise remain sensitive to precipitation patterns. Monitoring well locations are shown on Figure 4.

In Step 1, the changes in groundwater levels are most evident at the monitoring wells closest to the pumping test (CHMW-2S and CHMW-2D). The maximum groundwater level change at CHMW-2D is predicted to be approximately 9 feet, whereas minimal groundwater level change (less than 0.5 foot) is predicted at monitoring wells in Edmond Marsh (MW-EM-1D and MW-EM-2D).

During Step 2, the maximum change in groundwater level is approximately 45 feet and would occur at CHMW-2D located on the northeastern edge of the South Parcel and within the dewatering well network. The maximum groundwater level changes in the closest monitoring wells in Edmond Marsh (MW-EM-1D and MW-EM-2D) are predicted to be approximately 1.3 feet and 0.2 feet, respectively.

During Step 3, maximum groundwater level changes of up to about 60 feet are predicted at wells within the mine area. The maximum groundwater level changes at MW-EM-1D and MW-EM-2D (Edmond Marsh) are predicted to be approximately 5.2 feet and 0.4 feet, respectively. The groundwater levels during Step 3 are predicted to be approximately 10 to 20 feet above the Olympia Beds along the mine trough.

During Step 4, following cessation of active pumping, the maximum change in groundwater levels along the eastern slope of the mine ranges from about 14 to 49 feet. The maximum groundwater level changes at the closest Edmond Marsh Wells (MW-EM-1D and MW-EM-2D) are predicted to be approximately 5.0 feet and 0.4 feet,

respectively. A map of the predicted contours of groundwater drawdown after cessation of active pumping is shown on Figure 5. Solid drawdown contours on Figure 5 indicate areas of greater certainty closer to the monitoring well network and model calibration targets, dashed drawdown contours indicate areas of lesser certainty.

The groundwater model was used to develop performance thresholds for each well in each month during each dewatering step. The thresholds are based on the predicted range in water levels under seasonal and annual variation in climate. The performance thresholds were established at the lower 95th-percentile confidence interval for the predicted water levels.

As an example, Figure 6 provides the range of model predictions (groundwater elevation, and change from baseline water levels) over varying climate conditions for well CHMW-2D, located near the proposed location of the pumping test. The vertical lines in Figure 6 indicate the lower end of the predicted range. The bottom of the vertical line is the performance threshold. The performance threshold will change by well, by month (to account for annual seasonal patterns), and by dewatering steps. Similar figures have been prepared for each monitoring well and are presented in Appendix A.

4 Adaptive Management

This Monitoring Plan implements adaptive management to observe and respond to changes in groundwater levels occurring during mining of the South Parcel. This section first introduces the fundamental steps of effective adaptive management, then establishes key commitments by CalPortland to be met throughout the adaptive management process, and then walks through the detailed adaptive management plan, including the groundwater performance thresholds, for each dewatering step.

4.1 Process of Adaptive Management

Adaptive management has been described as "*a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs"* (Nyberg, 1999). Adaptive management typically consists of a monitoring system to identify changes in the environment coupled with a response system to adjust the activities in response to monitoring results. The adaptive management system proposed for implementation on this project was developed as a combination of the systems proposed by Ralph and Poole (2003) and Nyberg (1999). It consists of five key sequential elements, as illustrated on Figure 7:

A. **Assess:** Information is compiled from monitoring data, geologic investigations, groundwater modeling, and other available sources. The compiled information is used to identify issues, refine objectives, and screen potential alternative approaches. Predictions of the potential effects of the action on groundwater levels are developed.

B. **Design:** Based on the results of the assessment stage, design of the proposed action proceeds. Design will result in a specific plan of action, and supporting evaluations to ensure that the anticipated results are consistent with the identified objectives, the Monitoring Plan, and prior environmental assessments. Predictions of groundwater levels are refined as the design evolves. Analyses conducted during the design stage could result in an iterative process of assessment and design. Any required permitting is also included in the design stage.

C. **Implement and Monitor:** The approved plan is put into action, concurrently with monitoring focused on key indicators tied to the identified objectives. Monitoring data indicating conditions worse than forecasted are acted on rapidly, moving into the evaluation and adjustment stages.

D. **Evaluate:** Monitoring data are evaluated relative to the objectives and forecasted results developed in the assessment and design stages. Differences between forecasts and results are identified and the causes for those differences investigated.

E. **Adjust:** Information learned in previous steps is used to adjust the actions, if necessary. The Monitoring Plan provides an initial identification of potential adjustments in each dewatering step, but additional adjustments could be developed to fit specific situations.

The adaptive management process is iterative and would repeat until the mining project is completed. If an adjustment is identified, the process would begin again from the assessment and design stages, followed by implementation of the adjustment and associated monitoring, then evaluation and further response (if necessary). If an adjustment is not necessary, then the process still repeats. In this case, the assessment and design stages would largely rely on the previously approved plans, but there is still potential for more minor refinements based on the information learned.

Throughout the adaptive management process, status updates, monitoring data, and final reports will be shared with the Environmental Caucus. Should groundwater levels not meet the performance thresholds established in this plan, then CalPortland would notify the Environmental Caucus and plan and implement adjustments. If adjustments are unsuccessful in meeting predicted groundwater levels, CalPortland and the Environmental Caucus would initiate a technical review conference and, if necessary, meet and confer to share information and determine the appropriate additional steps.

4.2 Key Adaptive Management Commitments

This section establishes the commitments related to key components of adaptive management. First, an overview of the anticipated schedule for the four dewatering steps is presented. Then the commitments to the frequency that groundwater levels will be compared with the performance thresholds is established, followed by a summary of the notifications that will be provided if certain events occur (such as starting to pump new wells, or measurements of groundwater levels that are below performance thresholds). The next section summarizes the reports that will be provide throughout the process, ranging from relatively simple progress updates to detailed reports on the pumping tests. Then several overall limitations on advancement of mining and dewatering are established. Finally, the meet and confer process for resolving disputes is defined.

Additional detail about the adaptive management process as it applies to each dewatering Step is presented in Section 4.3.

4.2.1 Anticipated Schedule

Mining of the South Parcel will occur over many years, and the anticipated project schedule has been designed to include sufficient time for the adaptive management process to succeed in meeting performance thresholds before mining or dewatering advances. An overview of the anticipated schedule is presented on Figure 8; additional schedule detail is presented in the detailed adaptive management plan for each Step presented in Section 4.3.

Mining and dewatering activities would not begin until a series of conditions identified in Section 4.3 of the 2011 Settlement Agreement have been met. Those conditions include: 1) environmental review (SEPA) has been completed; 2) permits for the Restoration Plan have been issued [including the required authorizations and approvals from Joint Base Lewis-McChord (JBLM) for restoration activities on JBLM property], and applicable appeal periods have expired (except for federal permits); and 3) all necessary permits and approvals for South Parcel mining have been obtained. This paragraph is intended as a summary only; to the extent that it is inconsistent with the Settlement Agreement, the Settlement Agreement shall govern.

Step 1 is anticipated to require a year to complete from initial planning through reporting and discussion of the results and any resulting adjustments to the dewatering plan. Planning and well installation for Step 2 would overlap with completion of the reporting and review components of Step 1. Once Step 1 has been completed, the pumping test component of Step 2 would begin.

Step 2 is anticipated to require 6 months of active pumping—the first 2 months would be a larger-scale pumping test, and dewatering would continue over the subsequent 4 months in preparation for the start of mining. Reporting and review of results would be performed while dewatering continues.

Step 3 would only commence when groundwater levels are above the performance thresholds and water levels are at appropriately low levels for safe and efficient mining and processing. If groundwater levels meet performance thresholds, Step 2 would flow into Step 3 and the start of mining. Otherwise, Step 2 may require a longer period to perform the necessary adjustments to achieve sufficient dewatering for mining while maintaining groundwater levels consistent with the performance thresholds and prior environmental analyses, or update the environmental analyses, if necessary.

Mining would proceed south over a period of multiple years. The actual rate of mining depends on market demand. CalPortland expects that mining the first four segments (1A through 1D) would take 4 to 8 years and has committed (see Section 4.2.5) to completing those four segments in no less than 3 years total, or a minimum of 9 months for each segment. Figure 8 shows the timeline for mining of the South Parcel in the unlikely event that mining were to progress at this accelerated pace and the first four segments were to be completed in three years.

Step 4 will begin after active dewatering ceases. Depending on market demand for aggregate products, mining of the remainder of the South Parcel is expected to occur over 5 to 8 years after cessation of active dewatering.

4.2.2 Comparison of Groundwater Levels with Performance Thresholds

Success of the dewatering plan is evaluated by comparing groundwater levels with the performance thresholds.

A summary of the monitoring events where comparisons with the predicted ranges will be performed is provided in Table 1. The frequency of these comparisons will vary over time with more frequent evaluations at the start of each dewatering step or when changes to dewatering are made. If any of these monitoring results indicate groundwater levels are not above the performance thresholds, CalPortland will notify the Environmental Caucus according to the timelines described in Section 4.2.3, which vary by dewatering Step, and begin the adjustment process.

Table 1. Frequency of Comparison to Performance Thresholds

Dewatering Step	Frequency of Comparison
Step 1 – Initial Pumping Test	Changing frequency during test: hourly -> daily -> weekly
Step 2 – Preparation for Mining/ Dewatering Test	Changing frequency during first 2 months/ pumping test: daily -> weekly, then Weekly at key wells, Twice monthly at all others
Step 3 – Active Dewatering during Mining	For 3 months when new wells start pumping: weekly at key wells and twice monthly at all others, then Monthly.
Step 4 – Cessation of Active Dewatering	Monthly

Note: Key wells are the monitoring wells in the South Parcel (CHMW-1 through 4) and the closest marsh monitoring stations (EM-1 and -2), including both shallow and deep wells at those locations.

4.2.3 Notifications

Notifications are intended to alert the Environmental Caucus to the occurrence of an event. Routine reporting, including project status updates, data summaries, pumping test analyses, are described in the next section (Section 4.2.4).

CalPortland will inform the designated representative of the Environmental Caucus of each of the following types of events:

1) At the start of each dewatering step;

2) Major milestones within each step (such as addition of new pumping wells);

3) Upon collection of monitoring data indicating actual groundwater levels are lower than the performance thresholds; and

4) Implementation of response actions.

The Environmental Caucus will provide timely notice of any changes in its attorney, consultant, or designated representative or their contact information.

Notification points in each of the dewatering steps are summarized in Table 2, except for routine reporting milestones (which are summarized in Table 3). Notifications will be provided in writing by email, letter, or memorandum/report, as appropriate for the nature of the notification. It is anticipated that most notifications will be provided by email.

Groundwater monitoring data (including raw data) would be provided within 2 days of any notification that monitoring results are below performance thresholds.

Table 2. Summary of Notifications by Dewatering Step

Dewatering Step	Events Triggering Notification of Environmental Caucus	Timeline for Notification
Step 1 – Initial Pumping Test	Updates to pumping test plan	Within 3 days of updating plan
	Installation of pumping test wells	1 week prior to start of drilling
	Start of pumping test	1 week prior to start of pumping
	Monitoring results below performance thresholds	Within 24 hours of measurement
	Any adjustments implemented during pumping test	Within 24 hours of change
	End of pumping test	Within 24 hours
Step 2 – Preparation for Mining/ Dewatering Test	Updates to dewatering plan based on Step 1 results	Within 3 days of updating plan
	Installation of Step 2 dewatering wells	1 week prior to start of drilling
	Start of dewatering	1 week prior to start of pumping
	Monitoring results below performance thresholds	Within 48 hours of measurement
	Any adjustments implemented during dewatering	Within 24 hours of change
Step 3 – Active Dewatering during Mining	Commencement of mining in the South Parcel	1 month prior to start of mining
	Initiation of pumping at new wells	1 week prior to start of pumping
	Monitoring results below performance thresholds	Within 3 days of measurement
	Any adjustments implemented during dewatering	Within 3 days of change
	Cessation of active dewatering	Within 1 week of ceasing dewatering
Step 4 – Cessation of Active Dewatering	Monitoring results below predicted values	Within 3 days of measurement
	Completion of mining in South Parcel	Within 1 month of completion

The timeline for notification that monitoring results are below performance thresholds increases from 24 hours in Step 1 to 48 hours in Step 2 to 3 days in Steps 3 and 4 for four reasons:

1) the rate of change in groundwater levels will slow as mining progresses;

2) confidence increases over time as the number of wells pumping and set of successful groundwater measurements grows (mining and dewatering only advance when performance thresholds are met; see Section 4.2.5 for the specific limitations);

3) new wells begin pumping substantially in advance of mining both in time and space and dewatering proceeds from farthest away towards the creek and

marshes, which allows for the marginal impact of adding new wells to be reversible, even in during Step 3; and

4) Gravel would continue to be mined, but the volume that could be mined during the notification period is nominal compared with the volume of each mine segment, which are expected to require 1.5 to 2 years of mining to complete.

4.2.4 Routine Reporting

CalPortland will routinely share information about mining, dewatering, and the adaptive management process with the Environmental Caucus to achieve a variety of purposes, including sharing and interpreting monitoring data, documenting actions taken during a dewatering step, providing updated model predictions and analysis, and response actions, if necessary.

The specific reports required during each step of dewatering are summarized in Table 3. Additional detail about the individual reports and their role in the adaptive management process is presented in the Detailed Adaptive Management Plan in Section 4.3.

Table 3. Summary of Reporting by Dewatering Step

Dewatering Step	Reports	Minimum Frequency of Reporting
Step 1 – Initial Pumping Test	Pumping Test Design	One time
	Pumping Test Progress	Weekly during test
	Pumping Test Results	One time
Step 2 – Preparation for Mining/ Dewatering Test	Dewatering Plan for Step 2, if revised.	One time
	Pumping Test Progress	Weekly for first 2 months
	Pumping Test Results	One time – 4 months after start of Step 2
	Dewatering Summary Memos	Monthly
Step 3 – Active Dewatering during Mining	Dewatering Plan, Mining Plan, or SAP, if revised.	One time
	Dewatering Summary Memos,	Monthly for 3 months after each new set of dewatering wells, then quarterly
Step 4 – Cessation of Active Dewatering	Dewatering Summary Memos for first year	Quarterly for 2 years, then annually

The purpose and contents of each report are outlined below:

- Pumping Test Design/Dewatering Plans will provide the plan for performing the pumping tests and/or dewatering. These plans will include the proposed well pumping and observation well locations, depths, well construction, drilling methods, data collection, and timelines.

- Pumping Test Progress will provide a status update during the pumping test including an overview of progress toward completing the test, identifying which wells are pumping and pumping rates, locations and frequency of monitoring, any changes to the pumping test plan, and notes on how the test is proceeding.

- Pumping Test Results will present a detailed reporting of the execution of the pumping test, a summary of the data collected, including figures showing groundwater levels and pumping rates over time, comparisons of groundwater levels with performance thresholds, data analysis and results (estimates of key hydrogeologic parameters), and a comparison between model predictions and pumping test results for the purpose of model evaluation and validation.

- Dewatering Summary Memos will provide a summary of mining and dewatering progress, including information on any new wells installed, initiation of pumping at new wells, overview of wells that are pumping and pumping rates, cessation of pumping at wells, areas of active mining, and reclamation activities.

Reports will be prepared by a third-party consultant to be selected and paid for by CalPortland. The reports will be distributed to the Environmental Caucus electronically in protected documents, with hard copies available on request. Raw monitoring data will be provided with any groundwater measurement below a performance threshold, or when requested by the Environmental Caucus.

4.2.5 Limitations on Mining

In order to establish bounds on the pace and advancement of mining that will allow time for the adaptive management process to succeed, CalPortland commits to the following limitations on mining and dewatering activities in the South Parcel:

1) Mining associated with active dewatering (i.e., mining of the trough along the eastern boundary of the South Parcel; Figure 3) will last at least 3 years.

2) The mine trough has been divided into four segments (1A to 1D; Figure 3). Mining of each segment will last at least 9 months.

3) Mining will not advance into the next segment, unless groundwater levels meet performance thresholds.

4) Dewatering activity will not intensify through commencing pumping at new wells or increasing pumping rates at existing wells (except for normal seasonal changes in pumping rates), unless groundwater levels meet performance thresholds.

These limitations do not apply to operations of the existing mine and processing area, or extraction of gravel from areas west of the Olympia Bed truncation within the existing mine or North Parcel as these areas do not require dewatering.

4.2.6 Meet and Confer Process

Section 7.3 of the Settlement Agreement states that the Monitoring Plan will include a "process for the Parties to meet and confer if the groundwater levels do not meet the criteria provided in the Monitoring Plan." The process described below involves two steps for the parties (CalPortland and the Environmental Caucus) to follow with respect to groundwater information and data obtained during the monitoring process. The first step is for the parties' technical consultants to engage in one or more technical review conferences. If necessary, the second step would involve one or more meetings between the parties' designated representatives to discuss any differences of opinion or interpretation that the technical consultants are unable to resolve. Each of these two steps is discussed further below. This two-step process may be invoked at any time, including but not limited to the various specific points in the adaptive management process identified in Section 4.3 below.

Technical Review Conferences. The Environmental Caucus may initiate a request for a technical review conference of the parties' technical consultants at any time to discuss any questions or concerns it might have about any aspect of the groundwater monitoring data. The conferences may be in person or via conference call or other communications technology, and there may be multiple conferences to discuss any issues identified by the Environmental Caucus. The technical consultants would work in good faith during these review conferences to resolve any differences in interpretation of the groundwater monitoring data.

Party Representative Discussions. If the good-faith efforts of the technical consultants are unable to resolve any differences of opinion regarding the interpretation of the groundwater data, including but not limited to what the data shows regarding groundwater levels, either CalPortland or the Environmental Caucus may request a meeting of the parties' designated representatives or principals by providing notice to the other party of the desire to meet, and a brief explanation of the reasons for the request.

Once noticed is provided, CalPortland and the Environmental Caucus would work collaboratively to agree on a meeting format, date, time, and place to be held within 30 days of the request to hold a Technical Review Conference or a Party Representative Discussion. Meetings may be in person or via conference call or other communications technology, and there may be multiple meetings. This paragraph is intended to generally describe, but not constrain, the ways that the parties may choose to meet. Based on the issue raised, CalPortland would prepare and provide appropriate information summarizing the issue and current status of mining and dewatering activities, sharing related monitoring data (including raw data, if requested), and identifying potential responses.

Representatives of CalPortland and the Environmental Caucus will confer during the meeting on the most appropriate response with the goal of reaching consensus. If consensus cannot be reached, the parties would enter mediation, making good-faith efforts to hold a meeting with a mutually agreed-upon mediator within 45 days of the initiation of any request to the other party for mediation.

4.3 Detailed Adaptive Management Plan

This section is the core of the Monitoring Plan. It walks through each step of the dewatering plan providing conceptual details about how the stages of adaptive management would apply to that step. Specifically, this section establishes the objectives, provides an overview of monitoring activities, outlines an approximate schedule, summarizes the approach for data evaluation, and provides initial identification of potential response actions for each step of the dewatering plan.

Specific details of the monitoring activities (e.g., monitoring locations, frequency, and methods) are provided in the SAP in Appendix B.

Although the stages of adaptive management are presented sequentially in each step, it is important to recognize that the adaptive management process will be implemented iteratively within the step, particularly for Steps 2 and 3. For example, evaluation will be conducted each time monitoring data is collected, and that evaluation could trigger adjustment and looping back through the process during the same dewatering step. Alternately, if the monitoring data consistently indicate that performance thresholds are being met, the adaptive management process for a step could be completed without requiring iteration or adjustments.

4.3.1 Step 1 – Initial Pumping Test

Step 1 is envisioned as a 10-well pumping test, conducted for a minimum of 60 days, to validate model predictions of dewatering effectiveness in the local vicinity of the test wells, and make any necessary changes to the model parameters and/or to plans for subsequent dewatering and mining activities. No mining will occur in the South Parcel during Step 1.

The adaptive management process in Step 1 is illustrated on Figure 9.

A. Assess

The assessment stage for Step 1 will include compilation of existing monitoring data, geologic information, results from prior pumping tests conducted by CH2M Hill (2000), and the latest groundwater modeling simulations of the Step 1 pumping test. Monitoring data will continue to be collected and will be incorporated into the assessment for the pumping test.

Two initial objectives have been identified for the Step 1 pumping test:

1) Evaluate model predictions near the test wells.

2) Test dewatering design for meeting mining needs (i.e., achieving necessary drawdown), collecting information to refine the dewatering design, such as the number, screening, and spacing of wells.

B. Design

Based on the information collected during the assessment phase, CalPortland, and its consultants, will prepare a detailed plan for the pumping test. The plan will identify the number and location of pumping and observation wells, well drilling and construction, pumping rates, duration, monitoring locations, equipment, and frequency, etc.

The pumping test plan will be provided to the Environmental Caucus.

C. Implement and Monitor

CalPortland will install the pumping wells and any new observation wells, and conduct the pumping test. The minimum duration of pumping during the test will be 60 days.

Monitoring would consist of two components: 1) high-frequency automated monitoring at wells that are expected to be affected by the pumping test and at sensitive receptors, and 2) continuation of routine manual monitoring at other groundwater and surface water locations.

High-frequency monitoring using pressure transducers would be performed in observation wells near the pumping test location (CHMW-2D, -2S, and MW-D-3), and at wells located nearest to Sequalitchew Creek and West Edmond Marsh (CHMW-3S &-3D and MW-EM-1D). Typically, the frequency of data collection is programmed to vary throughout a pumping test with rapid data collection at the start tapering to less frequent as groundwater levels near stabilization.

Routine monitoring would continue to occur at the normal monitoring locations, including wetland, stream, and groundwater locations outside the area of influence of the pumping test. The streamflow monitoring stations are continuously recording. Manual measurements will be used at the wetland and groundwater locations not near the pumping test.

The Environmental Caucus will be notified of the installation of wells and the start and end of the pumping test. CalPortland will also provide weekly summaries of pumping test progress, and notification (within 24 hours) of any monitoring results below the performance thresholds. Routine reporting is summarized in Table 3 and notifications are outlined in Table 2.

D. Evaluate

Data will be screened as they are collected to determine if immediate action is required. In such an event, the Environmental Caucus would be notified within 24 hours, and the project would move immediately to the adjustment stage.

As monitoring data are collected, they also will be evaluated to see if the test is well-designed and the monitoring network is effective. If necessary, the project may enter the adjustment step to improve the pumping test to collect better information.

Once representative monitoring results are being collected, they will be screened against performance thresholds in Table 4 for the appropriate well and month. The performance thresholds were established at the lower 95th-percentile confidence interval for the predicted water levels [see Section 3.3 and the Groundwater Model Update (Aspect, 2017)]. The frequency of screening will vary during the test beginning with hourly at the start and reducing to daily then weekly as the test progresses, as outlined in Table 1.

If the monitoring results indicate that groundwater levels near the marshes are lower than the performance thresholds, CalPortland would develop and implement appropriate adjustments during the pumping test.

If monitoring results indicate groundwater levels are lower than the performance thresholds in wells that are not near the marshes or other sensitive receptors (i.e., monitoring wells on the South Parcel), then the test would be completed as planned. These results would be evaluated and any anticipated adjustments for future steps identified.

Even if the observations made during the test are above the performance thresholds, they still may provide valuable information for refining the model, mine plan, and Monitoring Plan. Those observations will be considered during assessment and design for Step 2.

The evaluation will also include comparison of climate and water level conditions prior to the test with the range of conditions experienced during the model calibration and validation period.

E. Adjust

Adjustments during the pumping test could occur for two reasons:

1) The monitoring data indicate that data collected are not sufficient to achieve the objectives of the test; or

2) The monitoring data indicate that groundwater levels are below the performance thresholds.

Potential adjustments consist of modifying or terminating the pumping test, and are listed in Table 5. Since no mining below the pre-project groundwater elevation would occur during this dewatering step, any change in groundwater could be reversed by turning the dewatering wells off.

Table 5. Potential Response Actions during Step 1 – Initial Pumping Test

Modify pumping test:
Changing pumping rates
Changing the number of pumping wells
Changing the duration of pumping
Changing monitoring locations including installing new wells
Performing additional testing
Cease pumping test.

CalPortland will notify the Environmental Caucus of any adjustments to the pumping test within 24 hours of the change.

Reporting and Discussion

At the conclusion of the Step 1 pumping test, whether completed as planned, adjusted, or terminated, CalPortland will prepare an interpretative report documenting the pumping test, summarizing the monitoring data, comparing monitoring results with prior model predictions, and making recommendations for the assessment and design phases of the next step.

The report will be provided to the Environmental Caucus, with a 3-month period for review and discussion of the results. CalPortland commits to meeting with the Caucus as often as necessary during the review period to facilitate open communications and timely review. Should the Environmental Caucus and CalPortland have different interpretations

of the dewatering test results, either party may request technical review conferences of the parties' technical consultants, followed by, if necessary, meetings of the parties' representatives, as described in Section 4.2.6 above.

Anticipated Schedule
The schedule for Step 1, in the context of the overall mining schedule, is illustrated in Figure 8. It is expected to require about a year to complete Step 1, with the following anticipated schedule:

- Planning the Pumping Test 1 month
- Installing and Developing Wells 2–3 months
- Performing the Pumping Test 2 months
- Evaluating Results and Reporting 2 months
- Model Updates (if necessary) 2–3 months
- Review by and discussion with Environmental Caucus 3 months

Incorporation of the results into the design of future steps could require additional time.

4.3.2 Step 2 – Preparation for Mining/ Dewatering Test

In Step 2, additional dewatering wells will be installed and will be pumped for several months to draw down groundwater until the gravel in the first mine segment of the South Parcel is dry enough to mine. If monitoring results are above performance thresholds during Step 2, the intent is to continue dewatering from those wells and transition smoothly into Step 3 – Active Dewatering during Mining. Step 3 would only commence when groundwater levels are above the performance thresholds.

The dewatering activity will also serve as a greatly expanded pumping test, the effects of which are completely reversible. The information collected in the first 60 days is most valuable as a pumping test, so evaluation and reporting on the test will focus on this period. The pumping test portion of Step 2 will occur for a minimum of 60 days.

The adaptive management plan for Step 2 is illustrated on Figure 10.

A. Assess
The planning for Step 2 will incorporate the results of Step 1, including any updates to the groundwater model, this Monitoring Plan, or mine plan resulting from Step 1.

In the assessment phase for Step 2, the results of the pumping test in Step 1 will be compared with the groundwater model. If they agree, then design would move forward as planned. If there are notable differences, the groundwater model would be evaluated and potentially modified.

The first level of model evaluation and modification would consist of updating the model to reflect the specific conditions of the Step 1 test (well locations, well construction, pumping rates, antecedent weather conditions, etc.) and developing a set of model predictions specific to the actual test conditions. These updates only modify the scenario for Step 1 and would not require recalibration of the model.

If the predictions from the updated model are notably inconsistent with the results of the pumping test, then the model parameters would be modified and calibrated to the observed data. Then, the full suite of predictive scenarios would be evaluated and compared with the groundwater levels included in the environmental analyses and permitting. If within the contemplated range, the project would move forward to the design phase with the revised model. If not, additional environmental analysis may be necessary.

The initially identified objectives for Step 2 are:

1) Evaluate whether groundwater levels at monitoring wells are above the performance thresholds; and,

2) Confirm that groundwater levels are low enough within the material to be mined to allow for safe and efficient mining and processing.

B. Design

Based on the results of the assessment step, the dewatering plan for Step 2 and the associated monitoring will be designed by CalPortland. Updates to the design will be simulated with the groundwater model and compared with prior environmental analyses as described above. If the model was updated in Step 1 or the assessment stage of Step 2, the predictive results from the updated model will be used to establish new performance thresholds.

Updates to the design and predictions of its impacts on groundwater will be provided to the Environmental Caucus.

C. Implement and Monitor

The additional dewatering wells for Step 2 will be installed and begin pumping. Pumped water will be discharged to an infiltration facility on the floor of existing mine. Pumping will occur for a minimum of 60 days to complete the dewatering test plus an estimated four additional months to dry gravels in Segment 1A sufficiently for mining.

Monitoring would consist of weekly monitoring at the key wells on the South Parcel in the portions of Edmond Marsh closest to the mine (key wells are defined in Table 1) and twice monthly monitoring at the other well, staff gage, and flow monitoring stations. Stations with continuously recording instrumentation, such as the flow monitoring stations, will be downloaded during these visits. Pressure transducers would also be installed to allow for continuous monitoring in key monitoring wells. Manual measurements will be collected from the other locations, such as staff gages and more distant wells.

The Environmental Caucus will be notified of the installation of wells and the start of dewatering. CalPortland will also provide weekly summaries of dewatering progress during the first two months, then monthly summaries. CalPortland will notify the Environmental Caucus (within 24 hours) of any monitoring results below the performance thresholds. Routine reporting is summarized in Table 3 and notifications are outlined in Table 2.

D. Evaluate

The evaluation stage in Step 2 is very similar to the evaluation stage of Step 1, as both actions are essentially pumping tests at different spatial scales.

Data will be screened as they are collected to determine if immediate action is required. In such an event, the Environmental Caucus would be notified and the project would move immediately to the adjustment stage.

Monitoring results will be screened against the performance thresholds in Table 6 for the appropriate well and month. The performance thresholds were established at the lower 95th-percentile confidence interval for the predicted water levels [see Section 3.3 and the Groundwater Model Update (Aspect, 2017)]. If the monitoring results indicate that groundwater levels are lower than the performance thresholds, CalPortland will develop and implement appropriate adjustments.

Even if the groundwater levels are above the performance thresholds, they still may provide valuable information for refining the model, mine plan, and/or this Monitoring Plan. Those observations will be considered during assessment and design for the next dewatering step.

The evaluation will also consider the effect of conditions occurring at the time of monitoring (such as climate conditions, development, and Restoration Plan activities) with the range of conditions experienced during the model calibration and validation period, and include that information in the interpretation of results.

E. Adjust

Adjustment during the pumping test could occur for two reasons:

1) The monitoring data indicate that dewatering could cause groundwater drawdown beyond that previously contemplated and permitted; or

2) The monitoring data indicate that groundwater levels are not sufficiently low within the mine to allow for safe and efficient mining and processing in Step 3.

The first case would trigger rapid development and implementation of adjustments by CalPortland. If adjustments are not feasible or are exhausted without success, CalPortland would request to initiate the technical review conference of the parties' technical consultants, followed by, if necessary, meetings of the parties' representatives, as described in Section 4.2.6. The Environmental Caucus may also initiate this process.

In the second case, CalPortland would refine the dewatering plan while pumping continues. Potential adjustments include modifying or terminating the pumping test, and are listed in additional detail in Table 7. The list of adjustments provided in Table 7 is not intended to limit the range of potential responses.

CalPortland will notify the Environmental Caucus of any adjustments within 24 hours of the change.

Step 2 is completely reversible as no mining below the pre-project groundwater elevation would occur. Any change in groundwater could be reversed by ceasing to pump from the dewatering wells.

Table 7. Potential Response Actions during Step 2 – Preparation for Mining/Dewatering Test

Revise monitoring (change frequency of monitoring, or monitoring locations).
Install additional monitoring locations.
Change pumping rates.
Change pumping locations (adding or decommissioning) wells.
Modify the duration of pumping.
Cease dewatering.

Reporting and Discussion

In addition to the dewatering summaries described above, an interpretative report will be prepared in the third month of pumping for Step 2. The report will summarize the pumping-test portion of Step 2 by summarizing the first 2 months of data, comparing monitoring results with prior model predictions, documenting any response actions taken, and making recommendations for the assessment and design phases of the next step.

The report will be provided to the Environmental Caucus, with a 2-month period for review and discussion of the results. CalPortland commits to making its technical consultant available to meet with the Caucus's technical consultant as often as necessary during the review period to facilitate open communications and timely review. Should the parties' technical consultants be unable to resolve any difference in opinion in interpreting the dewatering test results, either party may request a meeting of the parties' designated representatives, as described in Section 4.2.6 above.

Anticipated Schedule

Step 2 is expected to require a about a year to complete, though the planning and well installation stages may overlap with the later reporting and discussions related to Step 1. The schedule for Step 2 and relationship with the Step 1 pumping test are shown on Figure 8. The anticipated schedule for key elements of Step 2, assuming performance thresholds are met, is:

Planning the Dewatering	2 months	
Installing and Developing Wells	2–3 months	
Performing the Pumping Test	2 months	
Evaluating Results and Reporting	2 month	Simultaneously: Continue Dewatering in Preparation for Mining
Update Model (if necessary)	1 month	
Review by and discussion with EC	2 months	4 months

If groundwater levels meet performance thresholds, Step 2 would flow into Step 3 and the start of mining. Otherwise, Step 2 may require a longer period to perform the

necessary adjustments to achieve sufficient dewatering for mining while maintaining groundwater levels consistent with the performance thresholds and prior environmental analyses, or update the environmental analyses, if necessary.

Step 3 would only commence when groundwater levels are above the performance thresholds and water levels are at appropriately low levels for safe and efficient mining and processing.

4.3.3 Step 3 – Active Dewatering during Mining

During Step 3, mining will begin in the northeastern portion of the South Parcel and proceed south to mine a trough along the eastern boundary. Additional dewatering wells will be installed and pumped to dewater gravel in subsequent mine segments in the South Parcel. CalPortland would not start pumping additional dewatering wells until groundwater levels are at or above performance thresholds.

As mining is completed, reclamation of the eastern mined slope will begin. Pumping wells adjacent to mine segments that are under reclamation will be turned off incrementally to allow natural springs to form at the toe of the mined slope and vegetation to become established.

Steps 3 and 4 are different from the first two steps in that changes to groundwater in these steps are not as easily reversed. As such, the adaptive management plan is focused on identifying when adjustments are necessary.

The adaptive management plan for Step 3 is iterative, and activities would loop continuously through the adaptive management stages throughout implementation of Step 3. The adaptive management plan for Step 3 is illustrated on Figure 11.

A. Assess

The planning for Step 3 will begin prior to the completion of Step 2 to allow for a potentially smooth transition, if performance thresholds are being met. The planning stage will incorporate previously collected monitoring data as well as any updates to the groundwater model, monitoring plan, or dewatering and mining plans.

If monitoring data from prior steps meet the performance thresholds, the planning for Step 3 is expected to move forward in accordance with the mine plan.

Differences between monitoring results and predictions would result in re-evaluation of the groundwater model. The re-evaluation would first simulate the specific conditions of Step 2, then more broadly update the model if predictions still do not match observations. If significant model updates are required, the full suite of scenarios would be simulated and results compared with the prior environmental analyses and permitting. Only if model results are within the predicted range may the project move forward to the design phase with the revised model.

The initially identified objectives for Step 3 are:

1) Evaluate whether groundwater levels at monitoring wells are above the performance thresholds for the appropriate month; and

2) Confirm that groundwater levels are low enough within the material to be mined to allow for safe and efficient mining and processing.

B. Design

Based on the results of the prior steps and assessment for Step 3, the dewatering plan, mining plan, and the associated monitoring will be updated by CalPortland, if necessary. Updates to the design will be simulated with the groundwater model and compared with the performance thresholds. Updated documents will be provided to the Environmental Caucus.

C. Implement and Monitor

Mining will begin at the northern edge of the South Parcel in the area dewatered in Step 2. As mining progresses, additional dewatering wells will be installed to the south of the current wells and begin pumping. As mining is completed in an area, the nearby wells will be turned off, allowing groundwater to emerge from springs from the toe of the completed slope. Both pumped groundwater and spring flow will be conveyed to an infiltration pond installed on the floor of the existing mine.

Monitoring would continue at all normal well, wetland, and streamflow monitoring stations. Streamflow and select well monitoring stations would have continuous recording instruments installed. Other locations would use manual measurements.

The frequency of monitoring would vary during Step 3. In the 3 months after the start of pumping for each new group of monitoring wells, monitoring would be weekly at key wells (defined in Table 1) and twice monthly monitoring at the other well, staff gage, and flow monitoring stations. After that, monitoring will be performed monthly.

D. Evaluate

As with prior steps, monitoring results will be screened against performance thresholds for Step 3 (Table 8) for the appropriate well and month. The performance thresholds were established at the lower 95th-percentile confidence interval for the predicted water levels [see Section 3.3 and the Groundwater Model Update (Aspect, 2017)]. If the model was previously updated, performance thresholds based on predictive results from the updated model will be used for the comparison. The evaluation will also consider the effect of conditions occurring at the time of monitoring (such as climate conditions, development, and Restoration Plan activities) with the range of conditions experienced during the baseline period.

If the monitoring results indicate that groundwater levels are lower than the performance thresholds, CalPortland would evaluate and implement appropriate adjustments.

Although the primary focus is on changes in groundwater levels, streamflow and surface water monitoring results will also be reviewed. By this point in the project, streamflow and surface water monitoring results will be affected by Restoration Plan activities, which are likely to have a larger effect than mining on the surface water bodies. The Restoration Plan will incorporate its own adaptive management process.

E. Adjust

Step 3 involves mining below the current aquifer level. As such, it is more difficult to reverse than prior steps; however, mining is designed to begin away from the marshes

and Sequalitchew Creek and proceed southward toward them over a period of years. This will slowly change water levels beneath the marshes and creek and allow time for response actions should the monitoring data and evaluations indicate they are necessary.

If groundwater levels are below the performance thresholds, CalPortland would develop and implement adjustments. Unlike in the prior steps, re-examination of the groundwater model is not a first element of evaluating potential response actions in Step 3.

Either party may initiate a request for a technical review conference and, if necessary, meetings of the parties' representatives, as described under Section 4.2.6 above. If adjustments are not feasible or are exhausted without meeting performance thresholds, CalPortland would initiate the process to discuss alternative approaches and next steps.

Selection of potential response actions is shown in Table 9. The suite of appropriate response actions will change over time as mining progresses. For example, early in Step 3 there is more flexibility to alter the mine plan. As mining progresses further south, the ability for alterations to the mine plan to produce a meaningful change in groundwater levels is reduced.

Table 9. Potential Response Actions during Step 3 – Active Dewatering during Mining

Revise mine phasing to allow time for additional monitoring, analyses, testing, and planning.
Revise dewatering plan (number of wells, spacing, alignment, pumping duration).
Revise mining plan to change depth or extent of mining.
Install partial slurry cutoff wall.
Provide additional mitigation.
Cease dewatering and mining.

Reporting and Discussion

During Step 3, CalPortland will prepare summary memos providing comparison of observed groundwater levels over the past 3 months with model predictions, as well as an update on dewatering and mining status, and any response actions taken. The summary memos will be prepared monthly for 3 months after each new set of dewatering wells begins pumping, then quarterly. The memos will be provided to the Environmental Caucus.

Anticipated Schedule

Mining would proceed south over a period of years. Completion of Step 3 is expected to take 4 to 8 years. The mining schedule is, in part, driven by the market demand for aggregate. CalPortland has committed to complete Step 3 in no less than 3 years, or a minimum of 9 months per each of the first four segments (1A to 1D). The minimum timeline for completion of Step 3 is illustrated in Figure 8.

4.3.4 Step 4 – Cessation of Active Dewatering

This final step of dewatering commences once mining and reclamation advances to the point that the last dewatering wells installed in Step 3 have been turned off. At that point, groundwater will emerge from springs along the length of the toe of the mined (and reclaimed) slope along the eastern and a portion of the southern mine boundaries. Step 3 is expected to transition smoothly into Step 4, given the multiple-year duration of Step 3 and that ceasing to pump the dewatering wells will result in lower environmental impact.

Several steps of the adaptive management process (i.e., assess and design) are not as relevant in Step 4, because it is a largely passive step with respect to the effects on groundwater levels. Mining and reclamation activities will continue within the South Parcel, but those activities would no longer influence groundwater levels.

As such, this discussion focuses on ongoing monitoring, data evaluation, and potential response actions. The adaptive management plan for Step 4 is illustrated on Figure 12.

C. Monitoring

Monthly monitoring would continue for the duration of mining at the normal well, wetland, and streamflow monitoring stations. Continuous instrumentation will be maintained at streamflow monitoring stations. Staff gage and well monitoring locations will be manually measured.

D. Evaluate

Monitoring results would continue to be screened relative to the performance thresholds shown in Table 10, or as refined from the most recent groundwater model. The performance thresholds were established at the lower 95th-percentile confidence interval for the predicted water levels [see Section 3.3 and the Groundwater Model Update (Aspect, 2017)]. It is unlikely that events will result in short-term changes in groundwater levels in Step 4. Therefore, the evaluation will focus on longer-term comparisons with model predictions and observations of changes in the marshes and Sequalitchew Creek.

E. Adjust

If groundwater levels persist lower than the performance thresholds, CalPortland and the Environmental Caucus would hold one or more technical review conferences of the parties' technical consultants and, if necessary, meetings of the parties' representatives (as described in Section 4.2.6). to discuss and select appropriate adjustments. Either party may initiate this process.

Reporting

Quarterly summary memos will be prepared for the first year after cessation of dewatering. Annual reports will be prepared for the remaining duration of mining of the South Parcel.

Anticipated Schedule

Step 4 will begin after active dewatering ceases. Depending on market demand for aggregate products, mining of the remainder of the South Parcel is expected to occur over 5 to 8 years after cessation of active dewatering. Active adaptive management during Step 4 would cease when the following conditions are met:

- Mining of the South Parcel is complete, and

- Measured groundwater levels have been met performance thresholds for at least 3 consecutive years.

5 Relationship of Adaptive Management Process to Sequalitchew Creek Restoration Plan

Mining of the South Parcel and the restoration of Sequalitchew Creek are separate, but interacting, projects. Each project has its own adaptive management process tailored to achieving the goals and objectives of that project. The interaction between the two adaptive management processes is three-fold: 1) project schedules that encourage restoration in advance of the potential impacts from mining; 2) development of performance thresholds for mining that support restoration based on prior technical studies, including the cumulative effects analysis prepared in 2016 (Aspect and Anchor, 2016); and 3) coordinated monitoring and open sharing of information.

Project Schedules. The mining and restoration projects have been designed to facilitate restoration occurring in advance of the potential impacts from mining. This relationship between the project schedules is founded in key elements of the settlement agreement:

1) The mining project cannot begin until all permits for restoration have been obtained and the required authorizations or approvals from JBLM needed to implement the restoration elements on JBLM have been obtained.

2) The first actions of the mining project are pumping and dewatering tests (i.e., Steps 1 and 2) and are expected to take about 1.5 to 2 years to complete and no less than 9 months[1], as described in Section 4.2.1. The effects of Steps 1 and 2 on groundwater are completely reversible.

3) The first South Parcel mining segment is located furthest from the wetlands and Sequalitchew Creek. Mining and dewatering proceed slowly toward the Creek over a period of not less than 3 years, and more likely 4 to 8 years.

4) There are no schedule constraints or limits imposed on the pace of restoration activities.

The Restoration Plan schedule is anticipated to begin with the elements that immediately restore flow through the system—specifically, beaver management and improvements at the outlet of Sequalitchew Lake. The actions will be followed by improvements that enhance flows (e.g., connections from Hamer Marsh) and make it easier to maintain flows (e.g., installation of the Railroad Trail bridge and sealing\restoration of the losing reach). Finally, habitat restoration, through culvert replacements and enhancement of wetland and stream habitats, is the final component of the Restoration Plan.

Although a detailed schedule has not been developed for implementation of the Restoration Plan, it is anticipated restoration activities will begin immediately shortly after Restoration Plan permits are obtained and it should require no more than 6 years to complete construction and implementation of all elements of the Restoration Plan. The

[1] Minimum durations for the pumping test and review and discussion stages of Steps 1 and 2 are established in Section 4.3. The specified timeframes add up to a minimum duration of 9 months, however this duration is unrealistically short as it does not include time for other key steps, like well installation or report writing.

flow restoration actions should be completed within two years from the start of the project, and followed by flow maintenance and enhancement, which may require 3 years to complete, but could overlap with the flow restoration actions. Finally, construction of habitat restoration improvements could be completed within 3 years and could overlap or dovetail with the related flow maintenance and enhancement elements.

A timeline relating the anticipated schedules for restoration and mining is presented on Figure 13. Restoration activities should be successful in restoring flows to Sequalitchew Creek within the first 2 years. During this time, the mining project would complete the second pumping test (Step 2) and, if groundwater levels meet performance thresholds and mining progresses at the fastest allowable pace, mine Segment 1A and advance into Segment 1B. The anticipated increase in flow is much greater than the potential impact from the mining project, and the full benefit in flow quantity may be achieved in these first 2 years; whereas the impact from mining is minimal at first and increases slowly over time. The impact from mining is expected to peak during mining of Segment 1C, when the greatest number of wells are pumping[2].

Even if mining is proceeding rapidly, CalPortland has committed that mining of Segment 1 would not be completed in less than 3 years, with each segment lasting at least 9 months. At this pace, the peak impact from mining could be expected around 2 to 3 years after the start of restoration. Even if delayed, the flow restoration action should have occurred by this time and only a fraction of flow restoration is necessary to offset the impacts from mining.

Performance Thresholds that are Supportive of Restoration. The cumulative effects analysis (Aspect and Anchor, 2016) found that the changes in the marshes would be dominated by the Restoration Project (which requires lowering marsh water levels to achieve flow from Sequalitchew Lake to the ravine), rather than increased infiltration resulting from lower groundwater levels. The marshes would have significantly more water flowing through them than under current conditions, resulting in consistent water levels year-round at the target levels established in the Restoration Plan, except for some periods in the driest years.

The cumulative effects analysis also concluded that the predominant cumulative effect on Sequalitchew Creek would be an increase in annual average flows by approximately 10 cfs, with abundant year-round flow most of the time. By comparison, the stream flow reductions from mining is expected to be less than 1 cfs, and only apparent during limited periods in atypical summers.

The anticipated benefits to streamflow from restoration are much larger than the potential impacts from mining. As a result, the success of the restoration project is not expected to be particularly sensitive to the groundwater levels resulting from mining. Monitoring during mining will ensure that groundwater levels remain within the expected range that will support the anticipated increases in stream flow from the restoration project. If

[2] To be conservative, the potential impacts of mining described in the cumulative effects analysis (Aspect and Anchor, 2016) were based on all wells pumping at the same time. In practice, this condition is unlikely to occur as initial wells would be phased off as mining progresses.

groundwater levels are not maintained within the expected range, corrective actions will be implemented in accordance with the adaptive management plan for mining.

Coordinated Monitoring and Information Sharing. To facilitate the coordinated collection and exchange of information, the two projects share an integrated SAP (Appendix B). The SAP outlines the collection of information on groundwater levels, surface water levels, streamflow, and surface water quality to support both plans. Each plan also outlines how information will be shared so that plan implementers have the data necessary to make informed management decisions.

6 References

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Ralph, S. C., and G. C. Poole, 2003, Putting monitoring first: designing accountable ecosystem restoration and management plans, D. R. Montgomery, S. Bolton, and D. B. Booth, editor, Restoration of Puget Sound Rivers, University of Washington Press, Seattle, pp 188.

7 Limitations

Work for this project was performed for CalPortland (Client), and this report was prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. This report does not represent a legal opinion. No other warranty, expressed or implied, is made.

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TABLES

Table 4 - Performance Thresholds for Step 1 - Initial Dewatering Test

Project No. 040001-014-02, South Parcel, DuPont, Washington

Well	Performance Threshold = Groundwater Elevation in Feet (NGVD 29)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MW-EM-1S	203.6	202.4	202.9	202.2	202.3	201.4	200.4	200.4	199.5	199.5	202.1	202.9
MW-EM-1D	204.6	203.4	203.9	203.2	203.3	202.5	201.5	201.5	200.7	200.7	203.1	203.9
MW-EM-2S	210.6	210.3	210.4	210.3	210.2	210.0	209.7	209.6	209.3	209.5	210.2	210.4
MW-EM-2D	210.8	210.4	210.6	210.5	210.4	210.2	209.8	209.7	209.4	209.6	210.4	210.5
MW-EM-3	212.1	211.9	211.8	211.9	212.0	211.6	211.4	210.8	210.2	210.3	211.5	211.9
MW-SRC-2	213.2	212.4	212.7	212.6	212.8	212.0	211.4	210.2	209.6	210.5	212.3	212.7
MW-BM-1	218.0	217.0	216.6	217.4	217.3	216.6	216.1	213.1	213.3	214.2	216.8	217.4
MW-HM-1	214.2	213.5	213.3	213.8	213.6	212.7	211.8	211.2	210.6	211.1	213.1	213.6
MW-PL-1	200.8	200.1	200.4	200.1	200.0	199.4	198.6	198.7	198.0	197.7	199.6	200.2
CHMW-1	191.3	189.9	190.4	189.6	189.7	189.0	188.1	188.0	187.4	187.5	190.0	190.7
CHMW-2S	184.6	183.3	183.7	183.0	183.0	182.5	181.7	181.6	181.2	181.4	183.5	184.0
CHMW-2D	183.4	181.8	182.4	181.4	181.5	180.8	179.8	179.7	179.3	179.4	182.1	182.7
CHMW-3S	193.3	191.7	192.4	191.3	191.5	190.6	189.6	189.5	188.7	188.8	191.7	192.6
CHMW-3D	193.2	191.5	192.2	191.1	191.3	190.4	189.2	189.1	188.3	188.4	191.5	192.5
CHMW-4S	196.1	194.7	195.3	194.4	194.6	193.7	192.7	192.6	191.9	191.9	194.6	195.5
CHMW-4D	194.3	192.9	193.5	192.6	192.7	191.9	190.9	190.8	190.1	190.1	192.8	193.6
MW-D-3	196.5	195.3	195.7	195.0	195.1	194.6	193.9	193.7	193.3	193.5	195.6	195.9
MW-93-MFS-C5-3	192.3	191.2	191.7	191.0	191.0	190.5	190.0	189.9	189.5	189.8	191.6	191.7

Table 6 - Performance Thresholds for Step 2 - Preparation for Mining/Expanded Dewatering Test

Project No. 040001-014-02, South Parcel, DuPont, Washington

Well	Performance Threshold = Groundwater Elevation in Feet (NGVD 29)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MW-EM-1S	202.3	201.1	201.6	200.9	201.1	200.1	199.1	199.2	198.4	198.3	200.8	201.5
MW-EM-1D	203.4	202.3	202.8	202.2	202.3	201.4	200.5	200.5	199.7	199.7	202.0	202.7
MW-EM-2S	210.6	210.2	210.3	210.2	210.1	210.0	209.6	209.5	209.2	209.4	210.1	210.3
MW-EM-2D	210.8	210.4	210.5	210.4	210.3	210.1	209.7	209.6	209.3	209.5	210.3	210.5
MW-EM-3	212.1	211.9	211.8	211.9	212.0	211.6	211.4	210.8	210.2	210.3	211.5	211.9
MW-SRC-2	213.2	212.4	212.6	212.6	212.8	212.0	211.4	210.2	209.5	210.5	212.0	212.7
MW-BM-1	218.0	217.0	216.5	217.3	217.2	216.6	216.1	213.0	213.3	214.1	216.8	217.3
MW-HM-1	214.2	213.4	213.3	213.8	213.6	212.7	211.8	211.2	210.5	211.1	213.0	213.6
MW-PL-1	200.4	199.7	200.1	199.8	199.8	199.1	198.2	198.4	197.7	197.4	199.2	199.8
CHMW-1	187.0	185.7	186.3	185.5	185.6	184.9	184.0	184.0	183.3	183.4	185.8	186.4
CHMW-2S	143.8	141.4	142.2	141.0	141.0	140.1	139.1	138.9	138.3	138.6	141.8	142.9
CHMW-2D	142.5	141.0	141.6	140.7	140.7	140.0	139.1	138.9	138.3	138.5	141.2	141.9
CHMW-3S	190.6	189.0	189.8	188.8	189.0	188.1	187.0	187.0	186.2	186.2	189.0	189.8
CHMW-3D	190.2	188.6	189.4	188.3	188.5	187.5	186.3	186.3	185.4	185.3	188.4	189.3
CHMW-4S	193.7	192.3	193.0	192.1	192.3	191.4	190.4	190.4	189.6	189.6	192.2	193.0
CHMW-4D	191.8	190.5	191.2	190.3	190.5	189.6	188.6	188.6	187.8	187.8	190.4	191.1
MW-D-3	193.7	192.5	193.0	192.3	192.3	191.9	191.2	191.1	190.7	190.9	192.9	193.4
MW-93-MFS-C5-3	190.8	189.8	190.3	189.6	189.6	189.1	188.7	188.5	188.2	188.5	190.2	190.5

Table 8 - Performance Thresholds for Step 3 - Active Dewatering during Mining

Project No. 040001-014-02, South Parcel, DuPont, Washington

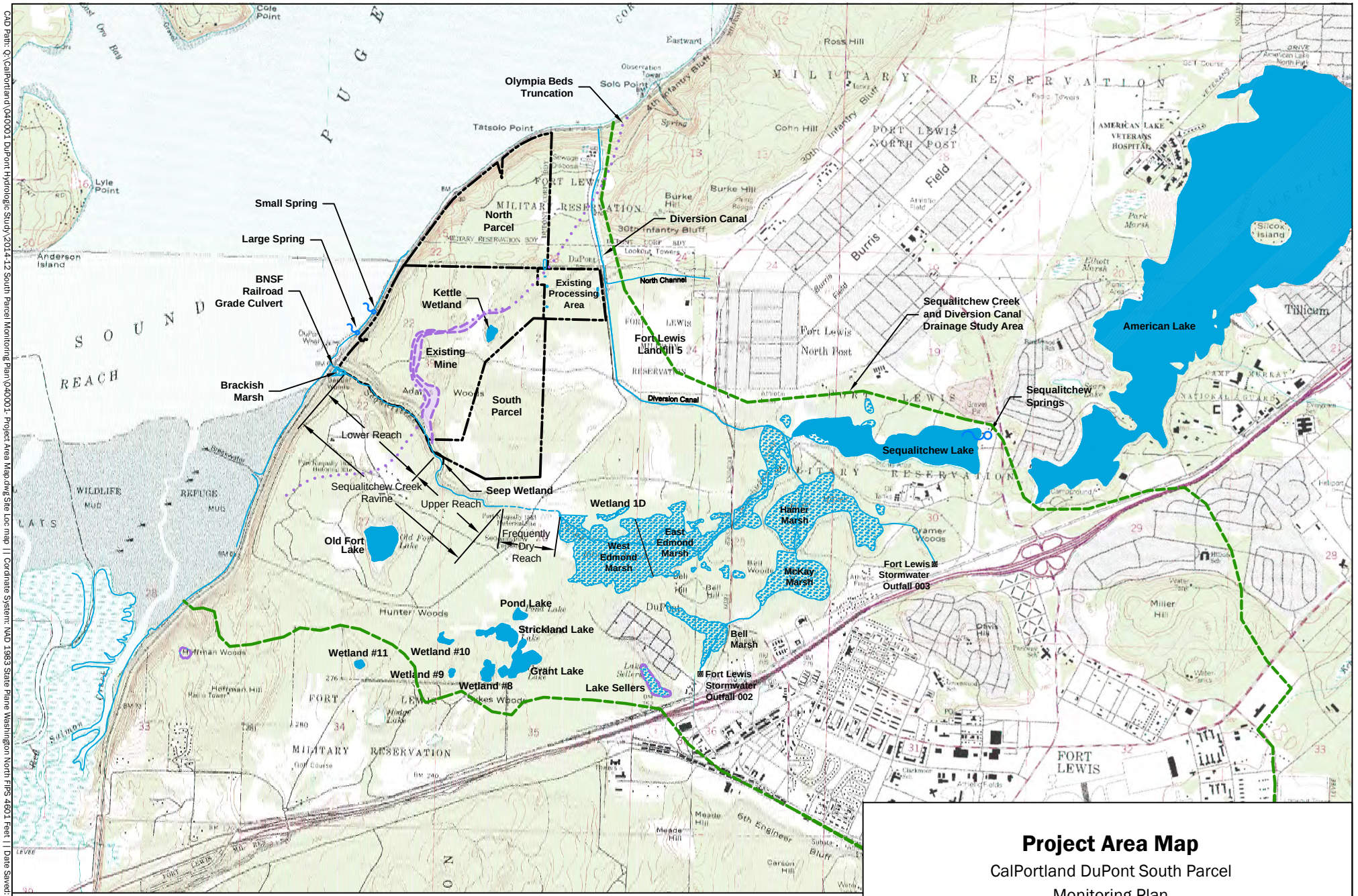
Well	Performance Threshold = Groundwater Elevation in Feet (NGVD 29)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MW-EM-1S	197.5	196.4	196.9	196.4	196.5	195.6	194.7	194.8	194.1	194.1	196.1	196.8
MW-EM-1D	199.4	198.4	198.9	198.3	198.4	197.6	196.8	196.9	196.2	196.2	198.1	198.7
MW-EM-2S	210.3	210.0	210.1	209.9	209.9	209.7	209.4	209.3	209.0	209.2	209.9	210.0
MW-EM-2D	210.5	210.1	210.3	210.1	210.0	209.8	209.5	209.4	209.1	209.3	210.0	210.2
MW-EM-3	212.1	211.9	211.8	211.9	212.0	211.6	211.4	210.8	210.2	210.3	211.5	211.8
MW-SRC-2	213.2	212.4	212.7	212.6	212.8	212.0	211.4	210.2	209.5	210.5	212.0	212.7
MW-BM-1	217.8	216.8	216.4	217.2	217.1	216.4	215.9	212.8	213.1	213.9	216.7	217.2
MW-HM-1	214.2	213.4	213.3	213.8	213.6	212.7	211.8	211.2	210.4	211.1	213.0	213.6
MW-PL-1	199.4	198.7	199.0	198.8	198.7	198.0	197.1	197.3	196.6	196.2	198.1	198.8
CHMW-1	129.8	129.1	129.4	128.9	128.9	128.5	127.8	127.8	127.3	127.4	129.2	129.5
CHMW-2S	136.0	134.5	135.0	134.1	134.1	133.5	132.9	132.8	132.3	132.5	134.9	135.5
CHMW-2D	135.9	134.7	135.1	134.3	134.2	133.7	133.1	132.9	132.4	132.6	134.9	135.5
CHMW-3S	131.1	128.4	130.3	128.9	129.2	127.9	126.6	127.0	126.2	126.3	129.0	130.2
CHMW-3D	128.3	127.4	127.9	127.6	127.6	126.8	125.8	126.1	125.4	125.1	127.0	127.6
CHMW-4S	181.0	179.7	180.4	179.6	179.7	178.8	177.7	177.8	176.9	176.9	179.5	180.3
CHMW-4D	178.5	177.3	178.0	177.1	177.3	176.4	175.3	175.4	174.5	174.4	177.1	177.8
MW-D-3	189.9	188.6	189.1	188.4	188.4	187.9	187.4	187.3	186.9	187.3	189.1	189.6
MW-93-MFS-C5-3	189.5	188.5	189.0	188.4	188.3	187.9	187.5	187.4	187.2	187.5	189.0	189.3

Table 10 - Performance Thresholds for Step 4 - Cessation of Active Dewatering

Project No. 040001-014-02, South Parcel, DuPont, Washington

Well	Performance Threshold = Groundwater Elevation in Feet (NGVD 29)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MW-EM-1S	198.1	197.0	197.6	197.0	197.1	196.2	195.4	195.3	194.8	194.7	196.8	197.4
MW-EM-1D	199.9	198.9	199.4	198.8	199.0	198.2	197.3	197.3	196.7	196.7	198.7	199.3
MW-EM-2S	210.3	210.0	210.1	210.0	209.9	209.7	209.4	209.3	209.0	209.2	209.9	210.1
MW-EM-2D	210.5	210.2	210.3	210.1	210.1	209.9	209.5	209.4	209.1	209.3	210.1	210.2
MW-EM-3	212.1	211.9	211.8	211.9	212.0	211.6	211.4	210.8	210.2	210.3	211.5	211.8
MW-SRC-2	213.2	212.4	212.7	212.6	212.8	212.0	211.4	209.9	209.4	210.4	212.0	212.7
MW-BM-1	217.9	216.9	216.4	217.2	217.1	216.5	216.0	212.3	213.0	213.8	216.7	217.2
MW-HM-1	214.2	213.4	213.3	213.8	213.6	212.7	211.8	211.0	210.3	211.1	213.0	213.6
MW-PL-1	199.5	198.8	199.2	198.9	198.9	198.2	197.3	197.5	196.8	196.4	198.2	198.9
CHMW-1	163.2	162.7	162.9	162.7	162.6	162.4	162.1	162.1	161.8	162.0	162.9	163.1
CHMW-2S	169.3	165.0	168.1	163.2	162.8	158.9	157.1	157.2	156.2	156.9	167.9	168.8
CHMW-2D	160.3	158.5	159.2	158.1	157.9	156.9	155.4	155.5	154.6	155.2	159.1	159.8
CHMW-3S	140.4	140.2	140.3	140.2	140.2	140.0	139.7	139.7	139.5	139.7	140.3	140.3
CHMW-3D	141.9	141.6	141.8	141.6	141.6	141.4	141.1	141.1	140.9	141.0	141.6	141.8
CHMW-4S	183.0	181.9	182.5	181.8	181.9	181.3	180.5	180.5	179.9	180.0	181.9	182.4
CHMW-4D	181.0	180.0	180.6	179.9	180.0	179.4	178.7	178.7	178.2	178.2	180.0	180.5
MW-D-3	191.4	190.2	190.7	190.0	189.9	189.5	188.9	188.8	188.5	188.9	190.7	191.1
MW-93-MFS-C5-3	190.1	189.1	189.5	188.9	188.8	188.4	187.9	187.9	187.6	188.0	189.6	189.9

FIGURES



Project Area Map

CalPortland DuPont South Parcel
Monitoring Plan
DuPont, Washington

Aspect CONSULTING	DEC-2014	BY: OGR/SCC	FIGURE NO. 1
	PROJECT NO. 040001-014	REVISED BY: -	

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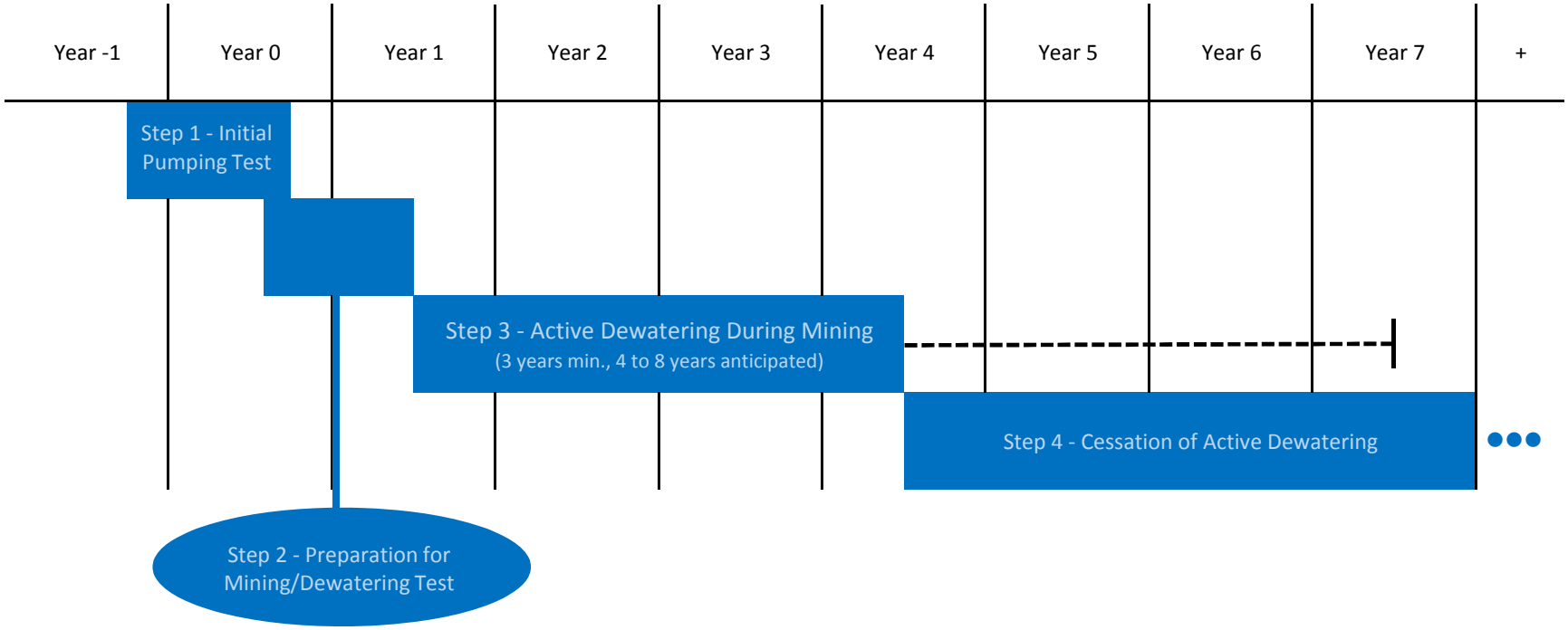
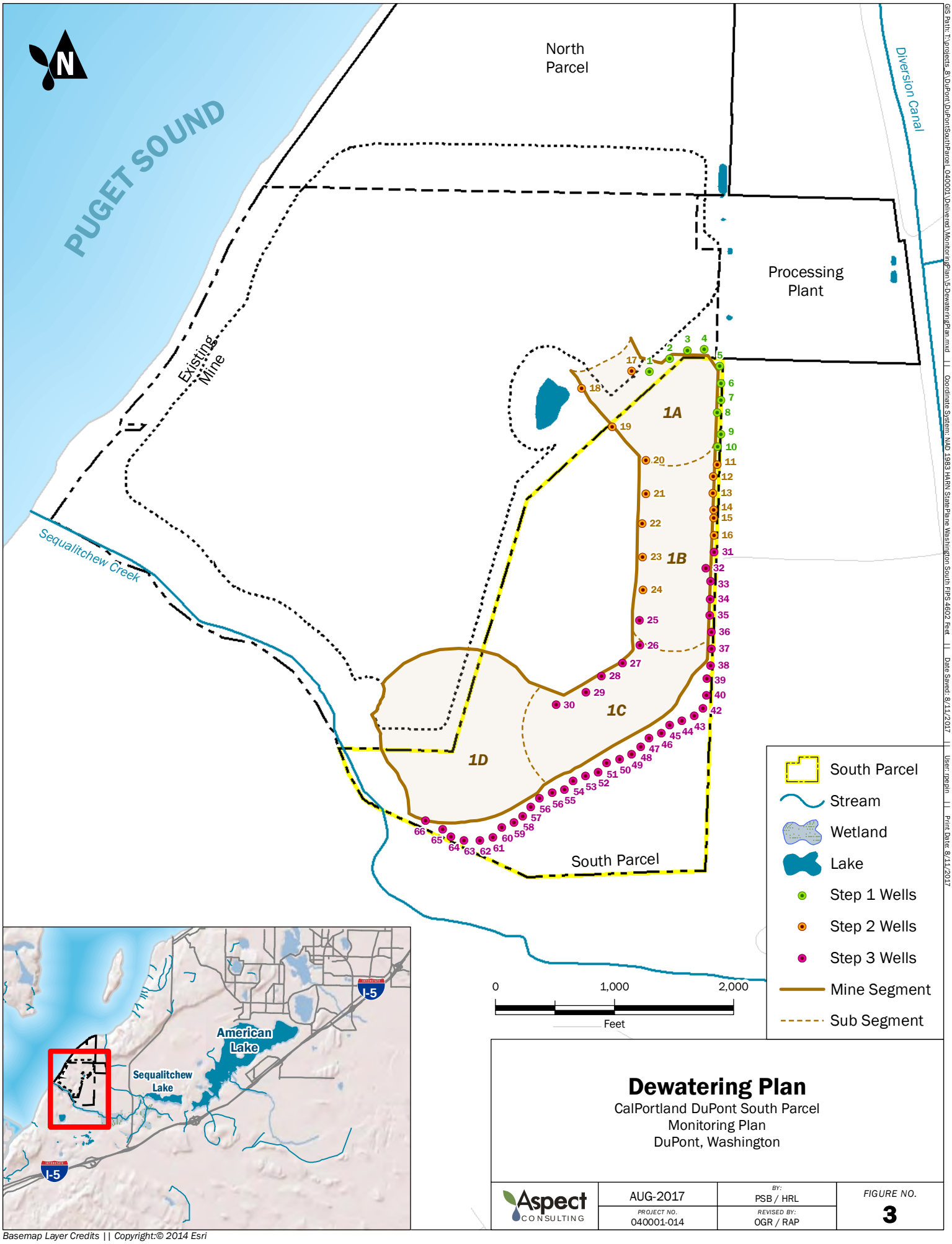


Notes:

1) Year 1 begins with the start of pumping in Step 2.

2) Timeline for Step 3 is based on CalPortland's commitment to a minimum duration of 3 years. The dashed line indicates the anticipated duration (6 years).

Figure 2
Timeline of Dewatering Steps
South Parcel Monitoring Plan
DuPont, Washington



Dewatering Plan

CalPortland DuPont South Parcel
Monitoring Plan
DuPont, Washington

Aspect CONSULTING	AUG-2017	BY: PSB / HRL	FIGURE NO. 3
	PROJECT NO. 040001-014	REVISED BY: OGR / RAP	

Basemap Layer Credits || Copyright:© 2014 Esri

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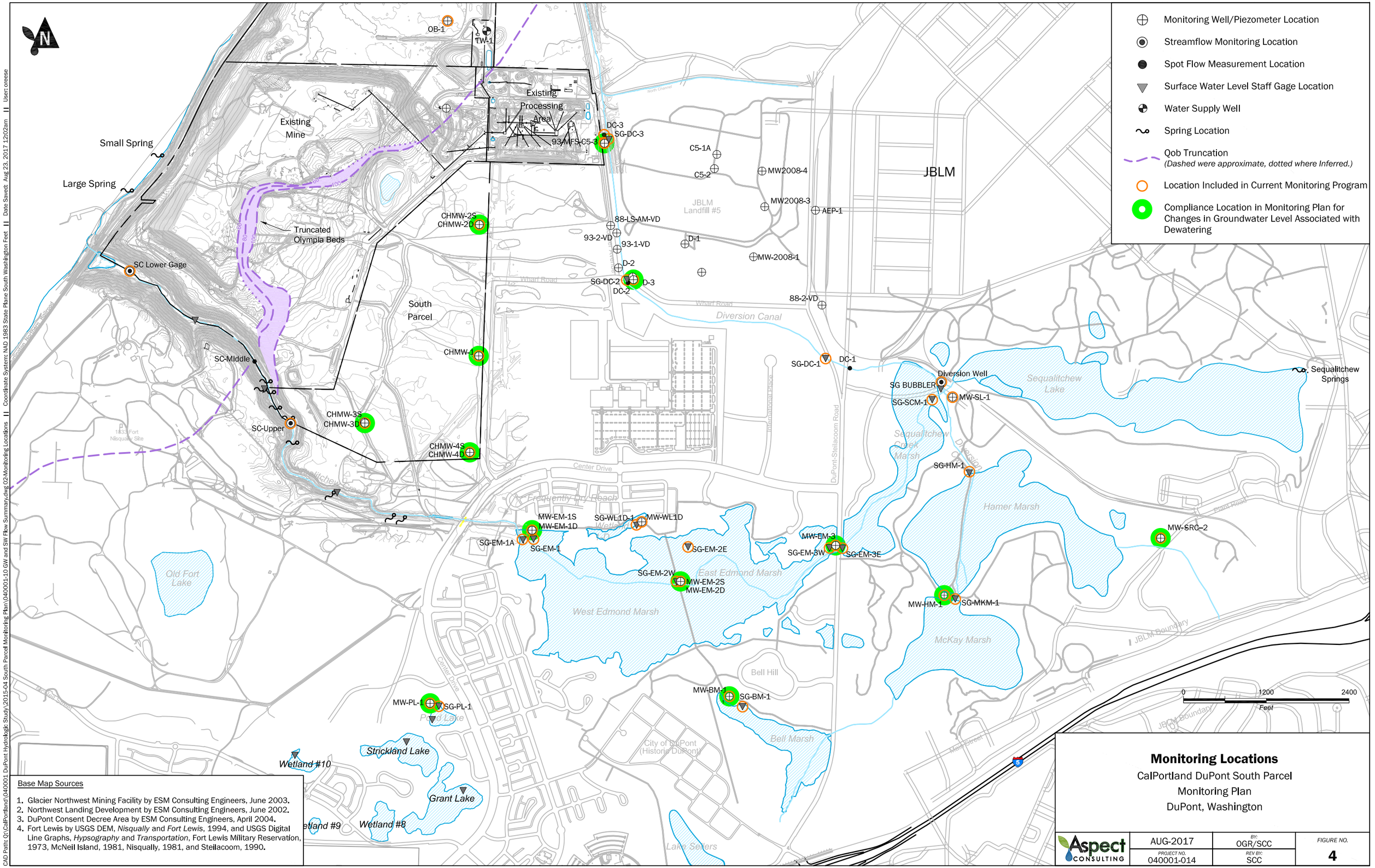

Base Map Sources

1. Glacier Northwest Mining Facility by ESM Consulting Engineers, June 2003.
2. Northwest Landing Development by ESM Consulting Engineers, June 2002.
3. DuPont Consent Decree Area by ESM Consulting Engineers, April 2004.
4. Fort Lewis by USGS DEM, *Nisqually* and *Fort Lewis*, 1994, and USGS Digital Line Graphs, *Hypsography* and *Transportation*, Fort Lewis Military Reservation, 1973, McNeil Island, 1981, Nisqually, 1981, and Steilacoom, 1990.

Monitoring Locations

CalPortland DuPont South Parcel
Monitoring Plan
DuPont, Washington

Aspect Consulting	AUG-2017	BY: OGR/SCC	FIGURE NO. 4
	PROJECT NO. 040001-014	REV BY: SCC	

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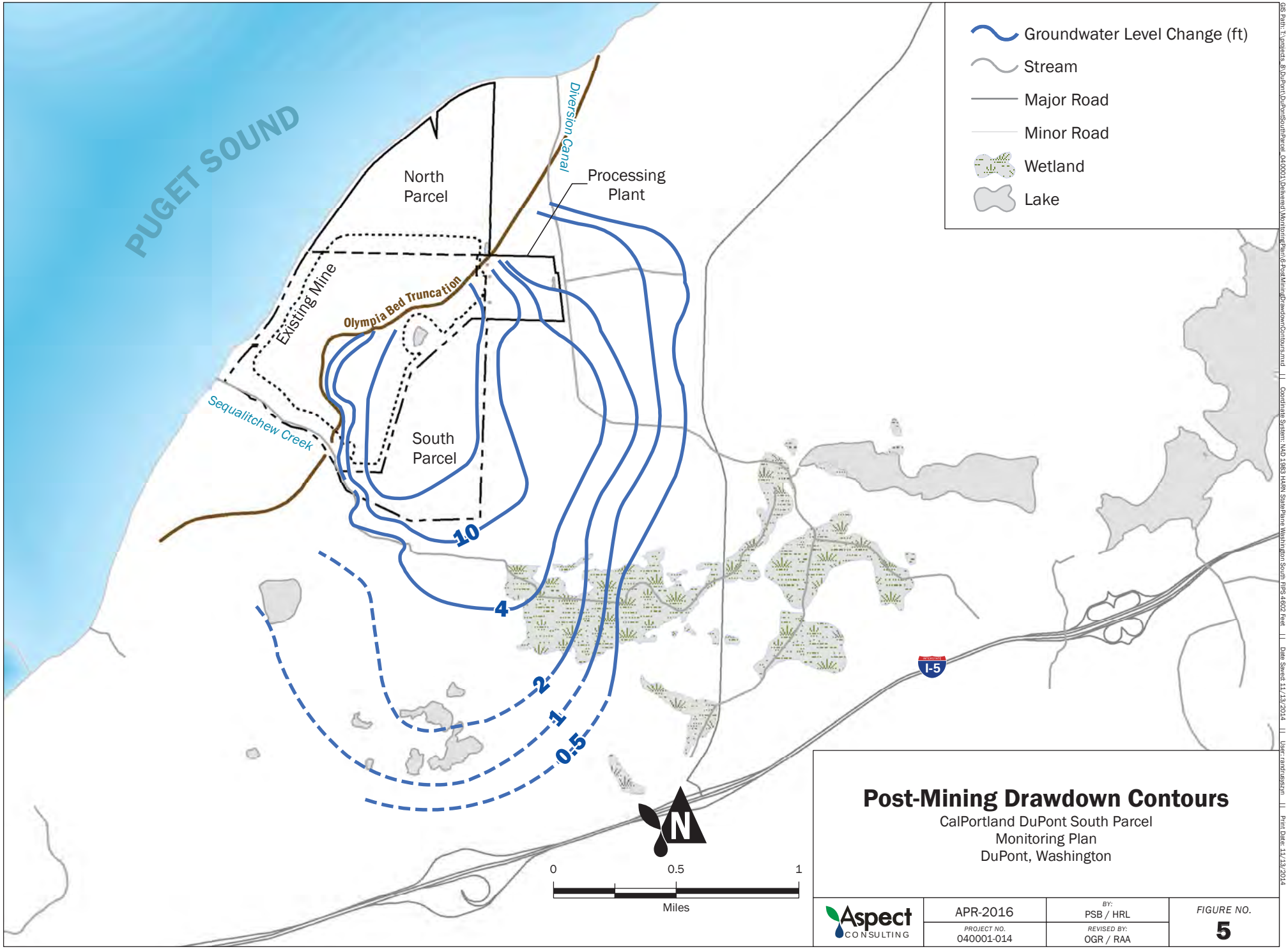

Post-Mining Drawdown Contours

CalPortland DuPont South Parcel
Monitoring Plan
DuPont, Washington

Aspect CONSULTING	APR-2016	BY: PSB / HRL	FIGURE NO. 5
	PROJECT NO. 040001-014	REVISED BY: OGR / RAA	

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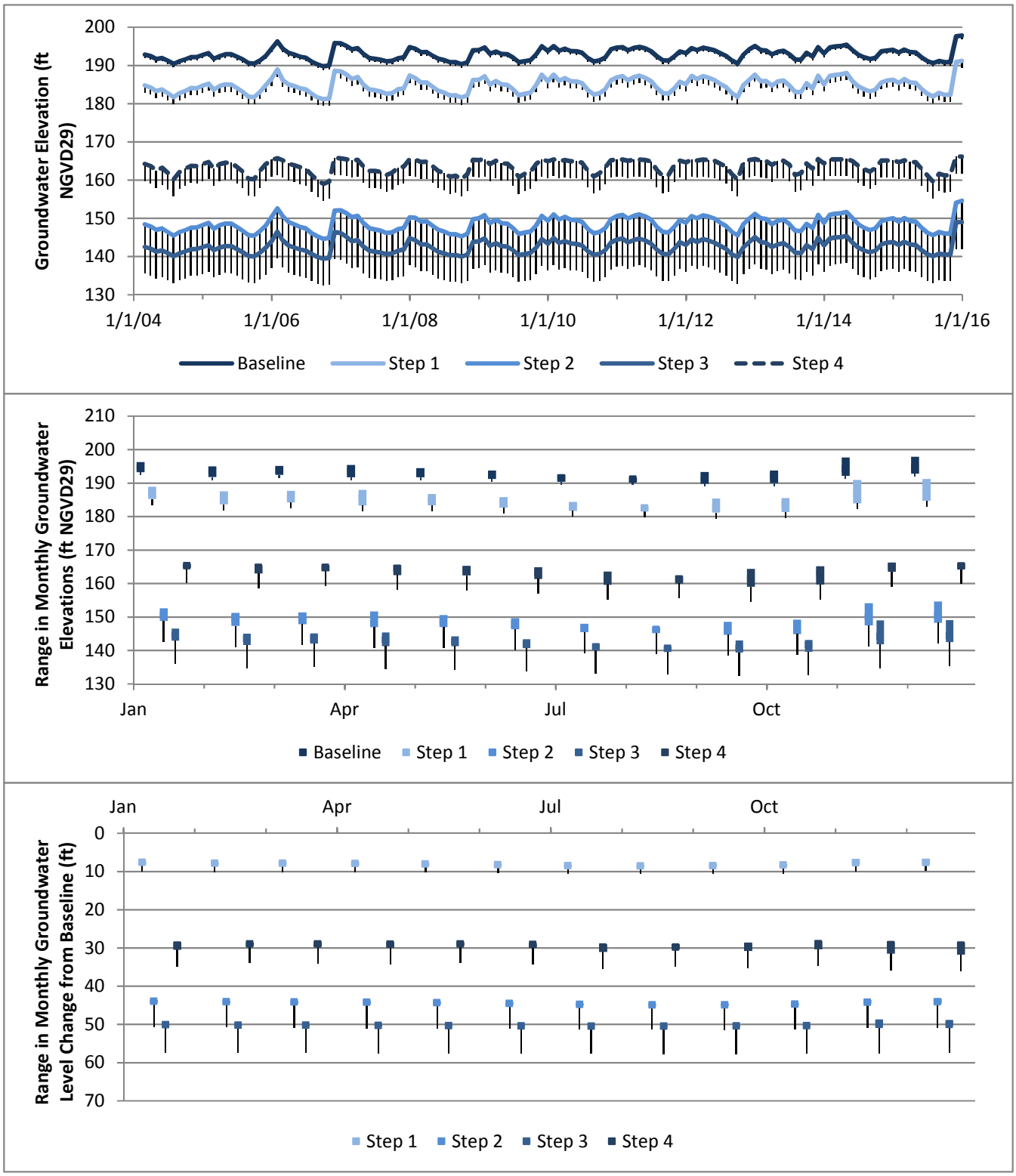
CHMW-2D



Aspect Consulting, LLC
03/20/2017
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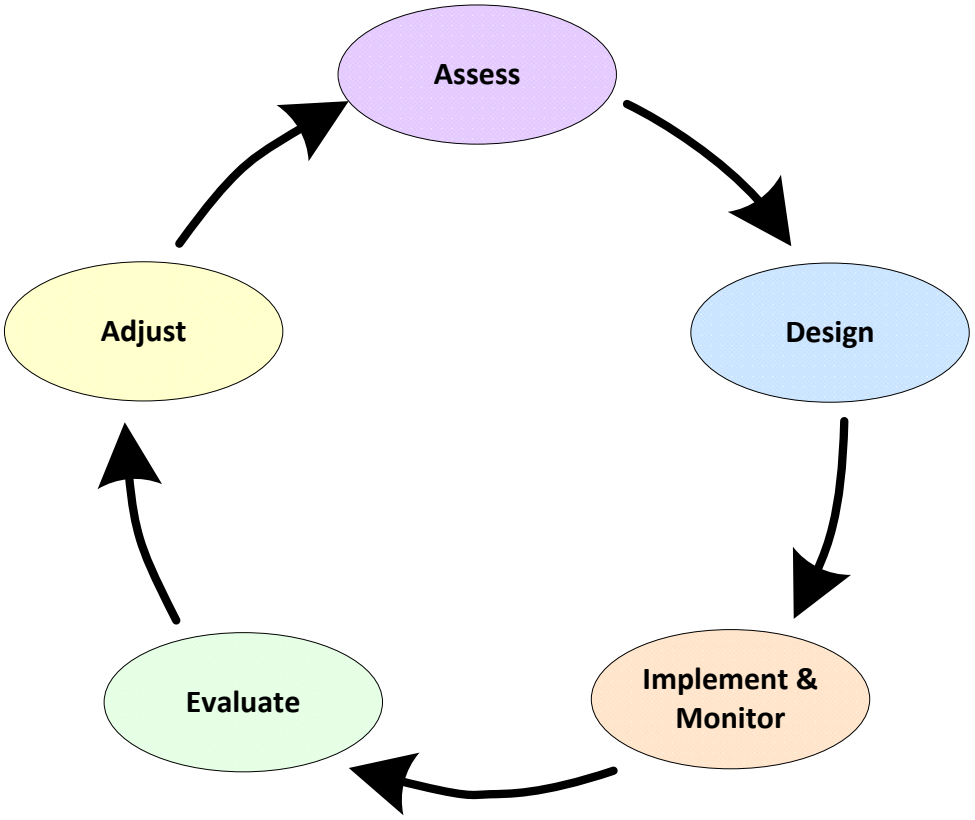
Figure 6
Predicted Changes and Ranges in Groundwater Levels



Adaptive Management Process

CalPortland DuPont South Parcel
Monitoring Plan
DuPont, WA

Aspect CONSULTING	APR-2016	BY: OGR	FIGURE NO. 7
	PROJECT NO. 040001-014	REV BY: ---	

VISIO PATH: S:\CalPortland\DuPont\South Parcel\Report Drafts\Monitoring Plan\Figures\AdaptManageCharts1.vsd | 11/12/2014

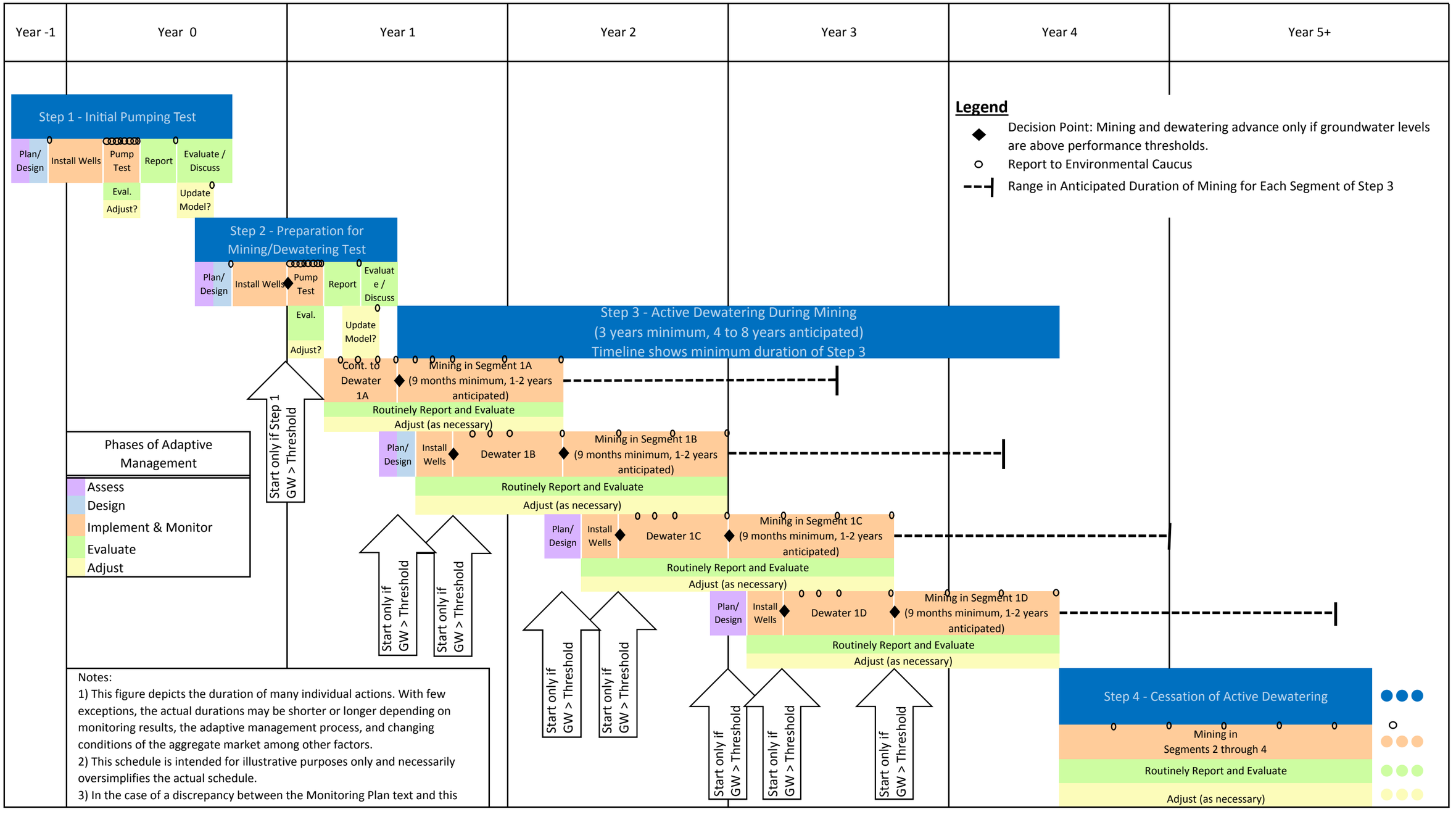
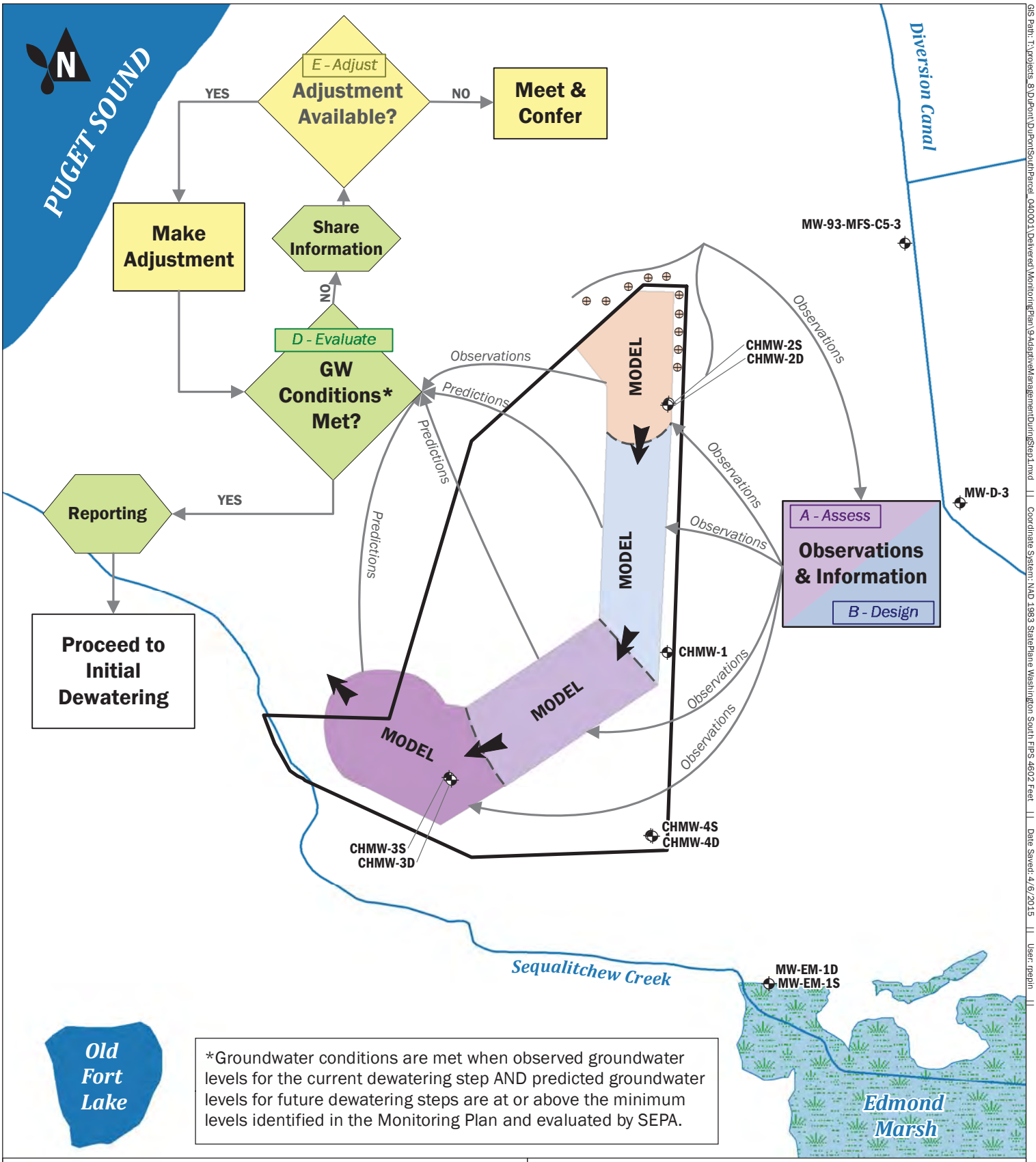


Figure 8
Timeline of Adaptive Management for South Parcel Mining



Adaptive Management Process During Step 1 - Initial Dewatering Test

CalPortland DuPont South Parcel
Monitoring Plan
DuPont, Washington

Aspect CONSULTING	APR-2016	BY: OGR / RAP	FIGURE NO. 9
	PROJECT NO. 040001-014	REVISED BY: ---	

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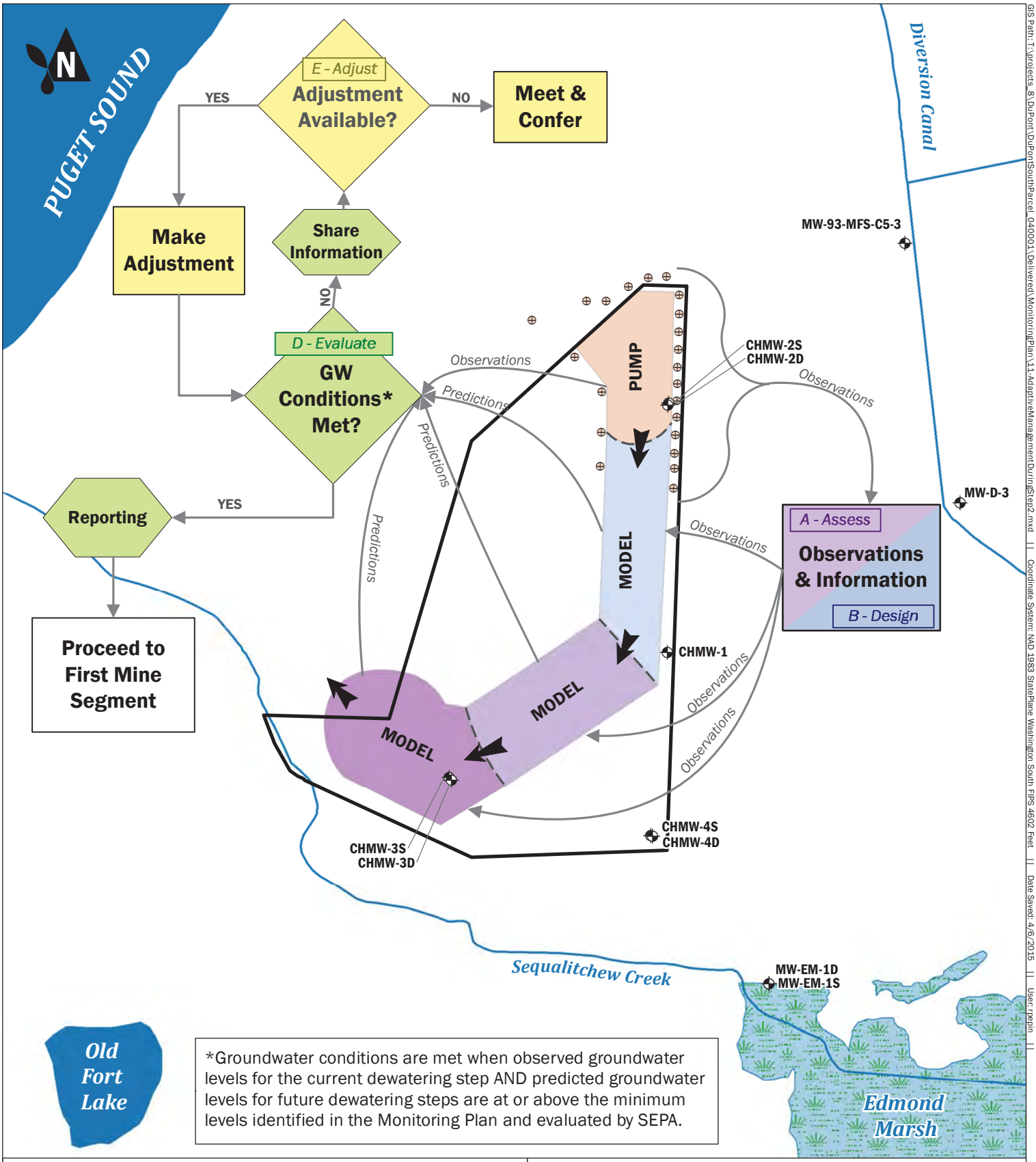

Adaptive Management Process During Step 2 - Preparation for Mining/ Dewatering Test

CalPortland DuPont South Parcel
Monitoring Plan
DuPont, Washington

Aspect CONSULTING	APR-2016	BY: OGR / RAP	FIGURE NO. 10
	PROJECT NO. 040001-014	REVISED BY: ---	

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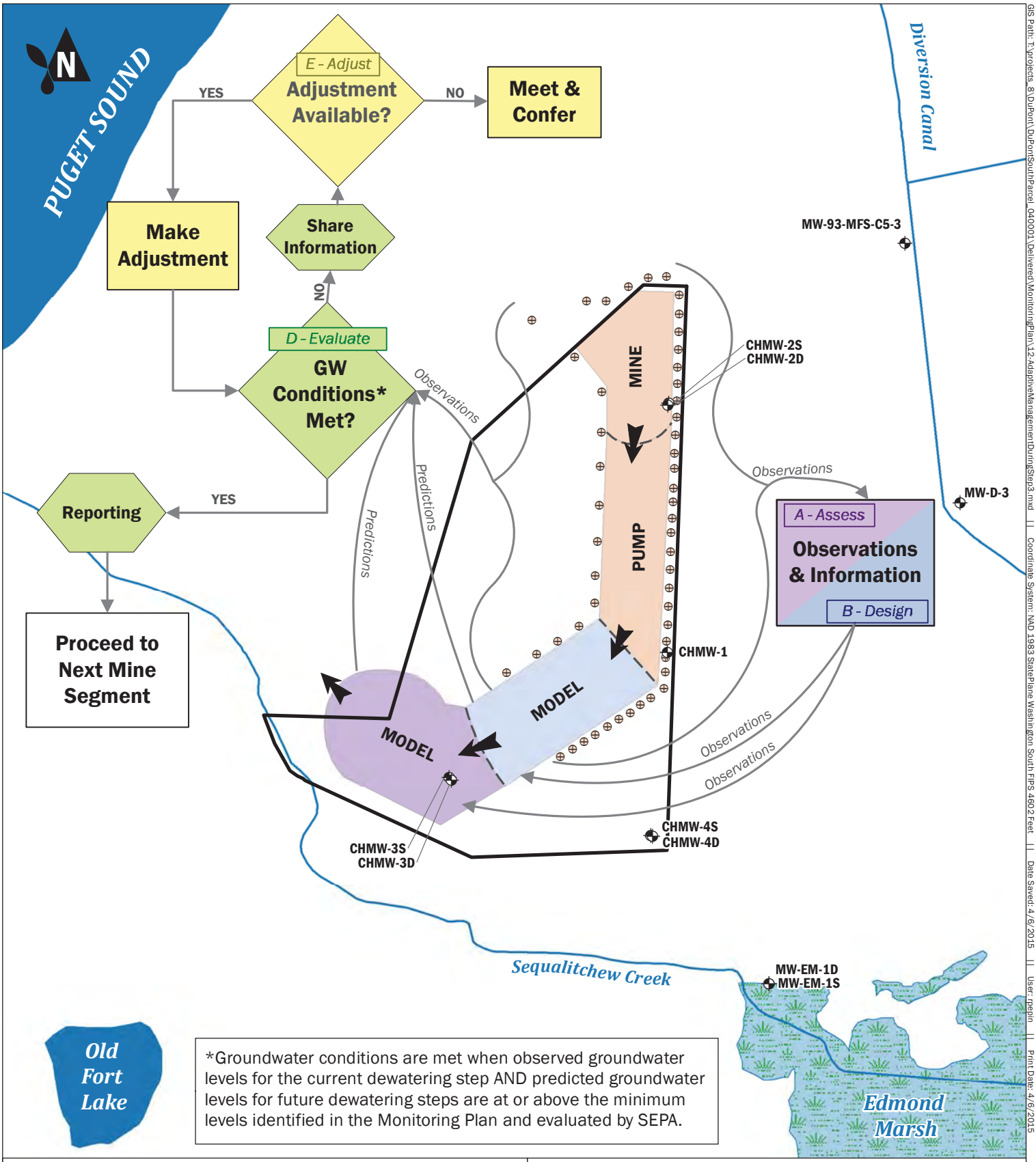
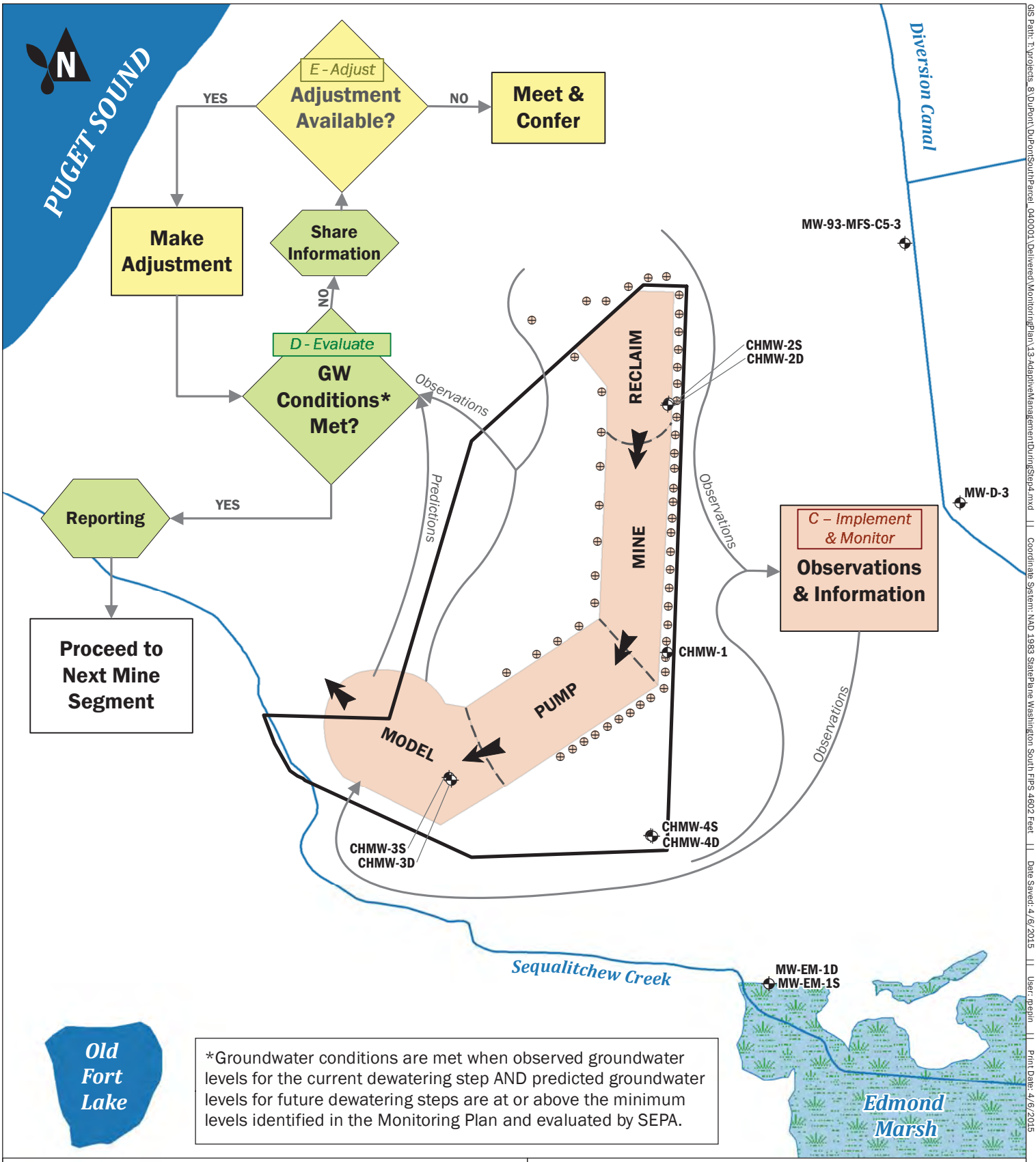


Adaptive Management Process During Step 3 - Active Dewatering and Mining

CalPortland DuPont South Parcel
Monitoring Plan
DuPont, Washington

Aspect CONSULTING	APR-2016	BY: OGR / RAP	FIGURE NO. 11
	PROJECT NO. 040001-014	REVISED BY: ---	

GIS Path: T:\projects_8\DuPont\DuPontSouthParcel_040001\Delivered\MonitoringPlan\12-AdaptiveManagementDuringStep3.mxd || Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet || Date Saved: 4/6/2015 || User: rpeplin || Print Date: 4/6/2015



*Groundwater conditions are met when observed groundwater levels for the current dewatering step AND predicted groundwater levels for future dewatering steps are at or above the minimum levels identified in the Monitoring Plan and evaluated by SEPA.

Monitoring Well
Dewatering Well
Wetland
Lake

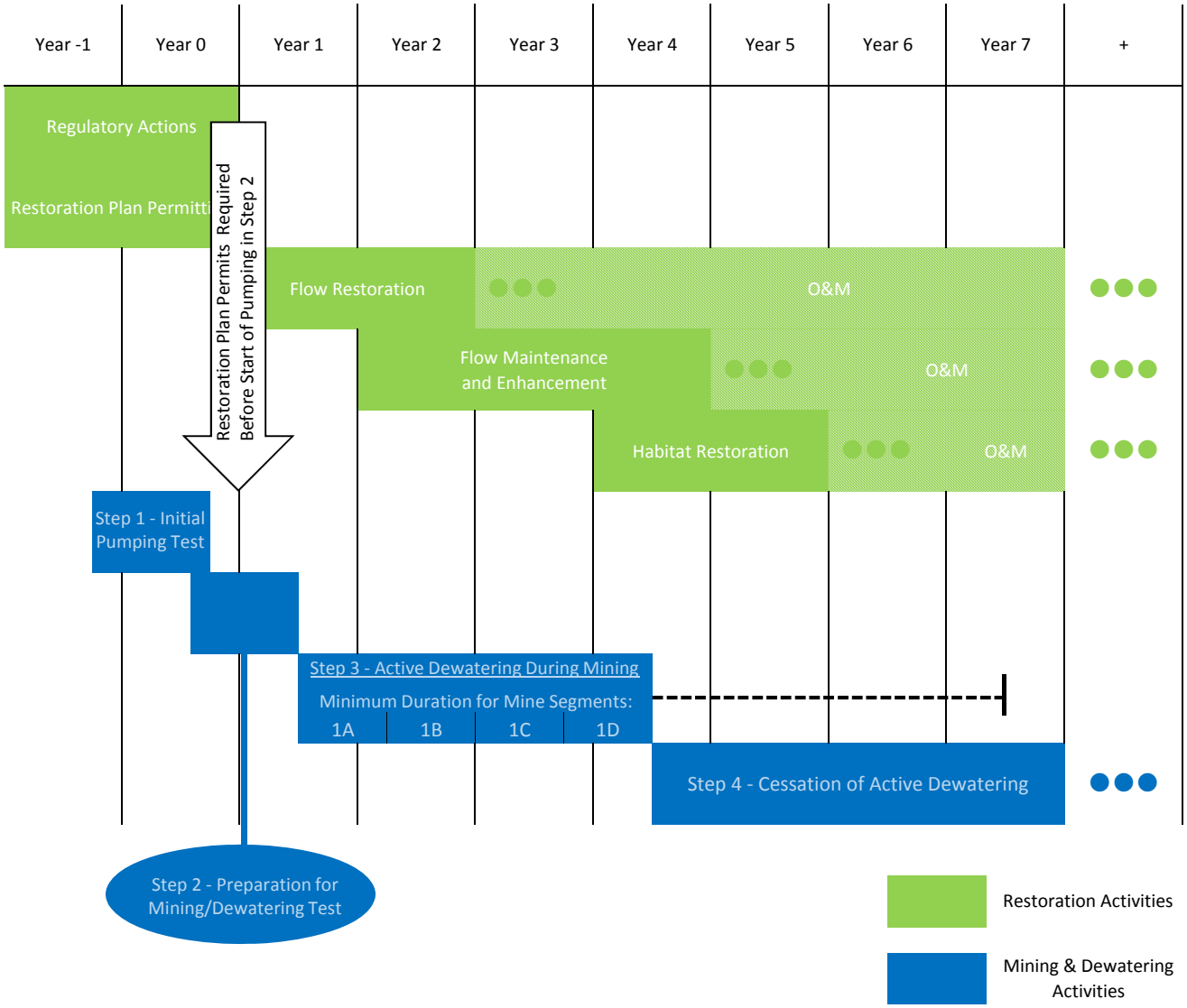
0 1,000 2,000
Feet

Adaptive Management Process During Step 4 - Cessation of Active Dewatering

CalPortland DuPont South Parcel
Monitoring Plan
DuPont, Washington

Aspect CONSULTING	APR-2016	BY: OGR / RAP	FIGURE NO. 12
	PROJECT NO. 040001-014	REVISED BY: ---	

GIS Path: T:\projects_8\DuPont\DuPontSouthParcel_040001\Delivered\MonitoringPlan\13-AdaptiveManagementDuringStep4.mxd || Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet || Date Saved: 4/6/2015 || User: rpeplin || Print Date: 4/6/2015

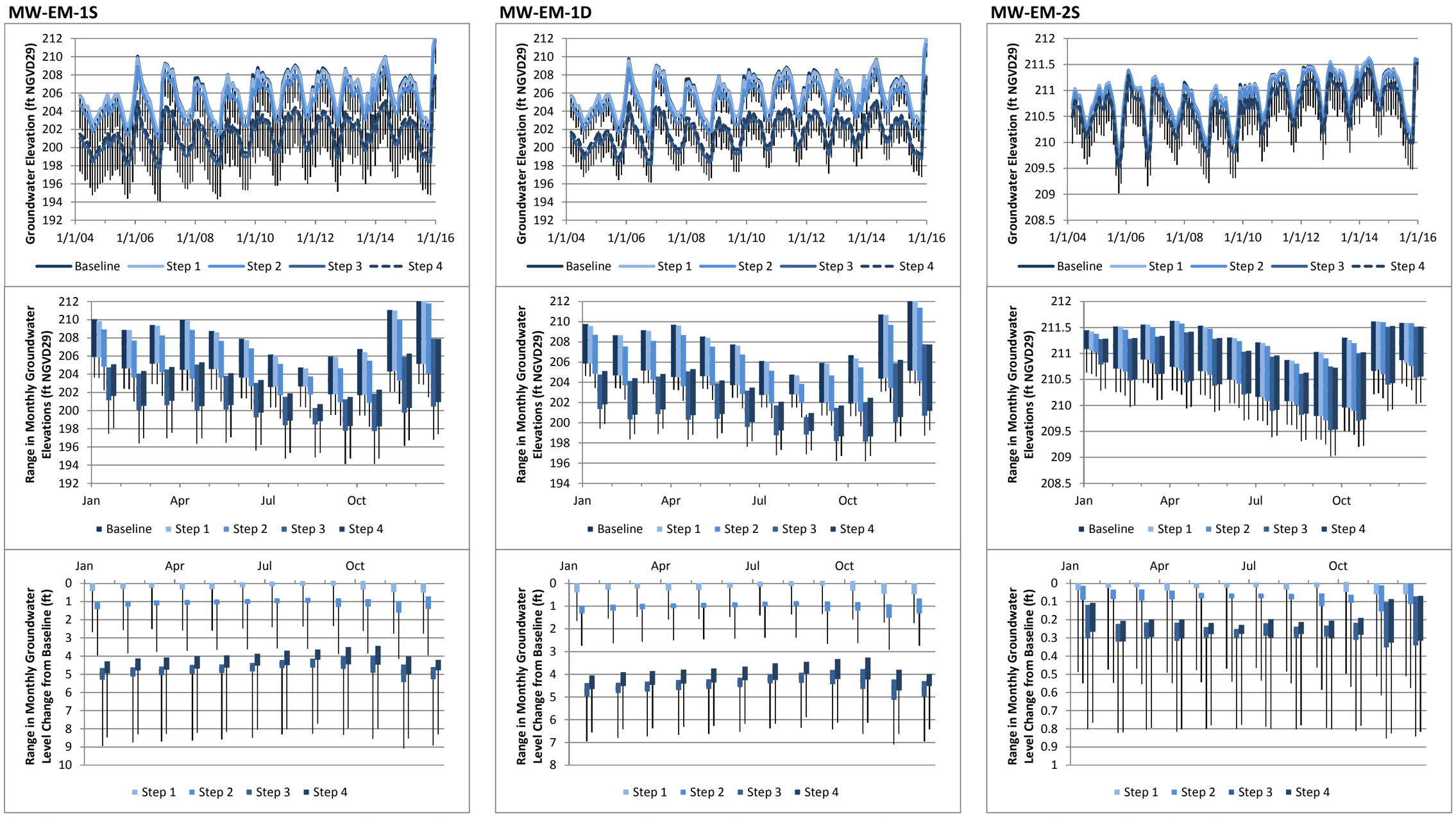


Notes:
1) Year 1 begins with the start of pumping in Step 2.
2) Mining timeline shown is based on the minimum duration of each mine segment in Step 3.
3) This figure depicts the duration of many individual actions. With few exceptions, the actual durations may be shorter or longer

Figure 13
Anticipated Timeline of Mining and Restoration Activities

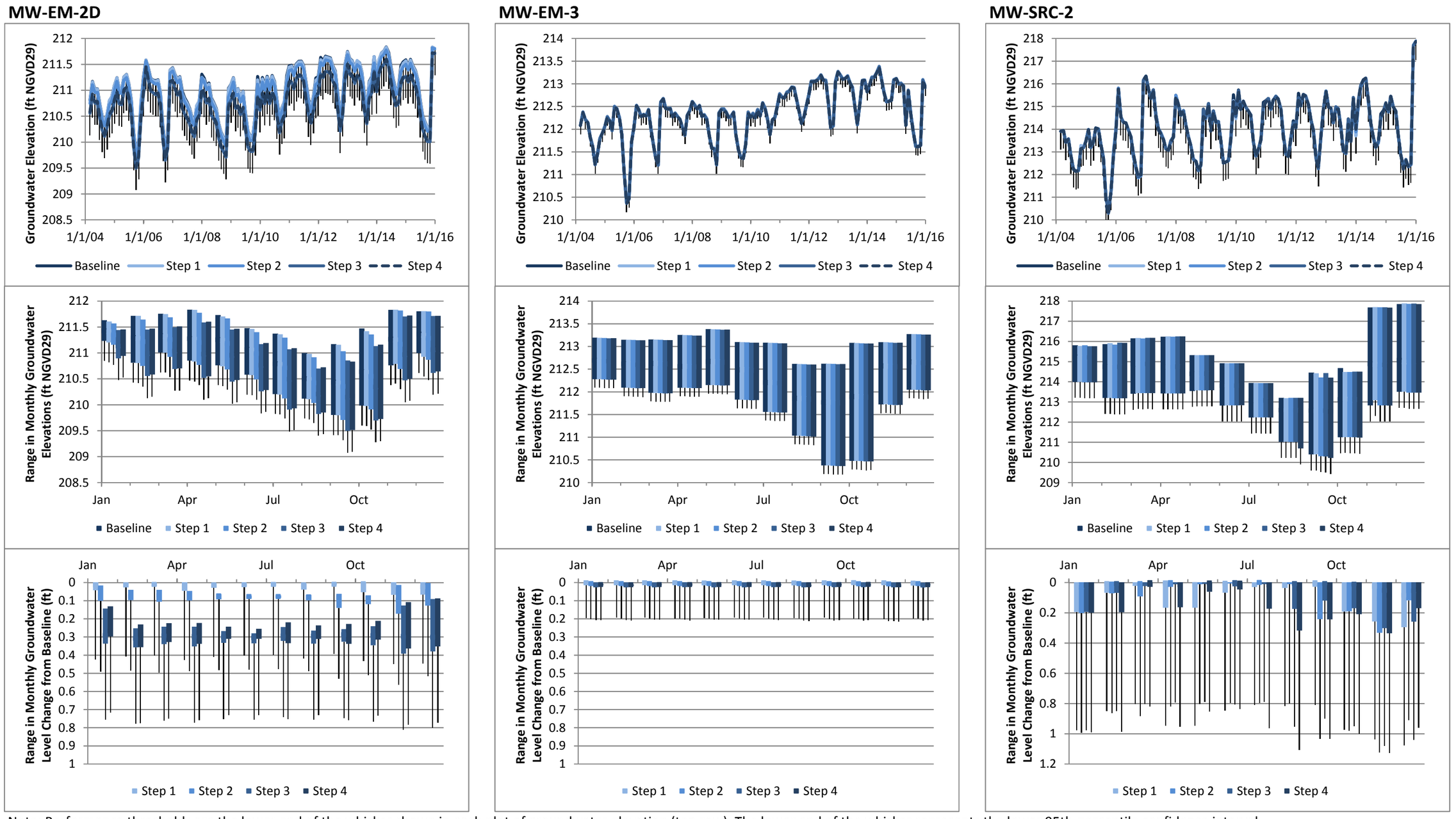
APPENDIX A

Performance Thresholds: Predicted Changes and Ranges in Groundwater Levels



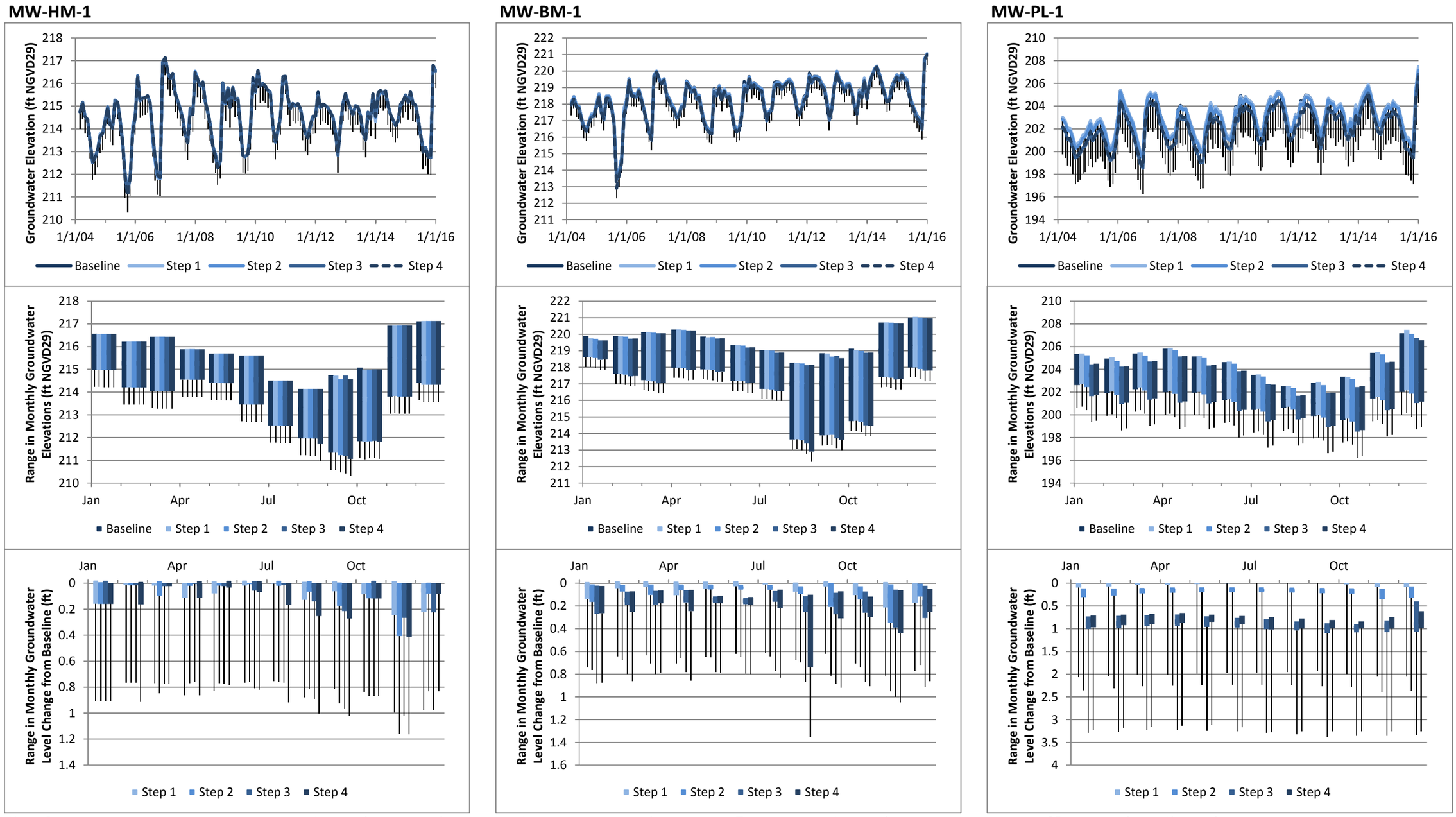
Note: Performance thresholds are the lower end of the whisker shown in each plot of groundwater elevation (top row). The lower end of the whisker represents the lower 95th-percentile confidence interval.

Figure A-1
Predicted Changes and Ranges in Groundwater Levels
Monitoring Plan



Note: Performance thresholds are the lower end of the whisker shown in each plot of groundwater elevation (top row). The lower end of the whisker represents the lower 95th-percentile confidence interval.

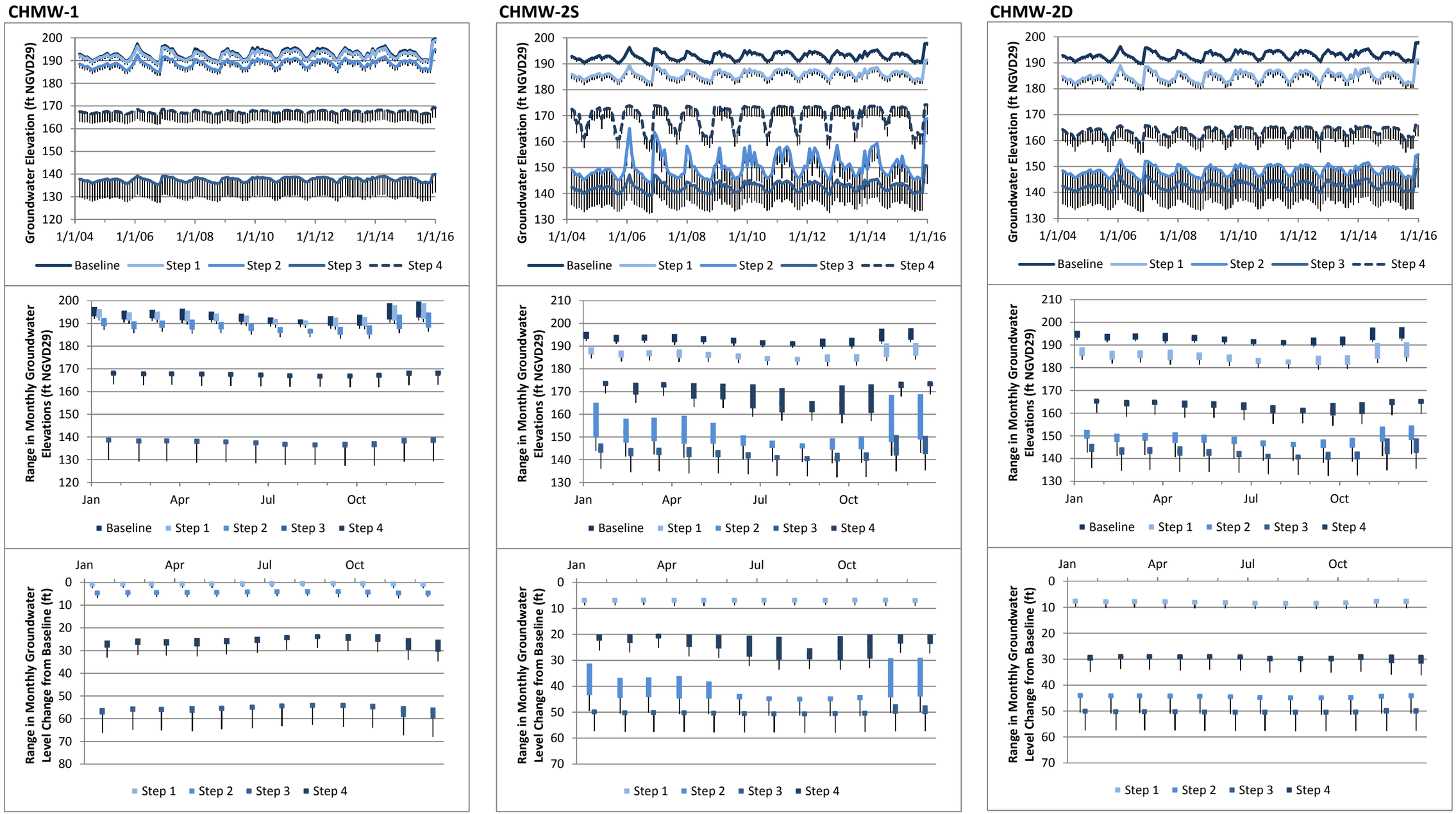
Figure A-1
Predicted Changes and Ranges in Groundwater Levels
Monitoring Plan



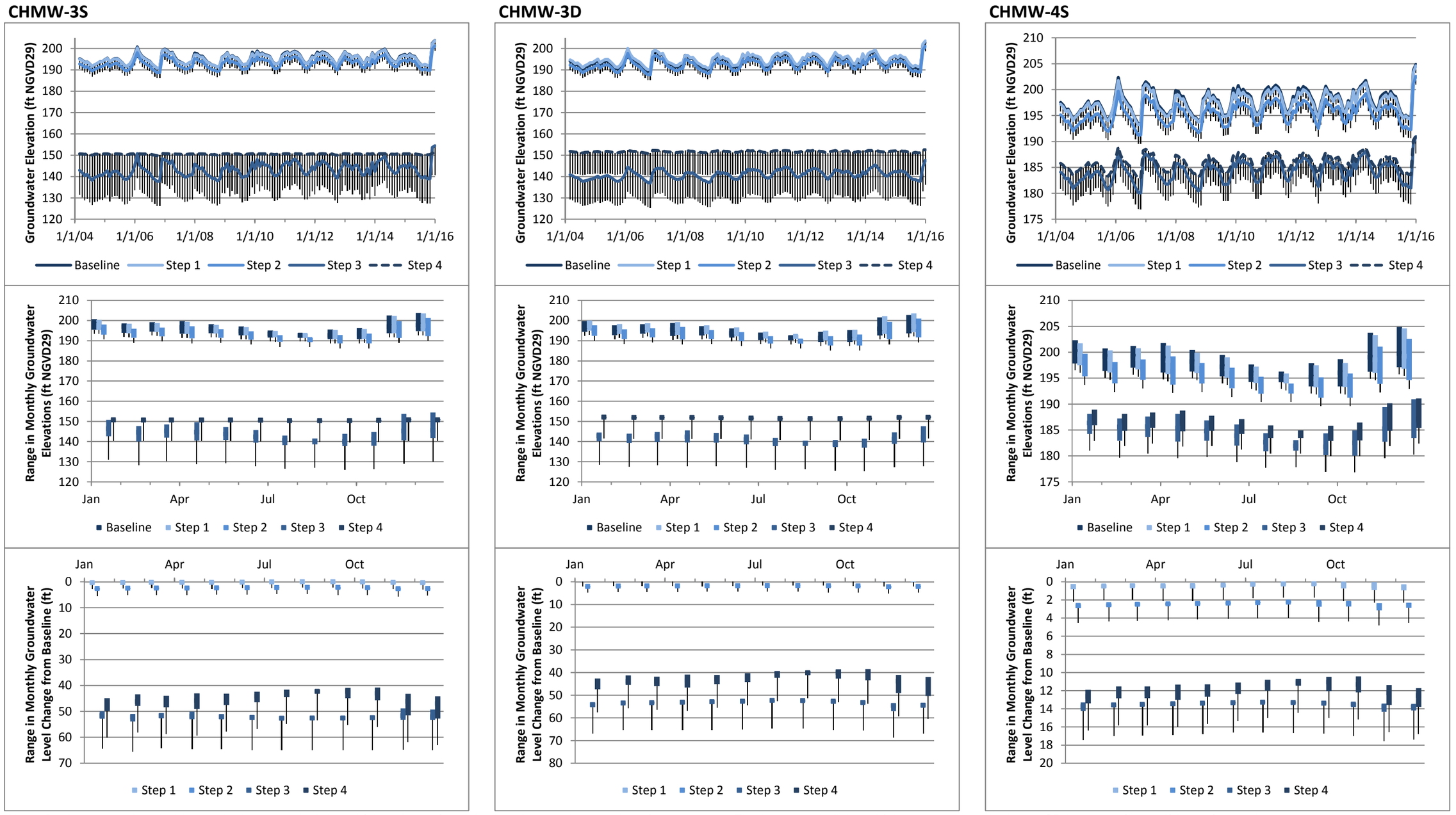
Note: Performance thresholds are the lower end of the whisker shown in each plot of groundwater elevation (top row). The lower end of the whisker represents the lower 95th-percentile confidence interval.

Figure A-1
Predicted Changes and Ranges in Groundwater Levels
Monitoring Plan

DRAFT



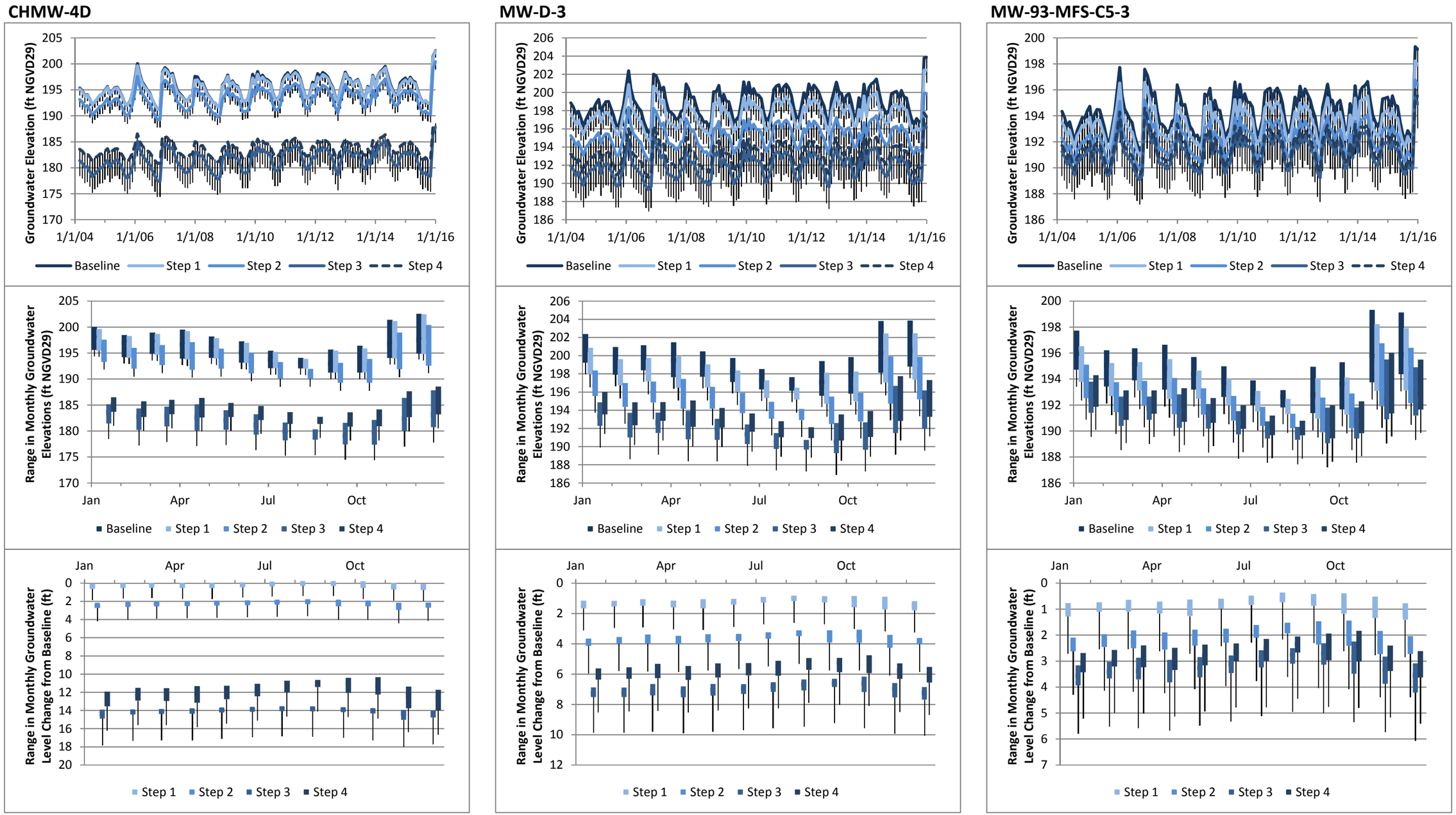
Note: Performance thresholds are the lower end of the whisker shown in each plot of groundwater elevation (top row). The lower end of the whisker represents the lower 95th-percentile confidence interval.



Note: Performance thresholds are the lower end of the whisker shown in each plot of groundwater elevation (top row). The lower end of the whisker represents the lower 95th-percentile confidence interval.

Figure A-1
Predicted Changes and Ranges in Groundwater Levels
Monitoring Plan

DRAFT



Note: Performance thresholds are the lower end of the whisker shown in each plot of groundwater elevation (top row). The lower end of the whisker represents the lower 95th-percentile confidence interval.

Figure A-1
Predicted Changes and Ranges in Groundwater Levels
Monitoring Plan

APPENDIX B

Sampling and Analysis Plan

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3 Relationship of Proposed Monitoring to Adaptive Management Thresholds
4 Water Quality Grab Sample Parameters and Methods *(in text)*
5 Field Monitoring Equipment Decontamination and Calibration Procedures *(in text)*
6 Stream Habitat Monitoring Parameters and Methods *(in text)*
7 Additional Habitat Observations *(in text)*

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A Well Logs
B Field Data Forms

Sampling and Analysis Plan

A.1. Introduction

This document presents the Sampling and Analysis Plan (SAP) to collect the information necessary to support the adaptive management processes of the South Parcel Monitoring Plan and the Restoration Plan for the Sequalitchew Creek Watershed. This SAP is intended to direct collection, processing, and reporting of data by a single, reliable, and consistent source that will be used to inform both adaptive management plans.

A.2. Background

A.2.1. Baseline Monitoring Program

A baseline monitoring program of surface water and groundwater within the Sequalitchew Creek basin is currently conducted by CalPortland as a component of mine planning. The monitoring program generally consists of measuring water levels and flows on a monthly basis at multiple locations in Sequalitchew Creek and its related marshes. The hydrologic monitoring program has four basic elements:

- Groundwater elevation monitoring;
- Surface water elevation monitoring;
- Surface water streamflow monitoring; and
- Surface water quality monitoring (e.g., temperature, dissolved oxygen, and turbidity).

The monitoring program is summarized in Table 1, and monitoring locations are shown on Figure 1.

The baseline monitoring program began in 1999, then expanded significantly in 2003. Monitoring data has previously been presented in four reports (Aspect, 2004a, 2004b; Aspect and Anchor, 2007; and Appendix B of Anchor QEA and Aspect, 2010). The 2004 reports describe the surface water and groundwater systems of the Sequalitchew Creek basin and summarize the monitoring data collected through 2004. The 2007 report presents monitoring data collected in 2005 and 2006. The 2010 report provides summary hydrographs of streamflow and marsh levels, illustrating the data available at that time.

A.2.1.1. Groundwater Level Monitoring

In the baseline monitoring program, groundwater levels are monitored monthly at a network of 20 wells located throughout the watershed, including within the mine area, marshes, and upland areas:

- North Parcel mine area: OB-1
- South Parcel mine area: CHMW-1, CHMW-2S and -2D, CHMW-3S and -3D, and CHMW-4S and -4D
- Marshes and Lakes:
    - Edmond Marsh: MW-EM-1S and -1D, MW-EM-2S and -2D, and EM-3
    - Hamer and McKay Marshes: MW-HM-1
    - Sequalitchew Lake: MW-SL-1
    - Pond Lake: MW-PL-1
- Upland areas: D-3 (near Landfill #5) and SRC-MW-2 (east of Hamer Marsh)

Water levels are measured manually by measuring the depth to water from the top of the well casing. The top-of-casing elevation of each well has been surveyed relative to the National Geodetic Vertical Datum of 1929 (NGVD 29) to allow for calculation of groundwater elevations. Well logs for the existing monitoring wells are provided in Attachment A.

A.2.2. Surface Water Monitoring

A.2.2.1. Water Levels

The baseline monitoring program includes monthly measurement of surface water elevations at 15 locations in the Sequalitchew Creek watershed (Figure 1).

In many locations, staff gages are located close to monitoring wells to allow for coupled observations of surface water and groundwater levels. The following staff gages are included in the baseline monitoring program:

- Bell Marsh: SG-BM-1
- McKay Marsh: SG-MKM-1
- Hamer Marsh: SG-HM-1
- Sequalitchew Creek Marsh: SG-SCM-1 and SG-EM-3E
- East Edmond Marsh: SG-EM-3W and SG-EM-2E
- West Edmond Marsh: SG-EM-1/1A and SG-EM-2W
- Wetland 1D: SG-WL1D-1
- Pond Lake: SG-PL-1

- Diversion Canal: SG-DC-1, SG-DC-2, and SG-DC-3

The typical staff gage installed on this project is an enamel plate capable of measuring water levels in 0.01-foot increments over a 3.33-foot range. The staff gages at the west end of West Edmond Marsh (SG-EM-1/1A) are paired, with SG-EM-1 located near well MW- EM-1 and used to measure higher water levels in winter and SG-EM-1A located in a low spot behind the beaver dam at the outlet and used for measuring lower water levels in summer.

In addition, surface water levels are measured as a component of the three continuous flow monitoring stations described in Section A.2.2.3.

A.2.2.2. Water Quality

Beginning in 2009, surface water quality has been monitored monthly at three locations: the Diversion Weir, the outlet of Hamer Marsh, and the mid-ravine gage on Sequalitchew Creek. Monthly monitoring consists of field measurements of temperature, dissolved oxygen, specific conductance, oxidation reduction potential, and turbidity with a YSI Pro Plus and a Hach Turbidimeter. Several samples have been collected for laboratory analysis for select metals (iron, copper, and zinc) and total petroleum hydrocarbons.

A.2.2.3. Streamflow

The baseline streamflow monitoring program consists of continuous measurements at three stations, periodic measurements at three stations, and visual observations at five locations. The specific locations monitored are:

- Continuous streamflow monitoring at the Diversion Weir, and mid-ravine[1] and lower-ravine stations in Sequalitchew Creek.
- Periodic streamflow measurements at three locations in the Diversion Canal (SG-DC-1, SG-DC-2, SG-DC-3); and
- Visual estimates of flow at five locations:
    - Culvert from Hamer Marsh to Edmond Marsh,
    - Culvert from Sequalitchew Creek Marsh to Diversion Canal
    - Ditch at Plant Road flowing to Hamer Marsh,
    - Sequalitchew Creek at footbridge downstream of W. Edmond Marsh, and
    - Sequalitchew Creek under Center Drive.

Measurements of streamflow are made using the conventional current-meter method as described by the U.S. Geological Survey (USGS, 1982). Stream velocities are measured and discharges are calculated using a SonTek Flowtracker.

Discharge measurements are initially made at various stream stages to determine a relationship between stage and discharge. Discharge measurements are then made at

[1] The mid-ravine station was formerly known as the Upper gage or SC-Upper.

periodic intervals to verify the stage-discharge relationship or to define any change in the relationship caused by changes in channel geometry and/or channel roughness.

Rating curves, which relate water depth to flow in the channel, have been developed for each flow monitoring location based on a number of manual flow measurements collected over a range of different flows. These rating curves are used to convert observed water depths (stage) to flows.

Stream stage at each station is measured using a 4230 Bubble Flow Meter manufactured by Teledyne ISCO and powered by a 12-volt deep-cycle lead-acid battery. The meter uses an internal air compressor to force a metered amount of air through a bubble line submerged in the flow channel. The water level above the bubble line orifice is determined by measuring the pressure needed to force air bubbles out of the line. An internal data logger records the water level as bubbler pressure at 15-minute intervals. The water level is converted to a stage height by correlating the meter readings to manual measurements taken during monthly site visits from a staff gage that is installed at each station. The equipment for the stations is serviced once a month by replacing the batteries and downloading the data to a portable computer.

Flow over the Diversion Weir is monitored by continuously monitoring stage using an ISCO 4230 and calculating discharge with a standard weir equation for a fully contracted rectangular weir from the United States Bureau of Reclamation's (USBR) Water Measurement Manual (USBR, 2001). The weir equation is presented in Section A.5.4.1.

A.2.2.4. Habitat Monitoring

Wetland Habitat

Wetland monitoring conducted to date has been focused on documenting baseline (pre-project) conditions of three key variables in habitats: topography, hydrology, and vegetation. Major changes to the boundary of Edmond Marsh have been analyzed from high-resolution aerial photos, and compared to field-collected data. Twelve vegetation monitoring transects are located throughout the Sequalitchew Creek basin: in Edmond Marsh, Sequalitchew Creek Ravine, Wetland 1D, Pond Lake, and Brackish Marsh. Overall, patterns in species presence detected during the monitoring in the period from 2004–2015 have been documented by Anchor QEA (2016).

Stream Habitat

Anchor Environmental (Anchor; now Anchor QEA) has previously evaluated stream habitat in Sequalitchew Creek using toe-width and stage-discharge analysis methods as a component of the Fish Habitat Benefit Evaluation for Sequalitchew Creek (Anchor, 2004). Additional information on the methodology and background can be found in that document.

The **Toe-Width Method** applies information on active channel width to estimate the optimal flows (maximum habitat) for salmon spawning and rearing. Within Reach 2 and 3, transects were established in areas with fairly uniform depth over a gravel/cobble substrate (5 transects and 4 transects, respectively). Since Reach 1 was located in the estuary, no toe-width transects were established. Additional transects were established to represent riffle habitat in all three reaches.

The **Stage-Discharge Analysis** provides a more detailed evaluation of how habitat availability changes with incremental increases in flow by linking data on the physical relationship between water surface elevation (stage), velocity, and discharge with the biological habitat preferences of spawning and rearing salmon. Stage-discharge relationships in lower Sequalitchew Creek were developed at numerous transects that were selected to be representative of habitat conditions in the study area.

A.3. Roles and Responsibilities

The roles and responsibilities of all key members of the monitoring team are shown in Table 2 below. The monitoring team may be comprised of one or more qualified consulting firms, governmental agencies (e.g., USGS or Ecology), or nongovernmental organizations.

Table 2. Monitoring Team Roles and Responsibilities

Position	Roles and Responsibilities
Project Manager—Monitoring Team	Responsible for oversight of monitoring personnel, coordinating project tasks defined in the Consultant scope of work, tracking project progress and schedule relative to budget, and manage staff to complete project activities.
Principal-in-Charge—Monitoring Team	Responsible for oversight to project team to ensure that QC procedures are followed and project data quality objectives (DQOs) are being met. Oversight of development of project SAP, field audits, and project reports.
Data QC/Reporting Lead—Monitoring Team	Responsible for developing SAP, standard operating procedures (SOPs), and data QA/QC procedures for project. Responsible for managing project database, completing data QC on all project data, and reporting for individual events and the overall project.
Technology Lead—Hydrology/Water Quality	Responsible for the design of each monitoring station. Provide oversight for installation of each station's monitoring system. Provide oversight for monitoring station maintenance and lead equipment troubleshooting activities.
Data Collection Lead—Hydrology/Water Quality	Manages and oversees monitoring and maintenance activities that are completed in the field for hydrology and water quality data collection.
Data Collection Lead—Habitat	Manages and oversees habitat monitoring activities.

A.4. Monitoring Approach

The monitoring conducted under this SAP will collect data necessary to assess whether activities associated with the South Parcel expansion and restoration of Sequalitchew Creek are achieving the objectives of the South Parcel Monitoring Plan and the Restoration Plan for the Sequalitchew Creek Watershed. The monitoring approach is targeted at the specific performance and aspirational thresholds identified in those plans.

The monitoring program includes six components that will be implemented at key locations within the watershed: groundwater level, surface water level, stream flow, surface water quality, habitat, and precipitation monitoring. Each of these components are described below. A cross walk between specific SAP elements and the objectives of the Monitoring Plan and Restoration Plan is provided in Table 3.

In addition to the main monitoring activities, stand-alone special studies will be implemented to address specific concerns of the mine expansion and watershed restoration. These special studies will be developed further as mining and restoration planning progresses, but are described generally in Section A.8.

A.4.1. Groundwater levels

Groundwater levels will be monitored primarily for comparison with the performance thresholds of the South Parcel Monitoring Plan.

Groundwater level monitoring will use the existing network of monitoring wells (described in Section A.2.1 and shown in Figure 1) and new dewatering wells and monitoring wells that will be installed specifically for this project. Water level monitoring will include a combination of spot measurements in active dewatering wells and adjacent temporary monitoring wells, continuous monitoring at key monitoring wells adjacent to the active dewatering area and beneath West Edmond Marsh, and routine monthly or semimonthly monitoring at other wells in the network.

As described in the Monitoring Plan, active dewatering of the South Parcel will occur in three sequential steps, involving progressively more dewatering wells, from 10 wells during Step 1, up to 66 wells during Step 3. Water levels will be measured periodically in the active dewatering wells, in new observation wells located adjacent to the active dewatering wells, and in several long-term monitoring wells installed in the interior of the South Parcel. Water level monitoring at these wells will be used to assess performance of the dewatering operation and, once mining operations commence in the South Parcel, will indicate if the moisture content of the mined aggregate is at appropriately low levels for safe, efficient mining and processing.

Outside of the South Parcel, groundwater level monitoring will consist of a combination of continuous monitoring and monthly or semimonthly manual measurements. During all Dewatering Steps, water levels will be monitored continuously in key wells located along the eastern boundary of the South parcel and in the western portion of Edmond Marsh. Specifically, the following key wells will be monitored continuously: CHMW-1, CHMW-2S and -2D, CHMW-3S and -3D, CHMW-4S and -4D. MW-EM-1S and -1D and MW-EM-2S and -2D. Water levels at all other groundwater monitoring wells will be measured monthly, except during Dewatering Step 2, when twice monthly measurements will occur, and Dewatering Step 3 when twice monthly measurements will occur for 3 months once new dewatering wells start pumping.

Monitoring wells are generally one- or two-inch-diameter PVC casings protected with a locking steel surface monument. Well depths vary from 5 feet for shallow piezometers to 85 feet for wells penetrating the Vashon Outwash gravels. Monitoring well logs are provided in Attachment A.

Continuous groundwater level monitoring will be conducted using a submersible pressure transducer connected to an aboveground data logger housed in a weather-resistant enclosure. Instruments will measure and record water level at 15-minute intervals. Data loggers will be downloaded by field staff at least weekly during Dewatering Steps 1 through 3 and once each month during Step 4.

A.4.2. Surface water levels

Surface water level monitoring data will primarily be used to compare the effects of restoration efforts with the performance and aspirational thresholds specified in the Restoration Plan. Surface water monitoring will occur at 12 stations as shown on Figure 1 and listed in Table 3 (station IDs have a "SG" prefix).

Continuous surface water monitoring will occur at SG-EM-1/1A and SG-EM-2E. Continuous water level data will be useful for assessing the water level response to precipitation. Water level will be measured manually once per month at the other stations; except during Dewatering Step 2, when twice-monthly measurements will occur. More frequent spot measurements will be made during specific restoration activities, such as the installation and adjustment of flexible levelers at beaver dams. New staff gage locations may be installed and added to the monitoring program as necessary to support adaptive management of the flexible levelers.

Surface water level monitoring at the seven locations in Sequalitchew Marsh, East Edmond Marsh, and West Edmond Marsh will provide feedback for efforts to increase westward flows in Sequalitchew Creek. Surface water level monitoring at SG-HM-1 in Hamer Marsh, in concert with groundwater level measurements at MW-HM-1 and MW-EM-3, will assess the increase in subsurface flow from Hamer Marsh to East Edmond Marsh following installation of the weir at Hamer Marsh outlet.

All surface water level monitoring stations are currently equipped with staff gages; either Stevens Style A or C porcelain-enameled iron plate. Style A gages are 3.33 feet long and 4 inches wide with graduated marks every 0.02 feet. Style C gages are also 3.33 feet long and are 2.5 inches wide with graduated marks every 0.01 foot. Water levels are measured to the nearest 0.01 foot. Water level is converted to surface water elevation by subtracting the staff gage height from the surveyed top-of-staff gage elevation and then adding the measured staff gage water level. At SG-EM-1 and SG-EM-2W, continuous water level monitoring will be conducted using a pressure transducer housed in a PVC stilling well that is mounted adjacent to the staff gage. The pressure transducer will be connected to the data logger used for continuous groundwater monitoring at the adjacent groundwater monitoring wells (MW-EM-1D for SG-EM-1/1A and MW-EM-2D for SG-EM-2W).

A.4.3. Streamflow

Streamflow monitoring will include:

- Continuous streamflow monitoring at five locations: the three existing streamflow monitoring stations (i.e., the Diversion Weir, and mid-ravine and lower stations in Sequalitchew Creek) and two new gaging stations on Sequalitchew Creek at the Lake Outlet and at Center Drive.

- Visual observations at the culvert from Hamer Marsh to Edmond Marsh.

At each continuous gaging station, water level will be measured and recorded every 15 minutes using a pressure transducer housed in a PVC stilling well and connected to a data logger that is housed in a weatherproof enclosure. Each continuous stream flow gaging station will include a Stevens Style A or C porcelain-enameled iron-plate staff gage, as described previous for the water level monitoring sites. Water level measured by the pressure transducer will be calibrated to the staff gage at the site. Field staff will service and download the data loggers at least monthly.

At the Diversion Weir, flow will be calculated using a standard discharge equation for a fully contracted rectangular weir as described above in Section A.5.4.1. At the other four gaging stations, stage-discharge or rating curves will need to be developed and maintained to calculate flow. Rating curves will be developed and maintained consistent with industry standard practices, as is currently done.

Flow through the culvert from Hamer Marsh to Edmond Marsh will be visually estimated monthly. Additional locations for visual flow estimates may be added at any time to respond to conditions observed in the field or adaptive management needs.

Following installation of the weir at the outlet of Hamer Marsh, outflow from Hamer Marsh to the Diversion Canal will be determined using the appropriate weir equation, based on water level observations at SG-HM-1, whose staff gage elevation relative the top of the weir will be established.

Continuous flow data from the Diversion Weir will be used to assess achievement of the Restoration Plan performance threshold to reduce flow to the Diversion Canal.

Continuous flow data from the Sequalitchew Lake Outlet and Center Drive gages will be used to assess achievement of the performance standard to match flows at those two locations.

Flow data at Center Drive, Upper Sequalitchew Creek, and Lower Sequalitchew Creek gages will be used to assess achievement of the performance standard to eliminate flow losses in the ravine.

Spot flow measurements at the Hamer Marsh Weir, at the culvert between Hamer Marsh and East Edmond Marsh, and in the ditch under Plant Road to Hamer Marsh, in concert with surface and shallow groundwater monitoring in and around Hamer Marsh, will be used to assess efforts to increase surface and groundwater flow from Hamer Marsh into East Edmond Marsh.

Going forward, the sampling program will no longer collect spot flow measurements in the Diversion Canal, since those data are not relevant to the objectives of the South Parcel Monitoring Plan or the Restoration Plan.

A.4.4. Surface Water Quality

The evaluation of habitat suitability will include monitoring water quality conditions in the watershed restoration area. In particular, stream temperature is predicted to increase in summer as a result of the restoration and mining projects for two reasons: 1) water

temperatures in Sequalitchew Lake are warmer than the groundwater discharge that currently provides the flow in Sequalitchew Creek during summer, and 2) dewatering for mining will reduce the groundwater discharge. Prior monitoring indicates that Sequalitchew Lake temperatures can reach up to 21°C in summer, whereas Sequalitchew Creek is currently 12 to 13°C. This condition is largely natural resulting from solar radiation on the lake surface. However, it also represents the primary tradeoff of restoration—greatly increased flow and reconnection to the natural water source in exchange for higher temperatures in summer.

The water quality monitoring program has been designed to monitor for unintended consequences, primarily focused on temperature, resulting from the restoration and mining projects. Stream temperatures will be monitored continuously at the five locations in the Sequalitchew Creek watershed where flow is measured (Sequalitchew Lake Outlet, Diversion Weir, Center Drive, and mid-ravine and lower ravine Sequalitchew Creek stations), as well as at the continuous water level monitoring stations in East Edmond Marsh (SG-EM-1 and SG-EM-2). The pressure transducers used to monitor water levels will be equipped with temperature sensors and will record water temperature every 15 minutes. The monitoring data will allow for developing temperature profiles along Sequalitchew Creek from headwaters to near the mouth.

These monitoring data will inform the adaptive management components of the Restoration Plan. The Restoration Plan includes several restoration elements that either include specific components that would reduce temperatures, or include flexible elements that could be implemented adaptively in response to monitoring data that indicate unanticipated effects on stream temperature. Specifically, the following elements of the Restoration Plan have components related to temperature, beyond those aimed at increasing flow through the system:

> G – Losing Reach—restoration of riparian vegetation in the losing reach will benefit stream temperature through shading.
>
> J – Ravine Habitat—this element is intended to adapt to habitat conditions that emerge once flow is restored in the ravine. Envisioned as being used to enhance stream structure through large woody debris placement, it could also be used to address temperature issues by creating pools as refugia or shading through riparian plantings.

In addition to temperature, water quality monitoring will include periodic *in-situ* monitoring of temperature, dissolved oxygen, and turbidity at select surface water level monitoring locations.

Periodic *in-situ* water quality measurements of temperature, dissolved oxygen, and turbidity will be collected using portable water quality meters. Measurements will occur monthly, except during Dewatering Step 2, when measurements will be taken twice each month. These water quality data, used in conjunction with measurements of physical habitat characteristics, will inform the assessment of habitat conditions relative to performance thresholds in the Restoration Plan.

A special study of Hamer Marsh water quality will be developed and implemented separately as described in Section A.8.

A.4.5. Habitat

A.4.5.1. Wetland Habitat

The most important effect of the combined mining and restoration projects would be the restoration of a surface water and wetland community connection between the ravine and Edmond Marsh. Data collection discussed in this section is focused on detecting changes to vegetation and habitat structure. This will be used in conjunction with the collection of hydrology data (see section A.5.2) and topography to understand the effects of the project. Hydrology (water surface elevation) data will be used to further understand habitat changes:

- Changes in water surface elevations, particularly in East Edmond Marsh;
- Changes in the magnitude of seasonal fluctuation in water surface elevations;
- Changes in the location and amount of open-water habitat, specifically any loss of open-water habitat in East Edmond Marsh, or greater persistence (later in the growing season) of open water habitats in West Edmond Marsh; and
- The establishment of a surface water and wetland community connection between the ravine and Edmond Marsh.

The baseline wetland habitat monitoring approach (see Section A.2.2.4) will continue to be used to identify patterns in plant species presence, hydrology, and topography under changing conditions along these established transects for comparison and analysis with post-project conditions. New transects will be established between Edmond Marsh and Lower Sequalitchew Creek. Baseline data was not collected in this reach due to the lack of flow and wetland or riparian vegetation during the baseline period.

A.4.5.2. Stream Habitat

Stream habitat will be monitored by measuring physical habitat characteristics at consistent locations over time. Habitat monitoring stations will be established as cross sections of Sequalitchew Creek spaced 100 feet apart for 1,500 feet upstream of the BNSF culvert, then 200 feet apart upstream to the east end of Edmond Marsh. This will provide additional resolution in the area likely to be used for spawning by Chum.

At each section, the following physical parameters will be monitored: flow depth, velocity, substrate size and cover. Cross sections will be monitored in years 0, 1, 2, 3, 5, and 10 commencing prior to construction of the first Restoration Plan element.

Observations of fish presence and active erosion will be noted during the cross-section surveys. Surveys of large woody material will be conducted in years 5 and 10.

A.4.6. Precipitation

Precipitation will be continuously monitored with a tipping bucket rain gage to be located on or near the South Parcel (e.g., City Hall, Pioneer Middle School, or Chloe Clark Elementary). An on-site, program-operated rain gage will likely provide a more complete data set that is of known quality and will better represent precipitation occurring within the watershed than would data from the McMillin Reservoir rain gage, which has been used for prior monitoring efforts.

A continuous precipitation record will provide a context for evaluating short-term changes in surface water and shallow groundwater levels, stream flows, and water quality conditions monitored within the watershed in response to storm events. Observed seasonal precipitation patterns will be used in the analysis of seasonal groundwater and surface water levels, stream flows, and water quality conditions.

The rain gage will be installed at the top of a 1.5-inch-diameter steel pole, approximately 10 feet above the ground surface. The rain gage will be wired to a data logger that will record and totalize rainfall on a 15-minute interval. The data logger will be housed in a durable, weatherproof steel enclosure.

The rain gage will be maintained per manufacturer's recommendations (see Section A.5.7 for methods). The rain gage will be capable of measuring only liquid precipitation (i.e., rainfall or melted snow); it will not be a heated rain gage capable of melting snow. Alternate rain data from the McMillin Reservoir rain gage or PRISM estimates of gridded precipitation for the project area will be used should the project rain gage malfunction.

A.5. Monitoring Procedures

This section provides specific procedural guidelines regarding routine field measurement and maintenance activities pursuant to the monitoring objectives detailed in the previous section.

Campbell Scientific (CSI) pressure transducers and data loggers will be employed at groundwater, surface water, streamflow monitoring stations, which continually measure level and water temperature. A project rain gage will be installed at one of the central monitoring stations, and be recorded by the station data logger. Equipment specifications and installation guidelines for continual monitoring stations includes the following:

- Parameter data (e.g., level, temperature, precipitation) will be recorded at a minimum of 15-minute intervals.
- Transducers selected for each station will be designed with a PSI range and cable length that is appropriate for the range of water levels expected in the observation well or surface water environment.
- Transducer sensor diaphragms will be vented to the atmosphere; eliminating corrections regarding barometric pressure compensation.
- Groundwater pressure transducers will be suspended from a fixed reference point in each monitoring well, at a point below the lowest expected water level. Suspending

the transducer prevents corrosion/interference of benthic sediment, or level discrepancies/drift due to settling.

- Surface water pressure transducers will be installed at a fixed point within a PVC stilling well, adjacent to the station staff plate.
- All level and flow rate measurements will be reported in decimal-feet and cubic feet per second (cfs), respectively.

Water levels measurements at stations recording continuous data will be maintained within a 0.02-foot tolerance. If the difference between the level measured during site inspections and the data logger recorded level is greater than ± 0.02 feet, field personnel will calibrate the data logger recorded level during routine site inspections. Differences in level, as well as calibration points, will be recorded on field sheets. Level drift observed from either the pressure transducer, or movement of the suspension cable, will be corrected by linear interpolation within the project dataset.

A.5.1. Routine Station Inspections

Routine site inspections will occur at least monthly while the project is actively collecting water quality, level, and/or flow data. Field staff will complete a field data collection form, or electronic equivalent, when conducting station inspections (see example in Attachment B). During monthly inspections, all equipment will be maintained per manufacturer recommendation, and include the following tasks:

- Download data logger module records;
- Maintain station grounds for clear and safe access;
- Clean and maintain enclosures, sensors, and monitoring equipment;
- Change/charge station batteries; and
- Calibrate/verify the accuracy, precision, and operation of sampling and monitoring equipment.

All observed and recorded field measurements, as detailed below, will be updated within the project database following routine inspection activities.

A.5.2. Groundwater levels

Groundwater levels are measured in monitoring well stations using a 150- or 300-foot electronic water level indicator. Depth to water is measured from a black mark on the top of the well casing and recorded to the nearest 0.01 foot. The depth to water is converted to a groundwater elevation by subtracting the depth to water from the surveyed top of casing elevations. Groundwater level measurements will be conducted and recorded on field sheets, or electronic equivalents, during each routine site inspection.

The well casings are accessed by unlocking and removing the lids on the steel stick-up-style monuments protecting each well. MW-C5-3 is maintained by JBLM. A key to unlock MW-C5-3 is obtained from JBLM during each site visit.

A.5.3. Surface water levels

Surface water levels are visually observed/measured during routine site inspections from staff plate gages; measured to the nearest 0.01 foot. Water levels will be converted to surface water elevation by subtracting the staff gage height from the surveyed top-of-staff gage elevation and then adding the measured staff gage water level.

A.5.4. Streamflow

Streamflow monitoring for this project will be performed by continuously observing the water level in the stream and calculating flow using one of two methods: a standardized weir-discharge equation or a stage-discharge rating curve.

Stream water levels will be visually observed/measured during routine site inspections from staff plate gages. CSI pressure transducers at continuous-record streamflow stations will be calibrated to the correspond station staff-gage level. Spot level measurements and observations at all other stations will be recorded during routine inspections. All level measurements will be used to calculate and update discharge flow volumes from each station.

A.5.4.1. Weir-Discharge Equations

Streamflow at the Diversion Weir is calculated using a standard discharge equation for a fully contracted rectangular weir from the USBR's Water Measurement Manual (USBR, 2001). The equation relates discharge (Q) to the length of the weir (l) and depth (d) of water over the weir as follows:

$$Q = 3.33*(l - 0.2*d)*d^{(3/2)}$$

It is imperative to maintain flow through weirs free from debris and obstructions, to ensure accurate level/flow measurements. Weir discharge equations will be incorporated into the project database, to ensure precision when field personnel transcribe field observations and measurements.

A.5.4.2. Stage-Discharge Rating Curve

Open-channel streamflow monitoring stations require the development of flow rating curves, which relate observed water depths (i.e., stage) to flow volumes. Rating curves will be developed for each flow monitoring location based on manual flow measurements collected over a range of different flows.

Measurements of streamflow (in cubic feet per second [cfs]) will be made using the conventional current-meter method as described by the USGS (1982). Stream velocities will be measured and discharges are calculated using a SonTek Flowtracker, or other similar velocity meter.

In accordance with the USGS current-meter method, observations of width, depth, and velocity will be made at approximately 10 to 15 intervals in a cross section by wading the stream. The average velocity of each subsection will be taken at 0.6 of the depth below the water surface. That velocity represents the average velocity for that stream subsection, whose cross-section area will be calculated from the corresponding width and

depth measurements. A streamflow measurement is the sum of the flow in each subsection.

The recorded discharge measurements are plotted against corresponding stage heights. The stage-discharge rating (i.e., regression equation) is determined by plotting a best-fit line through a series of stage-discharge points.

Rating curves will be developed at streamflow monitoring stations during a minimum of three (3) different flow event regimes, including flows covering the low-, mid-, and high ranges of the depths expected in each channel. To measure flows at these ranges, field personnel will collect flow measurements during various intensity storm events, as well as baseflow conditions. For existing stations, the rating curves developed during baseline monitoring will be used initially.

Rating curves are evaluated by comparing sets of flow event measurements to determine if the average rating curve for each event graphs similarly on a stage-discharge plot. A change in curve shape or shift in location indicates a change in channel geomorphology and a new rating curve is developed and updated, as necessary. Manual streamflow measurements are made at periodic intervals to verify the rating curve and evaluate if there has been any change in the stage-discharge relationship caused by changes in channel geometry and/or channel roughness. Rating curves were previously developed and reported for the mid-ravine and lower Sequalitchew Creek stations (Aspect and Anchor, 2007), and have continued to evolve since. The rating curves from these stations will be evaluated against new flow-discharge measurements, to ensure updated and accurate rating curves are used.

A.5.5. Surface water quality

Surface water quality parameters, including temperature, dissolved oxygen, pH, and turbidity will be monitored at all surface water stations. Water quality parameters are measured with a YSI Pro Plus multiparameter meter and a Hach Turbidimeter or equivalent instruments.

Surface water temperature will be continually logged by integrated CSI pressure transducer temperature sensors or equivalent equipment (e.g., Onset Hobo/Tidbit© temperature loggers). Temperature sensors will have a minimum accuracy/precision range of +/- 0.2°C. Temperature sensors will be calibrated and maintained in accordance with Ecology's (2015) Standard Operating Procedure (SOP) for Continuous Temperature Monitoring of Fresh Water Rivers and Streams (EAP080). Deployment techniques for temperature sensors/loggers will follow guidance and from Ecology's SOP; however, may vary slightly based on alternative equipment specifications.

Table 4 summarizes the water quality parameters and standard methods that will be employed for the surface water quality monitoring objectives of this project.

Table 4. Water Quality Grab Sample Parameters and Methods

Sample Type	Field Collection Containers	Parameter	Holding Time	Method	Lab Sample Container	Preservative
Continuous	*In-situ* stream or surface water station	Temperature	N/A	Continually logged via CSI pressure transducer, or equivalent	*In situ* (n/a)	*In situ* (n/a)
Grab	1-liter poly	pH	15 minutes	EPA 150.1 via YSI	*In situ* (n/a)	*In situ* (n/a)
		Dissolved Oxygen	15 minutes	EPA 150.2 via YSI	*In situ* (n/a)	*In situ* (n/a)
		Turbidity	15 minutes	EPA 180.1 via YSI	*In situ* (n/a)	*In situ* (n/a)

Manual grab samples will be collected by directly filling sample bottles from the monitoring discharge point, using a “clean hands” approach. The principle of the “clean hands” technique is that field personnel wear appropriate noncontaminating, disposable, powderless gloves during the entire grab sample collection procedure; changing gloves frequently with each change in task.

In-situ measurements with the YSI multiparameter meter may be conducted by directly submerging the sensors into surface waters, so long as there is no interference from bottom sediments or debris.

A.5.5.1. Equipment maintenance

Monitoring equipment will be inspected and serviced as recommended by the manufacturer, or at least once preceding the deployment of temporary monitoring station setups. Generally, equipment maintenance includes: inspection, testing, calibration, and replacement of worn or missing components. Table 5 summarizes the water quality field equipment specifications for this project, including: parameters, decontamination, and calibration procedures.

Table 5. Field Monitoring Equipment Decontamination and Calibration Procedures

Equipment	Parameters	Decontamination Procedure	Calibration Procedures
YSI water quality multimeter, or equivalent	pH; dissolved oxygen	Rinse sensors thoroughly with DI water as needed Store sensors in KCl solution between uses.	Perform the following prior to each site inspection: • Three-point calibration of pH (4,7,10) • Dissolved oxygen using barometric pressure and/or saturation method
HACH Turbidimeter, or equivalent	Turbidity	Rinse sample vials thoroughly with DI water as needed.	Perform reference calibration before every sample period, in accordance with manufacturer specifications.
Continually logged via CSI pressure transducer, or equivalent	Temperature	Gently clean temperature loggers with a soft cloth or soft-bristled brush to remove any biofouling or sediment.	Record ten reference *in-situ* measurements using NIST field thermometer. Compare the mean absolute value of the NIST thermometer measurements against the continuous temperature logger for the same time period; ensure the mean difference isn't greater than 0.2°C.

A.5.5.2. Qualitative Observations

In addition to the quantitative observations of water quality described above, surface water stations will be qualitatively inspected for the following, where applicable:

- Channel conditions, including the presence/absence of beaver dams, downed trees, streambed composition, vegetation, and particularly fast or slow flow velocities.
- Water color, floating oil and grease, floating debris/scum, and materials that may be toxic or harmful to human or other life.

A.5.6. Habitat

Habitat data are collected for two purposes: 1) stream cross sections are measured for comparison with the performance and aspirational thresholds of Goal 2 of the Restoration Plan, and 2) wetland and additional stream habitat measurements are collected to understand the linkages between stream restoration activities and effects on habitat. The wetland and additional stream habitat measurements could inform decisions to employ additional adaptive management strategies or modify existing strategies to limit impacts and/or increase benefits. The supplemental data would not be applicable to the evaluation of performance or aspirational thresholds.

A.5.6.1. Wetland Habitat

Wetland habitat will be measured using established transects with surveyed topography that has been related to surface water monitoring stations. The protocols for point intercept methods for determination of the vegetation community will generally follow Heady et al., 1959. Vegetation data will be collected annually at the end of the growing season (September or October, typically). A tape measure will be strung between fixed points (T-stakes or rebar, typically) and all vegetation species present at each given interval (1-foot or 2-foot, depending on transect length) will be recorded along with the distance from the start of the transect for correlation to surveyed ground surface elevation and surface water elevation data collected throughout the growing season.

A.5.6.2. Stream Habitat

Habitat monitoring stations will be established as cross sections and marked with driven rebar, or similar, in the field. Stations will be spaced 100 feet apart for 1,500 feet upstream of the BNSF culvert, and will be spaced 200 feet apart upstream to the east end of Edmond Marsh. At each section, the following data will be collected, at the frequency indicated in Table 6.

Table 6. Stream Habitat Monitoring Parameters and Methods

Parameter	Method	Precision/ units	Frequency
Depth	Measured every 2 feet within the wetted width of the section using a stadia rod.	0.1 foot	Years 0,1,2,3,5,10
Velocity	Measured at least every 2 feet within the wetted width of the section with a minimum of five measurements using a current velocity meter (Swoffer 2100 or similar).	0.1 feet per second (fps) for velocities between 0.5 and 25 fps	Years 0,1,2,3,5,10
Substrate size	D50 of randomly chosen substrate at least every 2 feet within the wetted width of the section with a minimum of 10 measurements.	1 mm	Years 0,1,2,3,5,10
Cover	Densiometer	Intersects	Years 0,1,2,3,5,10

Additional observations will be collected along the creek and referenced by distance upstream from the BNSF culvert (by station), as shown in Table 7.

Table 7. Additional Habitat Observations

Parameter	Method	Precision/ units	Frequency
Large Woody Material	Repeat existing survey based on methodology by Fox and Boulton (2007).	Count	Years 5, 10
Fish Presence	Visual identification	Species/ size (approx.)/ behavior	0,1,2,3,5,10
Active erosion	Visual identification	Photo documentation with scale	0,1,2,3,5,10

All data, except large woody material, will be collected once per indicated year in November or December when flows are between 100 and 200 percent of mean monthly average flow (or as predicted during years 1 and 2). Data on large woody material can be collected at any time of year.

All data will be presented in an annual monitoring report, including summarization and analysis of the data in terms of the quantity of usable and optimal habitat for Chum spawning and salmonid rearing. Trends over monitoring years will be included along with adaptive management considerations regarding the project performance or this sampling methodology.

A.5.7. Precipitation

For this project, a Hydrological Services Model TB3, or similar, tipping bucket rain gage will be installed at the designated site on the South Parcel. This instrument measures rainfall at 0.01-inch increments. The rain gauge will be connected to a CSI data logger, recording rainfall data at 15-minute intervals. The rain gage will be downloaded at least once each month. Field staff will inspect the rain gage monthly and service as needed. Rain gage calibration checks will occur using the method and at the frequency recommended by the manufacturer.

A.6. Quality Control

This section presents the quality control (QC) requirements for field and laboratory activities associated with this project.

A.6.1. Field

Field measurement equipment, dataloggers, and pressure transducers will be maintained and calibrated every month, at a minimum, to help ensure proper monitoring station operation. Preventative maintenance of the pressure transducers and water quality multimeters will be performed as specified by the manufacturer. The pressure transducers and sensors will be calibrated to the manufacturer's recommendations.

Original field records will be maintained in designated binders for all monitoring and field-related activities using project-specific forms, and guided by the procedures outlined in this SAP. Field documentation will include monthly inspection field sheets, maintenance/calibration logs, COC forms, and other required documentation. All entries in field notebooks will be written in pencil or waterproof ink. When errors are made,

project staff cross-out the error and enter the correct information. All corrections will be initialed and dated. Electronic equivalents of field forms may be used.

Field personnel will employ the following additional field-sample collection QC procedures, as needed:

- Collect grab water quality samples in certified contaminant-free or properly decontaminated containers.
- Use "clean hands/dirty hands" sampling techniques (that is, one team member performs "dirty tasks," while the other member performs "clean tasks," such as handling sample collection bottles).
- Hold samples on ice in coolers during retrieval and delivery to analytical laboratory.
- Deliver samples to analytical laboratory with proper chain of custody, and within holding times.

A.6.2. Laboratory

An accredited laboratory will be contracted to complete additional analyses, as needed, by the inclusion of special studies. Analytical test methods will be standardized and in accordance with procedures approved under 40 Code of Federal Regulations (CFR) §136. The minimum laboratory QA/QC requirements shall also include, but may not necessarily be limited to the following:

- Calibration of analytical laboratory instruments within acceptable limits.
- Periodic inspection, maintenance/servicing, and analysis of quality indicator samples, as necessary, to determine the accuracy and precision of procedures, instruments, and operators.
- Statistical procedures, such as control charts to monitor the precision and accuracy of the analytical data and to establish acceptance ranges and control limits. These data shall be maintained with project records and available upon request or during an audit.
- A continuous review of results to identify and correct problems originating with the instrument, the methodology or the analyst.
- Thorough documentation of the performance of systems, procedures, and operators.
- Certify that electronic data deliverables will exactly match all hard copy data.
- Provide notification of all nonconforming events and conditions, including missed holding times and delays in turnaround time, potentially impacting sample analysis.

A summary of laboratory QA/QC procedures will be requested in the final analytical report deliverables.

A.7. Data Management

This section describes the data management procedures to be used for ensuring access to consistently reliable data. The data management procedure includes 1) recording measurements in the field, 2) downloading data from storage devices in the field, and 3) transferring these data into project databases. There are two separate databases, one for hydrologic data and managed by the hydrology/water quality consultant, and a second for storing vegetation information from the wetland transects and quadrats in the marshes and creek, managed by the habitat consultant. This section defines the structure, inputs, outputs, and quality assurance(QA) and quality control (QC) procedures for the hydrologic database. These data management procedures closely follow those used for current and prior monitoring activities.

A.7.1. Hydrologic Data Collection

Field measurements/observations will be recorded in the field notebook. The field notebook will include the following data sheets: field visit data sheets, field equipment calibration sheets, and the equipment maintenance activity log. Custom field data sheets will be developed for the actual equipment installed. Examples of field data sheets are in Attachment B. Electronic equivalents of field forms may be developed and used.

The Data Collection Lead is responsible for updating and storing the field notebook. The field notebook will be photocopied monthly, and the copy stored at the Consultant's offices. Data loggers will be downloaded onto a project-designated field computer using applicable software and returned to the Consultant's office for transfer to the project database, as described below. Information from field notebook is transcribed into the project database manually. The project data files and database are stored on the Consultant's server, which is to be backed up for disaster recovery purposes at least once per week.

A.7.2. Hydrologic Database Structure

Hydrologic data are stored in an existing central Microsoft Access database created for the ongoing monitoring activities, and a set of specially formatted spreadsheets for ISCO datalogger data. The database will be used to assist with the analysis of groundwater and surface water conditions, and both consolidation and dissemination of information to other parties. The database provides a central storage area for ongoing data collected by Aspect Consulting, LLC and previous data sources, and allows data to be viewed in a uniform manner.

This database is structured such that, whenever possible, user input is validated using predefined formats and common terms making data input fast and simple, while ensuring that data can be accessed reliably through predefined queries. The data management tools in the database include:

- Task/field event setup for verifying completeness of data;
- Manual data entry;
- Querying and reporting tools; and

- Output of graphs and tabulated data.

Additional features designed to protect the integrity of the data and ensure smooth operation of the database include compact on close, tag data additions and modifications with date/time stamp and user id, and "*edit guard*" function that avoids inadvertent editing errors.

Due to the volume of ISCO bubbler data collected since 2004, it is currently managed as a set of Excel spreadsheets that combine to allow storage, correction, and graphing of the raw 15-minute stage data into final analysis and figures.

A.7.3. Database Inputs

Existing hydrologic data currently reside in the database. Data from planned monitoring described in this SAP will be routinely entered into the database as described below.

A.7.3.1. Existing Data

The following types of data were previously input for existing monitoring points:

- Survey coordinates and elevation data for staff gages and well top-of-casing elevations;
- Staff gage and well water level data;
- 15-minute continuous-record stream stage data;
- Stream stage-discharge rating equations for SC-Upper and SC-Lower;
- Standard weir equation for the Diversion Weir; and
- Spot flow measurements.

Existing water quality data is stored in an EQUIS database.

A.7.3.2. New Data

Data inputs from planned data collection include:

- Survey coordinates and elevation data for new staff gages (e.g., at SC-Center Drive gaging station and Sequalitchew Lake Outlet gaging station);
- New surface water staff gage measurements;
- Depth to groundwater measurements from wells;
- Monthly 15-minute stage-height data files for continuous flow and surface water monitoring stations;
- Monthly 15-minute groundwater level data files for continuous groundwater level monitoring stations;
- Monthly 15-minute precipitation data files from on-site rain gage;
- Water quality data;
- New manual streamflow flow measurements; and

- New stream stage-discharge rating equations, as necessary.

Staff gage, depth-to-groundwater, and spot water quality measurements are manually entered directly into the database using the manual data entry form following each field visit. The form includes fields for all monitoring data to help verify completeness.

Continuous stage height, groundwater level, temperature, and precipitation data files are loaded into the database and verified against manual measurements. Manual streamflow measurements and staff gage readings for the Sequalitchew Lake Outlet, SC-Center Drive, SC-Upper, and SC-Lower gaging stations are also entered into MS Excel to evaluate the appropriateness of the current rating curves for each station. When a new rating equation is necessary, it is entered manually into the database and applied to a specific date range for the station.

A.7.3.3. Back-up Precipitation Data

In the event the project rain gage malfunctions, precipitation data from the McMillin Reservoir weather station will be used to fill data gaps, as available. The McMillin Reservoir weather station is located about 20 miles northeast of the project area. This gage was selected as the most appropriate source of back-up precipitation data because it is the closest station with a lengthy period of record, and it receives similar monthly and annual precipitation amounts (Aspect, 2004a).

The precipitation data from McMillin Reservoir are collected as a part of the National Weather Service's (NWC) Cooperative Observer Program (COOP). Electronic files of daily precipitation can be downloaded from the COOP website and imported directly into the database using automated data import routines.

A.7.4. Database Outputs

Figures and tabulated data outputs are generated by an either automated output from the database, or generated via spreadsheet through Tableau. When new figures or tables are desired, water levels and flows are recalculated and printed from their appropriate software.

Water level elevations are calculated in the database, based on the supplied reference elevations for each point. The surveyed elevation of staff gages and monitoring wells is input in the database with a timestamp of when it was measured. Old water levels can be recalculated, based on resurveyed reference elevations when new ones become available.

Raw stage data from the continuous record stream gages is processed with the supplied stage-discharge ratings. Each station has a list of correlations that are applied over a specified time frame—typically for a given year or set of years. From the processed stage data, streamflow in either hourly or 15-minute data intervals is then averaged to mean daily flow for use in graphs and tables.

Precipitation data from the site rain gage is processed to calculate daily, monthly, and annual precipitation totals. Precipitation data at the appropriate time scale is exported to Excel for display on graphs and tables. The data export includes qualifiers indicating the quantity of missing data, if any.

Water quality data are stored and processed in the database. Continuous temperature data will be aggregated to calculate daily and monthly minimum and maximum temperatures as well as the 7-day average of daily maximum temperatures (7-DADMax), which has regulatory significance. Periodic water quality observations will also be output from the database.

A standard monthly report will be developed to assist with routine sharing of information during the mining and restoration projects. The report format will present a summary of observations for the prior month, and compare the observations with relevant performance and aspirational thresholds to determine if the adaptive management processes have been triggered.

A.7.5. QA/QC Protocol

QA/QC protocol for this project fall into three categories, based on which step of data collection and entry is taking place. Data QA/QC occurs during data collection in the field, data entry, and data reporting.

Key components of each QA/QC procedure are summarized below.

A.7.5.1. Data Collection

- The task/field event setup feature identifies all current monitoring points, and organizes them in the order that the data is typically collected on preprinted field forms. This feature helps ensure the completeness of data, especially in the event of field staff turnover.
- While measurements are being collected, the field staff quickly references the previous event's field form to verify the current measurement seems reasonable, and remeasures if necessary.

A.7.5.2. Data Entry

Manual data entry utilizes real-time data verification against defined valid values, acceptable data ranges, expected parameters, and standard data formats. Entries that fall outside these defined parameters will return an error message and reject the data.

A.7.5.3. Data Reporting

After each data entry event, data is reviewed in tabulated and graphical formats. This allows the user to readily identify data outliers and missing values. Data tables and figures will be inspected each month as a final step to verify the completeness and quality of monitoring data.

A.7.6. Data Archival (EIM)

To provide long-term data preservation by a neutral party, data collected under this SAP will be uploaded annually to Ecology's Environmental Information Management (EIM) database: http://www.ecy.wa.gov/eim/. Alternately, data collected by a governmental party with a similar, publicly accessible database (e.g., USGS's Nationwide Water Information System) may be stored in that database.

A.8. Special Studies

This SAP describes the routine monitoring approaches and methods for use in implementing the mining and restoration plans. Those plans also identify several special studies—notably the 60-day pumping test proposed as Step 1 of dewatering, and a study of water quality in Hamer Marsh to determine if it is adequate for improving the connection to Sequalitchew Creek. Specific plans will be developed for these studies, and others that may arise during implementation and adaptive management of the projects.

A.9. References

Anchor Environmental (Anchor), 2004, Fish Habitat Benefit Evaluation for Sequalitchew Creek, Pioneer Aggregates North Sequalitchew Creek Project, July 2004.

Aspect Consulting, LLC (Aspect), 2004a, Technical Memorandum: Surface Water and Groundwater System with Predictions on Effects to Wetland Hydrology Upstream of Proposed North Sequalitchew Creek, Prepared for Glacier Northwest, July 21, 2004.

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Heady, H. F., R. P. Gibbens, and R. W. Powell (Heady et al.), 1959, A comparison of the charting, line intercept, and line point methods of sampling shrub types of vegetation, Journal of Range Management 12:180–188.

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Washington State Department of Ecology (Ecology), 2015, Standard Operating Procedures for Continuous Temperature Monitoring of Fresh Water Rivers and Streams, EAP080, Version 2.0, Recertified: February 27, 2015.

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TABLES

Table 1 - Summary of Baseline Monitoirng Program

Project No.: 040001-014-03, DuPont, Washington

Station ID	Summary of Monitoring					Description
	Surface Water	Streamflow	Water Quality	Groundwater Elevation		
				Shallow	Deep	
MW-BM-1				X		Bell Marsh - Monitoring Well
SG-BM-1	X					Bell Marsh - Stage Gage
SG-MKM-1	X					McKay Marsh - Stage Gage
MW-HM-1				X		Hamer Marsh - Monitoring Well
MW-SRC-2				X		Hamer Marsh - Monitoring Well
SG-HM-1	X		X			Hamer Marsh - Stage Gage
G-Diversion Weir	X	X	X			Diversion Canal - Continuous Stage Gage and Discharge Transect
SG-DC-1	X	X				Diversion Canal - Stage Gage and Discharge Transect
SG-DC-2	X	X				Diversion Canal - Stage Gage and Discharge Transect
SG-DC-3	X	X				Diversion Canal - Stage Gage and Discharge Transect
MW-D-3				X		Diversion Canal - Monitoring Well
IW-93-MFS-C5-3				X		Diversion Canal - Monitoring Well
MW-SL-1				X		Sequalitchew Lake Outlet - Monitoring Well
SG-SCM-1	X					Sequalitchew Creek Marsh - Stage Gage
SG-EM-3E	X					Edmond Marsh - Stage Gage
SG-EM-3W	X					Edmond Marsh - Stage Gage
MW-EM-3				X		Edmond Marsh - Monitoring Well
SG-EM-2E Island	X					Edmond Marsh - Stage Gage
G-EM-2W Culvert	X					Edmond Marsh - Stage Gage
MW-EM-2(D)					X	Edmond Marsh - Monitoring Well
MW-EM-2(S)				X		Edmond Marsh - Monitoring Well
SG-WL1D-1	X					Edmond Marsh - Stage Gage
MW-WL1D-1				X		Edmond Marsh - Monitoring Well
SG-EM-1	X					Edmond Marsh - Stage Gage
SG-EM-1A	X					Edmond Marsh - Stage Gage
MW-EM-1(D)					X	Edmond Marsh - Monitoring Well
MW-EM-1(S)				X		Edmond Marsh - Monitoring Well
MW-PL-1				X		Pond Lake - Monitoring Well
SG-PL-1	X					Pond Lake - Stage Gage
CHMW-1				X		Mine Area - Monitoring Well
CHMW-2-D					X	Mine Area - Monitoring Well
CHMW-2-S				X		Mine Area - Monitoring Well
CHMW-3-D					X	Mine Area - Monitoring Well
CHMW-3-S				X		Mine Area - Monitoring Well
CHMW-4-D					X	Mine Area - Monitoring Well
CHMW-4-S				X		Mine Area - Monitoring Well
OB-1				X		Mine Area - Monitoring Well
SG-SC-Lower		X				Sequalitchew Creek - Continous Stage Gage and Discharge Transect
SG-SC-Upper		X	X			Sequalitchew Creek - Continous Stage Gage and Discharge Transect

Table 3 - Relationship of Proposed Monitoring to Adaptive Management Thresholds

DRAFT

Project No. 040001-014-03, DuPont, Washington

Plan Objectives			Sampling and Analysis Plan Elements[1]				
			Precipitation	Groundwater Level			
			on-site rain gage	Dewatering Wells	Key Wells: CHMW-1, CHMW-2S&D, CHMW-3S&D, CHMW-4S&D, MW-EM-1S&D, MW-EM-2S&D	MW-BM-1, MW-HM-1, MW-D-3, MW-93-MFS-C5-3, MW-SRC-2, MW-SL-1, MW-EM-3, MW-WLD-1, MW-PL-1	Two new monitoring wells in mine interior
South Parcel Monitoring Plan Objectives	Step 1 - Initial Pumping Test	Groundwater levels at monitoring wells near Edmond Marsh and Sequalitchew Creek are at or above predicted, approved-upon levels.	continuous		continuous	monthly	
		Moisture content of mined aggregate is at appropriately low levels for safe and efficient mining and processing.	continuous	continuous			
	Step 2 - Prep for Mining/ Dewatering Test	Groundwater levels at monitoring wells near Edmond Marsh and Sequalitchew Creek are at or above predicted, approved-upon levels.	continuous		continuous	twice monthly	
		Moisture content of mined aggregate is at appropriately low levels for safe and efficient mining and processing.	continuous	continuous			as needed
	Step 3 - Active Dewatering During Mining	Groundwater levels at monitoring wells near Edmond Marsh and Sequalitchew Creek are at or above predicted, approved-upon levels.	continuous		continuous	twice monthly for 3 months after new dewatering wells are brought on line, then monthly	
		Moisture content of mined aggregate is at appropriately low levels for safe and efficient mining and processing.	continuous	as needed			as needed
	Step 4 - Cessation of Active Dewatering	Groundwater levels at monitoring wells near Edmond Marsh and Sequalitchew Creek are at or above predicted, approved-upon levels.	continuous		continuous	monthly	
		Moisture content of mined aggregate is at appropriately low levels for safe and efficient mining and processing.	continuous	as needed			as needed
Sequalitchew Creek Restoration Plan Objectives	After Elements B, C, and D,	Achieve year-round surface water flow in Sequalitchew Creek from Sequalitchew Lake to the mouth, as climate conditions allow.	continuous				
		Minimize the flow lost to the Diversion Canal.	continuous				
	After B, C, D, and G	Increase access to suitable spawning and rearing habitat in Sequalitchew Creek	continuous				

Notes:

1) additional monitoring locations may be added through adaptive management

* Continue routine monitoring of flow and surface water stations to aid in interpretation of groundwater measurements. Flow and surface water stations do not have Monitoring Plan performance thresholds.

Table 3 - Relationship of Proposed Monitoring to Adaptive Management Thresholds

Project No. 040001-014-03, DuPont, Washington

Plan Objectives			Sampling and Analysis Plan Elements*					
			Flow			Surface Water Level		
			Sequalitchew Lake Outlet	Diversion Weir	Sequalitchew Creek gages (Center Drive, mid-ravine, and SC-Lower)	West Edmond (SG-EM-1/1A and SG-EM-2W)	East Edmond and Sequalitchew Creek Marshes (SG-SCM-1, SG-EM-3E, SG-EM-3W, SG-EM-2E)	Hamer, McKay, and Bell Marshes (SG-HM-1, SG-MKM-1, SG-BM-1)
South Parcel Monitoring Plan Objectives	Step 1 - Initial Pumping Test	Groundwater levels at monitoring wells near Edmond Marsh and Sequalitchew Creek are at or above predicted, approved-upon levels.	* continue routine monitoring			* continue routine monitoring		
		Moisture content of mined aggregate is at appropriately low levels for safe and efficient mining and processing.						
	Step 2 - Prep for Mining/ Dewatering Test	Groundwater levels at monitoring wells near Edmond Marsh and Sequalitchew Creek are at or above predicted, approved-upon levels.	* continue routine monitoring			* continue routine monitoring, but at twice monthly frequency		
		Moisture content of mined aggregate is at appropriately low levels for safe and efficient mining and processing.						
	Step 3 - Active Dewatering During Mining	Groundwater levels at monitoring wells near Edmond Marsh and Sequalitchew Creek are at or above predicted, approved-upon levels.	* continue routine monitoring			* continue routine monitoring, but at twice monthly for first three months after new dewatering wells are brought on line, then monthly		
		Moisture content of mined aggregate is at appropriately low levels for safe and efficient mining and processing.						
	Step 4 - Cessation of Active Dewatering	Groundwater levels at monitoring wells near Edmond Marsh and Sequalitchew Creek are at or above predicted, approved-upon levels.	* continue routine monitoring			* continue routine monitoring		
		Moisture content of mined aggregate is at appropriately low levels for safe and efficient mining and processing.						
Sequalitchew Creek Restoration Plan Objectives	After Elements B, C, and D,	Achieve year-round surface water flow in Sequalitchew Creek from Sequalitchew Lake to the mouth, as climate conditions allow.	continuous		continuous	continuous	monthly	monthly
		Minimize the flow lost to the Diversion Canal.		continuous				
	After B, C, D, and G	Increase access to suitable spawning and rearing habitat in Sequalitchew Creek			continuous	continuous	monthly	

Notes:

1) additional monitoring locations may be added through adaptive management

* Continue routine monitoring of flow and surface water stations to aid in interpretation of groundwater measurements. Flow and surface water stations do not have Monitoring Plan performance thresholds.

Table 3 - Relationship of Proposed Monitoring to Adaptive Management Thresholds

Project No. 040001-014-03, DuPont, Washington

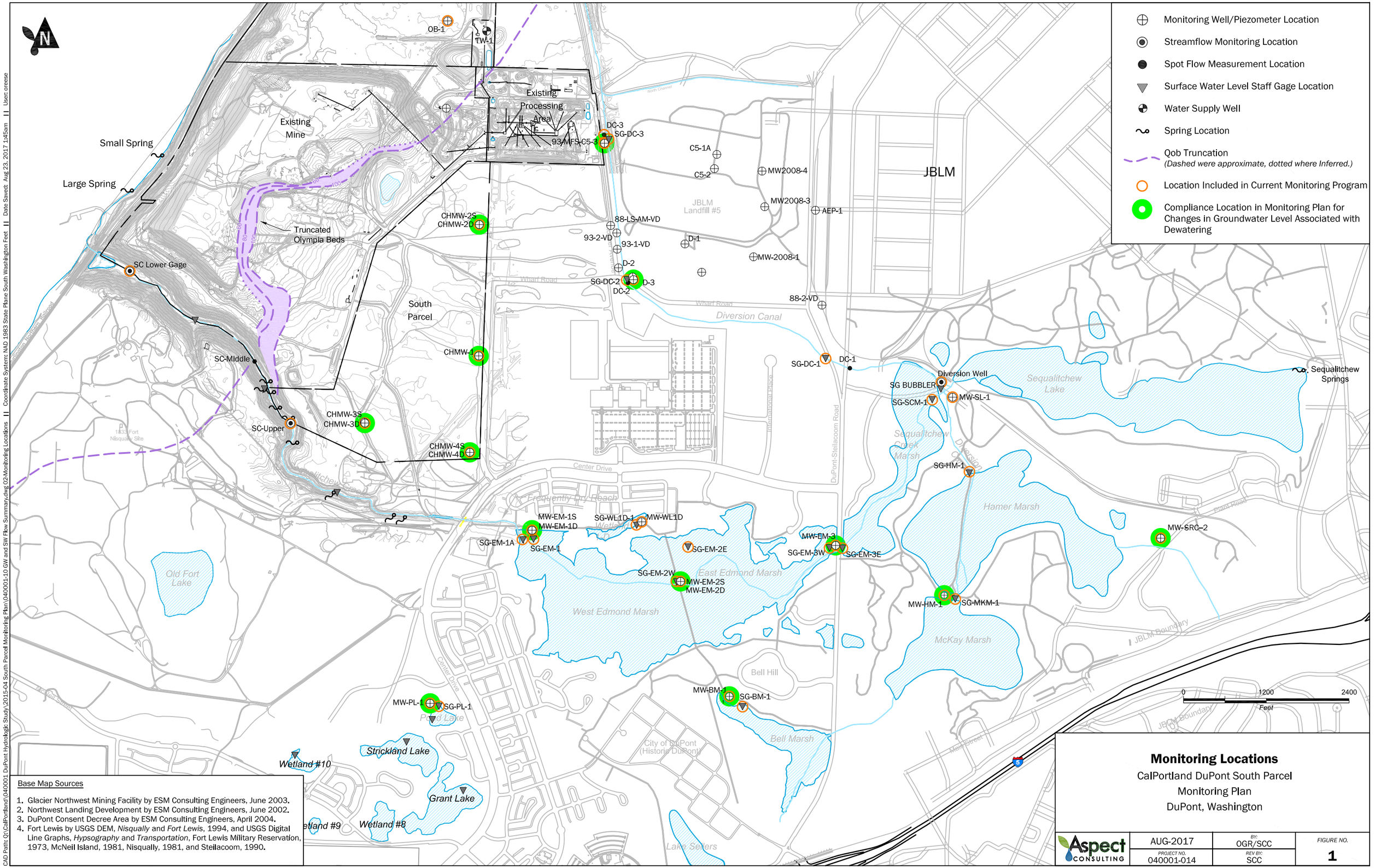
Plan Objectives			Sampling and Analysis Plan Elements*				
			Water Quality		Habitat		
			Temperature at SG-EM-1, SG-EM-2W, Diversion Weir, Sequalitchew Lake Outlet, SC-Center Drive, mid-ravine, SC-Lower	Water quality sampling for DO, turbidity, pH, Temperature at select surface water stations	Cross-section physical characteristics (depth, velocity, substrate,and cover)	Visual Observations (fish presence, active erosion)	Large Woody Material
South Parcel Monitoring Plan Objectives	Step 1 - Initial Pumping Test	Groundwater levels at monitoring wells near Edmond Marsh and Sequalitchew Creek are at or above predicted, approved-upon levels.					
		Moisture content of mined aggregate is at appropriately low levels for safe and efficient mining and processing.					
	Step 2 - Prep for Mining/ Dewatering Test	Groundwater levels at monitoring wells near Edmond Marsh and Sequalitchew Creek are at or above predicted, approved-upon levels.					
		Moisture content of mined aggregate is at appropriately low levels for safe and efficient mining and processing.					
	Step 3 - Active Dewatering During Mining	Groundwater levels at monitoring wells near Edmond Marsh and Sequalitchew Creek are at or above predicted, approved-upon levels.					
		Moisture content of mined aggregate is at appropriately low levels for safe and efficient mining and processing.					
	Step 4 - Cessation of Active Dewatering	Groundwater levels at monitoring wells near Edmond Marsh and Sequalitchew Creek are at or above predicted, approved-upon levels.					
		Moisture content of mined aggregate is at appropriately low levels for safe and efficient mining and processing.					
Sequalitchew Creek Restoration Plan Objectives	After Elements B, C, and D,	Achieve year-round surface water flow in Sequalitchew Creek from Sequalitchew Lake to the mouth, as climate conditions allow.					
		Minimize the flow lost to the Diversion Canal.					
	After B, C, D, and G	Increase access to suitable spawning and rearing habitat in Sequalitchew Creek	continuous	monthly	Years 0, 1, 2, 3, 5 and 10		Years 5 and 10

Notes:

1) additional monitoring locations may be added through adaptive management

* Continue routine monitoring of flow and surface water stations to aid in interpretation of groundwater measurements. Flow and surface water stations do not have Monitoring Plan performance thresholds.

FIGURE



Base Map Sources

1. Glacier Northwest Mining Facility by ESM Consulting Engineers, June 2003.
2. Northwest Landing Development by ESM Consulting Engineers, June 2002.
3. DuPont Consent Decree Area by ESM Consulting Engineers, April 2004.
4. Fort Lewis by USGS DEM, *Nisqually* and *Fort Lewis*, 1994, and USGS Digital Line Graphs, *Hypsography* and *Transportation*, Fort Lewis Military Reservation, 1973, McNeil Island, 1981, Nisqually, 1981, and Steilacoom, 1990.

Monitoring Locations

CalPortland DuPont South Parcel
Monitoring Plan
DuPont, Washington

Aspect Consulting	AUG-2017	BY: OGR/SCC	FIGURE NO. 1
	PROJECT NO. 040001-014	REV BY: SCC	

CAD Path: Q:\CalPortland\040001 DuPont Hydrologic Study\2015-04 South Parcel Monitoring Plan\040001-10 GW and SW Flow Summary.dwg 02-Monitoring Locations || Coordinate System: NAD 1983 State Plane South Washington Feet || Date Saved: Aug 23, 2017 1:45am || User: oreese

APPENDIX A

Boring Logs

14P1

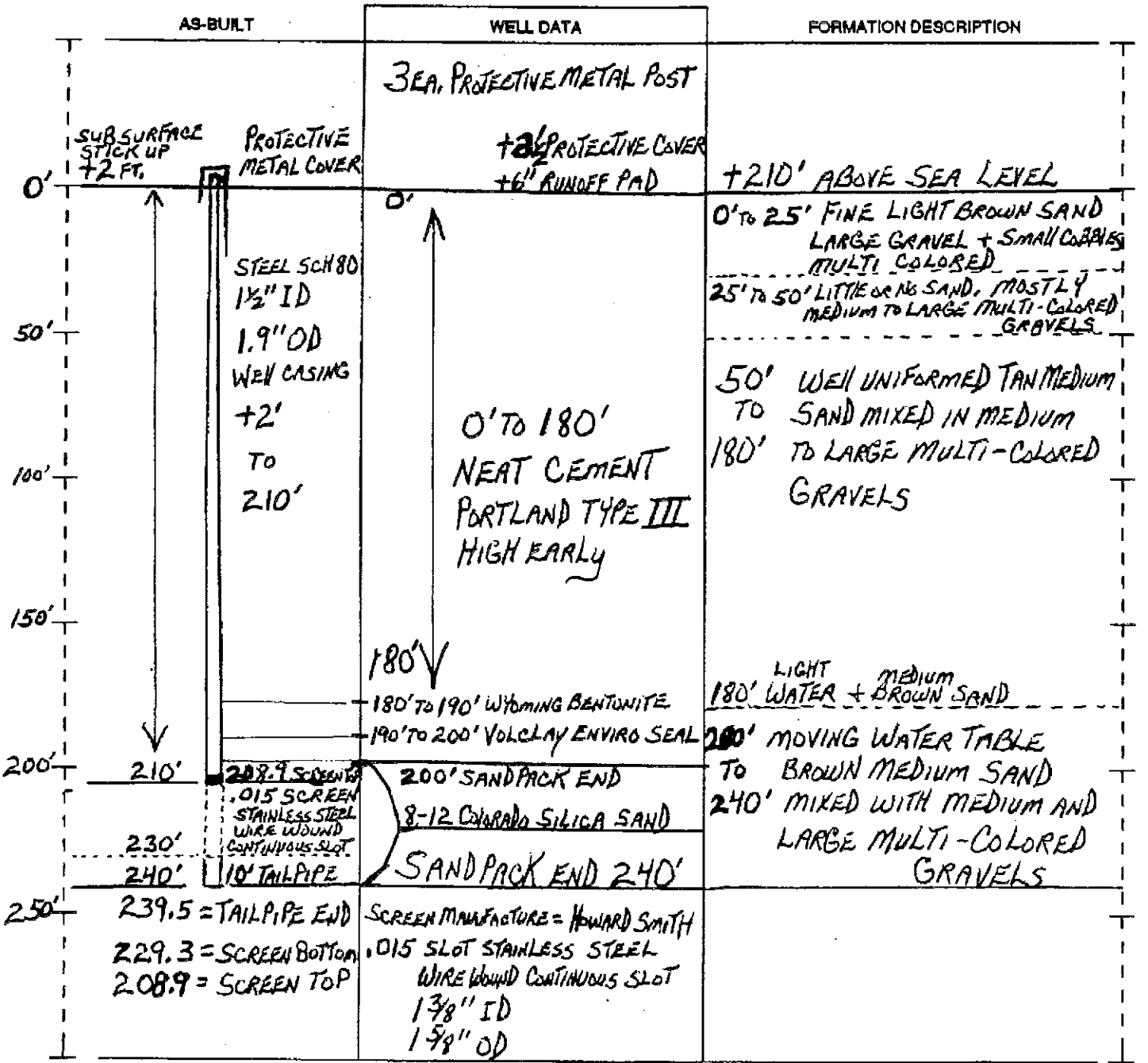
21 FEB 9

RESOURCE PROTECTION WELL REPORT

START CARD NO. 063977

PROJECT NAME: LONESTAR NW OBSERVATION WELL
WELL IDENTIFICATION NO. LONE STAR OB-1
DRILLING METHOD: REVERSE CIRCULATION ROTARY
DRILLER: DOUGLAS GRABOWSKI
FIRM: BECKER DRILLS INC.
SIGNATURE: William J. Flickey
CONSULTING FIRM: HART CROWSER
REPRESENTATIVE: TOM NOYES

COUNTY: PIERCE
LOCATION: SE¼ SW¼ Sec 14 Twn 19N R 1E
STREET ADDRESS OF WELL: NORTHWEST LANDING ANNEX DUPONT STEILACOOM ROAD DUPONT WASHINGTON
WATER LEVEL ELEVATION: 200 FT. STATIC
GROUND SURFACE ELEVATION: +210
INSTALLED: FEBRUARY 15, 1991
DEVELOPED:



SCALE: 1" = 50 FEET

PAGE 1 OF 1

ECY 050-12 (Rev. 11/89)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report

CH2MHILL

Well Number: CHMW-1

Sheet: 1 of 1

Client: Glacier NW
Project: N Sequalitchew Creek Aquifer Tests
Location: DuPont, Washington
Project Number: 151973.A2.AT

Driller: Hokkaido Drilling (Bill & Steve)
Drilling Method: Speedstar 15 Truck-Mounted Air Rotary
Sampling Method: Sand pump (water added)
Logged by: driller
Start/Finish Date: 9/23/99 - 9/24/99

Depth (ft)	Sample Info: Sample #	Sample Info: STP (6"-6"-6")	Soil Log	Soil Description	Depth / Elev	Well Drawing	Well Construction Notes
-5					5		
					217		Monument (not shown)-- Lockable 6" steel protective casing in concrete.
0				Ground Surface			
				Topsoil	2		
5				Sand and gravel with silt, dry, brown	210		
10							Casing - 2" sch 40 PVC pipe
15							
20					22		
				Brown silty gravel	190		
25					26		
				Brown gravel, like till	186		
30					33		
				Brown silt	179		
35				Light brown gravel, productive water-bearing zone			
40							
45							
50							
55					57		
				Dark brown gravel and sand. Note no "soupy sand" like in CHTW-1.	155		
60							Casing Seal - Hydrated medium bent
65							
70							
75					76		Filter pack - 10-20 CSSI sand
				Dark brown sand and gravel	136		Screen - 2" sch 40 PVC, 0.020-in slot
80					82		
				Gray-blue silty sand, sand and gravel.	130		
85					85		6" end cap
					127		

CH2MHILL

Well Number: CHMW-2(S)

Sheet: 1 of 1

Client: Glacier NW
Project: N Sequalitchew Creek Aquifer Tests
Location: DuPont, Washington
Project Number: 151973.A2.AT

Driller: Hokkaido Drilling (Daryl & Tom)
Drilling Method: Star 71 cable tool, 8" steel casing
Sampling Method: Sand pump (water added)
Logged by: driller
Start/Finish Date: 11/17/99 - 11/19/99

Depth (ft)	Sample Info: Sample #	Sample Info: STP (6"-6"-6")	Soil Log	Soil Description	Depth / Elev	Well Drawing	Well Construction Notes
-5					5 212		Monument (not shown)-- Lockable 6" steel protection casing in concrete.
0				Ground Surface Topsoil and gravel	3		
5				Brown silty sand and gravel	204		
10							Casing - 2" sch. 40 PVC pipe
15							Casing seal - Hydrated medium bentc
20					21		
25				Larger gravel and sand, slightly silty, very hard	186 26		
30				Brown silty sand, gravel Sandier with gravel	181		Sandy filterpack - 10-20 CSSI sand
35					36		
40				Clean sand and gravel, water	171		Screen - 2 centralizers, 2" sch 40 PV(0.020-inch slot width
45					43		6" end cap
50				End of Log	164		

CH2MHILL

Well Number: CHMW-2(D)

Sheet: 1 of 1

Client: Glacier NW
Project: N Sequalitchew Creek Aquifer Tests
Location: DuPont, Washington
Project Number: 151973.A2.AT

Driller: Hokkaido Drilling (Steve & Tom)
Drilling Method: Speedstar 15 & Star 71 Cable Tool
Sampling Method: Sand pump (water added)
Logged by: Driller
Start/Finish Date: 11/12/99 - 11/18/99

Depth (ft)	Sample Info: Sample #	Sample Info: STP (6"-6"-6")	Soil Log	Soil Description	Depth / Elev	Well Drawing	Well Construction Notes
-5					5 212		Monument (not shown): Lockable 6' steel protection casing in concrete
0				Ground Surface			
				Topsoil	4		
5				Brown silty gravel	203 9		
10				Brown gravel	198		Casing--2" sch 40 PVC pipe
15				Brown silty gravel, moist	15 192		
20					24		
25				Hard till, brown	[illegible]		
				Loose sand and gravel, water	181		
30							Casing Seal--Hydrated medium bentc
35				Brown till	35 172		
40							
45					48		
50				Loose sand and gravel, water	159		
55					58		
60				Brown silt bound sand and gravel, tight	149		
65					66		Screen - 2" sch 40 PVC, 0.020-in slot with centralizer
				no record	141		
70					73		6" end cap
75				End of Log	134		

CH2MHILL

Well Number: CHMW-3(D)

Sheet: 1 of 1

Client: Glacier NW
Project: N Sequalitchew Creek Aquifer Tests
Location: DuPont, Washington
Project Number: 151973.A2.AT

Driller: Hokkaido Drilling (Steve)
Drilling Method: Speedstar 15 Air Rotary Drill Rig
Sampling Method: Sand pump (water added)
Logged by: driller
Start/Finish Date: 11/4/99 - 11/5/99

Depth (ft)	Sample Info: Sample #	Sample Info: STP (6"-6"-6")	Soil Log	Soil Description	Depth / Elev	Well Drawing	Well Construction Notes
-5					5		Monument (not shown): Lockable 6" steel protective casing in concrete
					221		
0				Ground Surface			
				Brown topsoil	2		
5				Loose brown gravel	214		
10							Casing - 2" sch 40 PVC pipe
15					16		
				Brown silty sand and gravel	200		
20							
25					26		
				Brown silty sand and gravel (moist)	190		Casing seal - hydrated medium bento
30					31		
				Brown sand and gravel, dirty, water	185		
35							
40					41		
				Brown till	175		
45							
					48		
50				Sand and gravel, water	168		
					54		
55				Brown till	162		
				Silt, sand and gravel, brown, wet			
60							
					64		
65				Clean sand and gravel	152		
70							
							Filter pack - 10-20 CSSI sand
75							Screen - 2" sch 40 PVC, 0.020-in slot
80							
					85		6" end cap
85				End of Log	131		
90							

CH2MHILL

Well Number: CHMW-3(S)

Sheet: 1 of 1

Client: Glacier NW
Project: N Sequalitchew Creek Aquifer Tests
Location: DuPont, Washington
Project Number: 151973.A2.AT

Driller: Hokkaido Drilling (Steve)
Drilling Method: Speedstar 15 Air Rotary Drill Rig
Sampling Method: Sand pump (water added)
Logged by: driller
Start/Finish Date: 11/5/99

Depth (ft)	Sample Info: Sample #	Sample Info: STP (6"-6"-6")	Soil Log	Soil Description	Depth / Elev	Well Drawing	Well Construction Notes
-5					5 221		Monument (not shown): Lockable 6" steel protection casing in concrete
0				Ground Surface Brown topsoil	2		
				Loose gravel	214		
5							Casing - 2" sch 40 PVC pipe
10							
15					16		Casing seal - Hydrated medium bentc
				Silty brown sand and gravel	200		
20							
25					26		
				Moist silty brown sand and gravel	190		Filter pack - 10-30 CSSI sand
30					31		Screen - 2" sch 40 PVC, 0.020-in slot
				Clean sand and gravel, water	185		
35							
40					40		6" end cap
				End of Log	176		
45							

CH2MHILL

Well Number: CHMW-4(S)

Sheet: 1 of 1

Client: Glacier NW
Project: N Sequalitchew Creek Aquifer Tests
Location: DuPont, Washington
Project Number: 151973.A2.AT

Driller: Hokkaido Drilling (Steve)
Drilling Method: air rotary
Sampling Method: Sand pump (water added)
Logged by: driller
Start/Finish Date: 11/23/99

Depth (ft)	Sample Info: Sample #	Sample Info: STP (6"-6"-6")	Soil Log	Soil Description	Depth / Elev	Well Drawing	Well Construction Notes
-5					5 219		Monument (not shown): Lockable 6" steel protective casing
0				Ground Surface Topsoil with large gravel	3		
5				Brown silty sand and gravel	211		
10					11		Casing - 2" sch 40 pvc pipe w/ j-plug
				Brown silty sand and large boulders	203		
15					15		Casing seal - hydrated medium bento
				Sand and gravel with water	199 17		
				Brown silt with gravel	197		
20							
25							Filterpack - 10-20 CSSI sand
							Screen - 2" sch 40 pvc, 0.020-in slot v
30							
35							
					37		6" end cap
				End of Log	177		
40							

CH2MHILL

Well Number: CHMW-4(D)

Sheet: 1 of 1

Client: Glacier NW
Project: N Sequalitchew Creek Aquifer Tests
Location: DuPont, Washington
Project Number: 151973.A2.AT

Driller: Hokkaido Drilling (Steve)
Drilling Method: air rotary
Sampling Method: Sand pump (water added)
Logged by: diller
Start/Finish Date: 11/11/99

Depth (ft)	Sample info: Sample #	Sample info: STP (6"-6"-6")	Soil Log	Soil Description	Depth / Elev	Well Drawing	Well Construction Notes
-5					5 / 219		
0				Ground Surface			
				Topsoil	2		
5				Brown gravel	212		Monument: Lockable 6" steel protective casing in concrete
10							
15					15		
				Brown till	199		
20							
25							Casing - 2" sch 40 PVC pipe
30							
					34		
35				Sand, gravel, making water	180		Casing seal - hydrated medium bento
40							
45							
					48		
50				Brown till	166		
					53		
55				Sand, gravel, making water	161		
60							
65					66		
				Brownish orange silty gravel	148		
70				Sand, gravel, water			
75							Filter pack - 10-20 CSSI sand
							Screen - 2" sch 40 PVC, 0.020-in slot
80							
					85		6" end cap
85					129		

CH2MHILL

PROJECT NUMBER : 151973.A1.AT

WELL NUMBER : CHMW-1

WELL CONSTRUCTION/BORING LOG

PROJECT : **LONE STAR, DUPONT** LOCATION : **50' S. OF CHTW-1**

WATER LEVELS : **21'6 3/4" ATD**

DRILLING METHOD/EQUIPMENT : **SPEEDSTAR 15 TRUCK-MOUNTED AIR ROTARY**

START : **9/23/99** END : **9/24/99** LOGGER: **HOKKAIDO(BILL&STEVE)**

DEPTH BELOW SURFACE (FT)	CORE DESCRIPTION/COMMENTS
0	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.
	0-2FT Topsoil
	2-22FT Sand/gravel w/silt (dry,brown)
5	
10	
15	
20	
	22-26FT Brown silty gravel
25	
	26-33FT Brown gravel (like till)
30	

CH2MHILL

PROJECT NUMBER : 151973.A1.AT	WELL NUMBER : CHMW-1 SHEET 2 OF 3

WELL CONSTRUCTION/BORING LOG

PROJECT : **LONE STAR, DUPONT** LOCATION : **50' S. OF CHTW-1**

WATER LEVELS : **21'6 3/4" ATD**

DRILLING METHOD/EQUIPMENT : **SPEEDSTAR 15 TRUCK-MOUNTED AIR ROTARY**

START : **9/23/99** END : **9/24/99** LOGGER: **HOKKAIDO(BILL&STEVE)**

DEPTH BELOW SURFACE (FT)	CORE DESCRIPTION/COMMENTS
	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.
	33-35FT Brown silt
35	35-57FT Lt.brown gravel, productive water-bearing zone
40	
45	
50	
55	
	57-59FT Dk.brown gravel & sand NOTE: No "soupy sand" at 50' like in CHTW
60	

CH2MHILL

PROJECT NUMBER : 151973.A1.AT

WELL NUMBER : CHMW-1

WELL CONSTRUCTION/BORING LOG

PROJECT : **LONE STAR, DUPONT** LOCATION : **50' S. OF CHTW-1**

WATER LEVELS : **21'6 3/4" ATD**

DRILLING METHOD/EQUIPMENT : **SPEEDSTAR 15 TRUCK-MOUNTED AIR ROTARY**

START : **9/23/99** END : **9/24/99** LOGGER: **HOKKAIDO(BILL&STEVE)**

DEPTH BELOW SURFACE (FT)	CORE DESCRIPTION/COMMENTS
	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.
65	
70	
75	76-82FT Dk.brown sand & gravel
80	82-83FT Gray silty sand & gravel
85	83-85FT Blue sand & gravel
	WELL: STICKUP=2' (2"sch 40 pvc) SCREEN=75'-84.5' (2"sch 40 pvc, 20-slot) 6" endcap 84.5 -85 fbgs ANNULUS=15 bags 10-20 cost sand (50lb. ea) 52 bags med. bentonite chips (50lbs ea) MONUMENT=6" steel protective casing in concrete
0	

CH2MHILL

PROJECT NUMBER : 151973.A1.AT	WELL NUMBER : CHMW-2(S)
	SHEET 1 OF 2

WELL CONSTRUCTION/BORING LOG

TOC elev = 209.39 Stickup = 1.45
grd = 207.94

PROJECT : **LONE STAR, DUPONT** LOCATION : **50' N. OF TW-2(~15FT E.OF MW-2(D)**

WATER LEVELS :

DRILLING METHOD/EQUIPMENT: **STAR 71 CABLE TOOL, 8" STEEL CASING**

START : **11/17/99** END : **11/19/99** LOGGER: **HOKKAIDO(DARYL & TOM)**

DEPTH BELOW SURFACE (FT)	CORE DESCRIPTION/COMMENTS
0	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.
	0-3FT Topsoil & gravels
	3-21FT Brown silty sand and gravels
5	
10	
15	
20	
	21-26FT Larger gravels & sand slightly silty, very hard
25	
	26-27FT Brown silty sand & gravel
	27-28FT Sandier w/gravel (gravel smaller)
30	

CH2MHILL

PROJECT NUMBER : 151973.A1.AT	WELL NUMBER : CHMW-2(S) SHEET 2 OF 2

WELL CONSTRUCTION/BORING LOG

PROJECT : **LONE STAR, DUPONT** LOCATION : **50' N. OF TW-2(~15FT E.OF MW-2(D)**

WATER LEVELS :

DRILLING METHOD/EQUIPMENT: **STAR 71 CABLE TOOL, 8" STEEL CASING**

START : **11/17/99** END : **11/19/99** LOGGER: **HOKKAIDO(DARYL & TOM)**

DEPTH BELOW SURFACE (FT)	CORE DESCRIPTION/COMMENTS
	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.
35	36-43FT Clean sand & gravel w/H20 Total casing=46'-81/2" Well: Stickup=2' (2" sch 40 pvc) w/j-plug Screen=33'-421/2' bgs w/2 centralizers & 6' end (2"sch 40 pvc, 20-slot) Annulus=13 50-lb bags 10-20 cgsi sand 18 50-lb bags medium bentonite chips Monument= 6"steel protecting casing in concrete (7 bags)
40	
45	
50	
55	
60	

CH2MHILL

PROJECT NUMBER : 151973.A1.AT	WELL NUMBER : CHMW-2(D) SHEET 1 OF 3

WELL CONSTRUCTION/BORING LOG

TOC elev = 209 Stickup = 1.8 grd = 207.2

PROJECT : **LONE STAR, DUPONT** LOCATION : **50' N. OF TW-2**

WATER LEVELS :

DRILLING METHOD/EQUIPMENT: **SPEEDSTAR 15, 8" STEEL CASING(TO58") &STAR 71 CABLE TOOL, 8" CASING**

START : **11/12/99** END : **11/18/99** LOGGER: **HOKKAIDO(STEVE & TOM)**

DEPTH BELOW SURFACE (FT)	CORE DESCRIPTION/COMMENTS
0	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.
	0-4FT Dark brown topsoil
	4-9FT Brown silty gravel
5	
10	9-15FT Brown gravel
15	15-24FT Brown, silty gravel, moist
20	
25	24-26FT Hard till, brown
	26-35FT Loose sand & gravel H20
30	

CH2MHILL

PROJECT NUMBER : 151973.A1.AT	WELL NUMBER : CHMW-2(D) SHEET 2 OF 3

WELL CONSTRUCTION/BORING LOG

PROJECT : **LONE STAR, DUPONT** LOCATION : **50' N. OF TW-2**

WATER LEVELS :

DRILLING METHOD/EQUIPMENT: **SPEEDSTAR 15, 8" STEEL CASING(TO58") &STAR 71 CABLE TOOL, 8" CASING**

START : **11/12/99** END : **11/18/99** LOGGER: **HOKKAIDO(STEVE & TOM)**

DEPTH BELOW SURFACE (FT)	CORE DESCRIPTION/COMMENTS
	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.
35	35-48FT Brown till
40	
45	
50	48-58FT Loose sand & gravel H20
55	
60	58-66FT Brown tight Silt Bound sand & gravel

CH2MHILL

PROJECT NUMBER : 151973.A1.AT	WELL NUMBER : CHMW-2(D) SHEET 3 OF 3

WELL CONSTRUCTION/BORING LOG

PROJECT : **LONE STAR, DUPONT** LOCATION : **50' N. OF TW-2**

WATER LEVELS :

DRILLING METHOD/EQUIPMENT: **SPEEDSTAR 15, 8" STEEL CASING(TO58") &STAR 71 CABLE TOOL, 8" CASING**

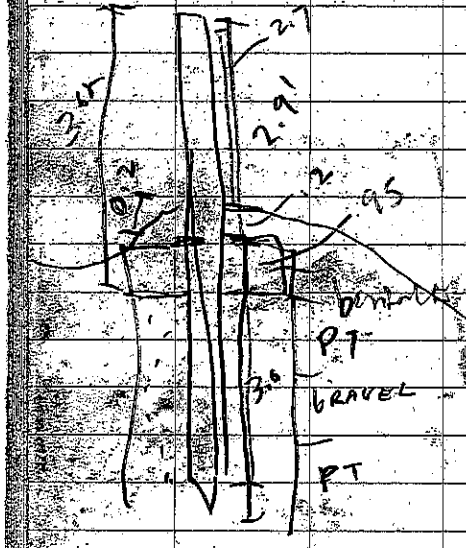
START : **11/12/99** END : **11/18/99** LOGGER: **HOKKAIDO(STEVE & TOM)**

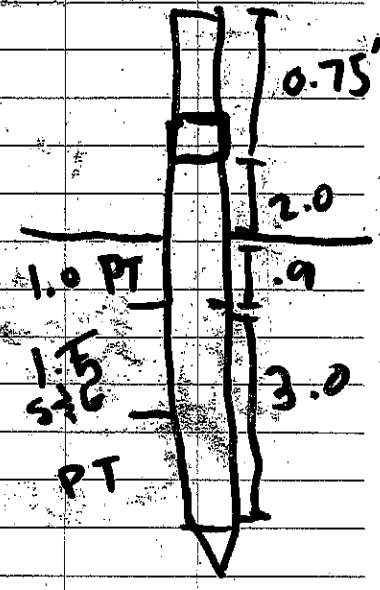
DEPTH BELOW SURFACE (FT)	CORE DESCRIPTION/COMMENTS
	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.
65	66-73FT NO RECORD
	Total Casing=72'-41/4"
	Well:
70	Stickup=2' (2"sch 40 pvc) w/j plug
	Screen= 63'-721/2' bgs (2" sch 40 pvc, 20-slot)
	w/centralizer 6"end cap 721/2-73 fbgs
	Annulus=13 50-lb bags 10-20 cssi sand
	34 50-lb bags medium bentonite chips
	Monument= 6" steel protectivecasing in concrete
75	
80	
85	
90	

CHMW- 4 (S) 18.42

4 (D) 20.81

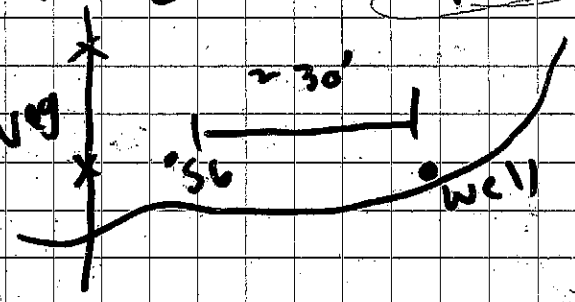
CHMW-1 19.40 14:21





Pond L. well 2.95

Pond L. SG 1.07



BM-MW-1 14.23' 12:30

BM-SG-1 2.53' 12:32

EM-1A 3.69' 12:40

Top 6.65'

SG EM1 dry Top 3.33

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
040001	SL-1	1 of 1

Project Name: North Sequalichew Creek
Location: Fort Lewis, WA
Drilling Method: Hollow stem auger, 4" ID ; Holt Drilling
Sampling Method: 3" diameter D&M
Ground Elevation 214.94

Top of PVC Casing Elev. (ft mllw) 217.74
Depth to Water (ft BTC) 6.25
Start Date March 11, 2004
Finish Date March 11, 2004

Depth feet	Well Construction	Tests\Remarks	Blows/ 6"	Sample ID	Mtl. Graphic	Description
	5" diameter steel monument, 3' stickup; Concrete seal 0'-2'					Grass, duff
						FILL
						Gravel up to 1-1/2" diameter, to a depth of 8" below ground surface
			4 3 3	S-1		Medium stiff, moist to very moist, dark brown, gravelly SILT with SAND
		3/26/04 ▼				
5			3 3 4	S-2		•Very gravelly drilling, no recovery
			9 8 11	S-3		Medium dense, wet, gray, sandy GRAVEL; sand medium to coarse, gravel fine to coarse
			4 6 6	S-4		•Low recovery, trace gravel in sampler
			7 7 7	S-5		RECESSIONAL OUTWASH Medium dense, wet, gray, very gravelly SAND; sand predominantly coarse
10	Bentonite chips 2'-13'		7 7 9	S-6		Medium dense, wet, gray-brown, sandy GRAVEL; sand predominantly coarse
			6 7 12	S-7		
			11 10 9	S-8		•Trace silt
15	10/20 silica sand filter pack 13'-20'		10 7 7	S-9		•Trace silt
	20-slot screen 15'-20'; slip cap with SS screw 20'-20.3'		4 6 7	S-10		
20						Bottom of boring at 20 feet.

Sampler Type (ST):
- 3.25" OD D & M Split-Spoon Ring Sampler
- No Recovery
- 2" OD Split-Spoon Sampler

PID - Photoionization Detector
▼ Water Level (ATD)
▽ Static Water Level

Logged by: RRH
Approved by: LJH
Figure No. B - 2

SEQUALICHEW CREEK.GPJ July 20, 2004
MW_GEOLG

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
040001	HM-MW-1	1 of 1

Project Name: North Sequalitchew Creek
Location: DuPont, Washington
Drilling Method: Hollow Stem Auger - 4" ID ; Holt Drilling
Sampling Method: 3" Diameter D&M

Top of Casing Elev. (ft mllw): 221.06
Ground Surfave Elev. (ft): 217.75
Depth to Water (ft bgs): 5
Start Date: August 2, 2004
Finish Date: August 2, 2004

Depth feet	Well Construction	Tests\Remarks	Blows/ 6"	Sample ID	Mtl. Graphic	Description
1						Brown, slightly silty GRAVEL; gravel, predominantly coarse and cobbles (observed from drill action and cuttings) (GP)
2	5" diameter steel monument, cement seal 0'-4'					
3		18"/5"	3 27 30	2.5-4		Brown, moist, slightly silty to trace silt, sandy GRAVEL; sand medium to coarse; gravel fine to coarse, abundant cobbles, subangular to rounded (GW)
4						
5		8/2/04 ▼ 18"/8"	11 23 23	5-6.5		Brown to olive gray, wet, very sandy GRAVEL, trace silt; sand medium to coarse, predominantly medium; gravel fine to coarse with cobbles, subangular to subround; no apparent organization.
6	Bentonite Chips 4'-7.5'					
7						
8		18"/11"	19 22 24	7.5-9		Color change to olive gray; grades to medium to coarse sand and predominantly fine gravel; increase in silt (still trace silt), less cobbles.
9						
10		18"/6"	22 28 32	10-11.5		Olive gray to gray-green, wet, SAND; trace gravel; sand medium to coarse, occasional zones of fine to medium; gravel fine (SP-SW)
11	10/20 silica sand filter pack 7.5'-20.3'					
12						
13		18"/12"	21 30 35	12.5-14		Olive gray, wet, slightly silty, very sandy GRAVEL; gravel fine to coarse; with cobbles; sand predominantly medium to coarse (GW-GM)
14						
15	20-slot screen 10'-20'; slip cap with SS screw 20'-20.3'	18"/10"	21 31 44	15-16.5		Gray-green to olive gray, wet, SAND, trace gravel; sand predominantly medium to coarse; gravel fine (SW)
16						Olive gray, wet, very sandy GRAVEL, trace silt, sand medium to coarse, occasional fine, predominantly coarse; gravel fine to coarse (GW)
17						
18		18"/10"	26 50/6"	17.5-19		Gray-green, wet SAND; trace gravel; sand predominantly medium to coarse (SW)
19						Olive-gray, wet, very sandy GRAVEL, trace silt; gravel fine to coarse; sand predominantly medium to coarse (GW)
20		18"/11"	26 50/6"	20-21.5		Gray to olive gray, wet SAND; sand medium; homogenous (SP)
21						
22						Olive gray to gray, wet, sandy GRAVEL, trace silt; gravel fine to coarse; subrounded to rounded; sand medium to coarse, predominantly medium (GW)
23						Total depth = 20' drilled, 22.5' driven.
24						
25						
26						
27						
28						
29						

Sampler Type (ST):
- 3.25" OD D & M Split-Spoon Ring Sampler
- No Recovery
- 2" OD Split-Spoon Sampler

PID - Photoionization Detector
▼ Water Level (ATD)
▽ Static Water Level

Logged by: ILE
Approved by: LJH
Figure No. A-2

APPENDIX B

MW_GEOL S CRK.GPJ November 23, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
040001	EM-3	1 of 1

Project Name: North Sequalichew Creek
Location: Fort Lewis, WA
Drilling Method: Hollow stem auger, 4" ID ; Holt Drilling
Sampling Method: 3" diameter D&M
Ground Elevation 214.63

Top of PVC Casing Elev. (ft mllw) 217.38
Depth to Water (ft BTC) 4.96
Start Date March 11, 2004
Finish Date March 11, 2004

Depth feet	Well Construction	Tests\Remarks	Blows/ 6"	Sample ID	Mtl. Graphic	Description
	5" diameter steel monument, 3' stickup; Concrete seal 0'-2'					Sod and dark brown organic soil
						FILL
		3/26/04 ▼				Gravel, some cobbles at 0.5'
			3 7 10	S-1		Medium dense, moist, dark brown, sandy GRAVEL with SILT and ORGANICS, trace wood
			3 6 8	S-2		Medium dense, wet, gray SAND and GRAVEL
5			6 2 1	S-3		MARSH DEPOSITS
		K Test K = 1x10^{-6} cm/s	1 1 9	S-4		Soft, wet, brown, slightly fibrous PEAT, trace gravel
			8 12 14	S-5		Medium dense, wet, brown, sandy GRAVEL to GRAVEL, trace silt
10	Bentonite chips 2'-13'		2 6 6	S-6		RECESSIONAL OUTWASH
			7 8 13	S-7		Medium dense, wet, gray SAND, trace gravel; sand fine to medium; 1/4" silt seam
			1 12 25	S-8		No recovery, coarse gravel in shoe of sampler
15			16 17 16	S-9		Dense, wet, brown, gravelly SAND to sandy GRAVEL
	10/20 silica sand filter pack 13'-20'		11 16 32	S-10		Dense, wet, sandy GRAVEL
	20-slot screen 15'-20'; slip cap with SS screw 20'-20.3'		15 25 35	S-11		
20						Bottom of boring at 20 feet.

Sampler Type (ST):
- 3.25" OD D & M Split-Spoon Ring Sampler
- No Recovery
- 2" OD Split-Spoon Sampler

PID - Photoionization Detector
▼ Water Level (ATD)
▽ Static Water Level

Logged by: RRH
Approved by: LJH

Figure No. B - 1

SEQUALICHEW CREEK.GPJ 7/29/04

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
040001	BM-MW-1	1 of 1

Project Name: North Sequalitchew Creek
Location: DuPont, Washington
Drilling Method: Hollow Stem Auger - 4" ID ; Holt Drilling
Sampling Method: 3" Diameter D&M

Top of Casing Elev. (ft mllw): 232.32
Ground Surfave Elev. (ft): 229.37
Depth to Water (ft bgs): 12.5
Start Date: August 3, 2004
Finish Date: August 3, 2004

Depth feet	Well Construction	Tests\Remarks	Blows/ 6"	Sample ID	Mtl. Graphic	Description
1	5" diameter steel monument, cement seal 0'-1.5'					Brown, dry, GRAVEL, trace silt; gravel fine to coarse, predominantly coarse; abundant cobbles, subrounded to rounded (GW)
2						
3						(Road fill)
4	Natural Fill 1.5'-5'					
5		18"/4"	11	5-6.5		Brown to tan, moist sandy GRAVEL, trace silt; gravel fine to coarse, subrounded to rounded; sand predominantly medium to coarse.
6			12			
7			10			
8		18"/12"	4	7.5-9		Brown to reddish brown, moist, slightly gravelly SAND, trace silt; sand fine to coarse, predominantly medium; gravel fine, subangular to rounded (SP)
9	Bentonite Chips 5'-12'		10			
10			16			
11		18"/5"	9	10-11.5		Occasional coarse gravel and grades medium to coarse sand.
12		8/3/04 ▼	15			
13		18"/6"	19			
	10/20 silica sand filter pack 12'-26.5'		8	12.5-14		Brown to red-brown, wet, gravelly SAND, trace silt; sand predominantly coarse; gravel fine to coarse, predominantly fine.
15		18"/10"	14			
16			15			
17			9	15-16.5		
18		18"/8"	10			Yellowish-green to brown, highly oxidized, wet, slightly to trace silt; sandy GRAVEL; gravel fine to coarse; sand predominantly coarse (GW-GM)
19			16			
20	20-slot screen 15'-25'; slip cap with SS screw 25'-25.3'	18"/12"	5	17.5-19		Yellow brown, highly oxidized, wet, slightly gravelly SAND, trace silt; sand medium to coarse, predominantly coarse; gravel predominantly fine (SP)
21			8			Grades to slightly silty and gravelly in shoe (SP-SM)
22			8			
23		18"/14"	9	20-21.5		Gray olive, wet, SAND; trace gravel; trace to no silt; sand predominantly medium to coarse (SP)
24			11			
25		18"/3"	13			Gray green, wet, slightly silty to trace silt, sandy GRAVEL; gravel fine to coarse, subrounded to rounded; sand medium to coarse. (GP-GM)
26			13	22.5-24		Gray green, wet, SAND; sand medium (SP)
27			25			
28			24			Gray olive, wet, sandy GRAVEL, trace silt; gravel fine to coarse, sand predominantly medium to coarse (GP)
29			28	25-26.5		Gray olive, wet, slightly silty sandy GRAVEL; gravel fine to coarse; sand medium to coarse (GP-GM)
			19			
			17			Total depth = 25' drilled; 26.5' driven.

Sampler Type (ST):
- 3.25" OD D & M Split-Spoon Ring Sampler
- No Recovery
- 2" OD Split-Spoon Sampler

PID - Photoionization Detector
▼ Water Level (ATD)
▽ Static Water Level

Logged by: ILE
Approved by: LJH
Figure No. A- 1

APPENDIX B

MW_GEOL S CRK_SEQ CRK.GPJ November 23, 2004

CH2MHILL

GS elev = 212.1'

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-2
Sheet: 1 of 3

SOIL BORING LOG

PROJECT: N. Sequalitchew Creek Wetland **LOCATION:** ~10' S. of Edmond Marsh Trail
ELEVATION: **DRILLING CONTRACTOR:** Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log **START:** 12/12/02 0934 **FINISH:** 12/12/02 1228 **LOGGER:** S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0					Ground Surface	
		DM	12	2-5-5 (10)	SILTY SAND WITH ORGANICS (SM) Dark brown, moist, loose, fine grained sand, trace fine to medium round to subround gravel, est. 30-40% fines, 20% organics (TOPSOIL)	Two piezometers installed in separate monuments. EM-2(S) is the shallow piezometer, and EM-2(D) is the deep piezometer
		DM	6	5-6-6 (12)	SANDY SILTY GRAVEL (GM) Dark brown, moist to wet, medium dense, well graded round to subround gravel, est. 20% fines, 30-40% sand, trace organics (FILL)	3': Driller states in gravel and a little water
		DM	18	3-1-1 (2)	SILTY SAND WITH GRAVEL (SM) Light brown, moist, medium dense, fine to medium grained sand, fine to medium round to subround gravel, est. 15-20% gravel, 20% fines, trace organics (FILL)	
5		DM	18	6-16-18 (34)		5': Driller states drilling in gravel
					PEAT (PT) Dark brown, wet, very soft, fiberous	
					SANDY SILTY GRAVEL (GM) Gray, moist, medium dense, well graded round to subround gravel, fine to medium grained sand, est. 20% fines, 30% sand	8': Sampled, then loaded hole with water
		DM	12	18-21-15 (36)	SILTY SAND WITH GRAVEL (SM) Gray, wet, medium dense, fine to medium grained sand, fine to coarse round to subround gravel, est. 20-30% fines, 20-30% gravel, not compacted, soupy	
10						
		DM	12	18-22-18 (40)	GRAVELLY WELL GRADED SAND (SW) Gray, wet, medium dense, round to subround sand and gravel, fine to medium gravel, trace coarse gravel, est. <5% fines, 30-40% gravel	13': Driller states from 8-13' pretty sandy, not much gravel 14': Sampler wet
15						
		DM	10	44-50/6" (50/6")	GRAVELLY WELL GRADED SAND (SW) Gray, moist to wet, very dense, fine to coarse grained sand, fine round to subround gravel, est. 30-35% gravel	18': Top of sample was heave
20						

CH2MHILL

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-2
Sheet: 2 of 3

SOIL BORING LOG

PROJECT: N. Sequalitchew Creek Wetland **LOCATION:** ~10' S. of Edmond Marsh Trail
ELEVATION: **DRILLING CONTRACTOR:** Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log **START:** 12/12/02 0934 **FINISH:** 12/12/02 1228 **LOGGER:** S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		DM	12	24-26-30 (56)	GRAVELLY WELL GRADED SAND (GW) Gray, moist to wet, medium dense, fine to coarse grained sand, fine to coarse round to subround gravel, est. 30-40% gravel	20.5': Heave in sampler
		DM	12	34-50/6" (50/6")	SANDY WELL GRADED GRAVEL (GW) Gray, moist to wet, very dense, well graded sand, round to subround gravel, est. 30-35% sand	
25		DM	12	23-36-50/6" (86/12")	SANDY WELL GRADED GRAVEL (GW) -Similar to above, gray, moist to wet, dense to very dense, well graded sand, est. 30-40% sand, becomes siltier toward bottom of sample, est. up to 10% silt toward bottom of sample	25.5': Driller drained water out of samples before opening split spoon. Driller loads hole with water, difficult to determine if samples are wet from drilling water or groundwater. All heave in sample from 25.5'. Resampled.
30		DM	12	32-40-50/6" (90/12")	GRAVELLY WELL GRADED SAND (SW) Gray, moist to wet, very dense, fine to coarse grained sand, fine round to subround gravel, "clean"-little to no fines	
		DM	12	36-44-50/6" (94/12")	GRAVELLY WELL GRADED SAND (SW) -Similar to above	
35		DM	2	44-50/3" (50/3")	WELL GRADED SAND (SW) Gray, moist to wet, very dense, fine to coarse round to subround sand	
		DM	6	36-50/6" (50/6")	SANDY WELL GRADED GRAVEL (GW) Gray, moist to wet, very dense, well graded sand, round to subround gravel, est. 30-40% sand, est. 5% silt	
40		DM	3	33-40-50/6" (90/12")	POORLY GRADED SAND WITH GRAVEL (SP) Gray, moist to wet, very dense, fine to medium grained sand, coarse round to subround gravel, est. 15-20% gravel	38': 3" of heave in sampler

CH2MHILL

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-2
Sheet: 3 of 3

SOIL BORING LOG

PROJECT: N. Sequalitchew Creek Wetland **LOCATION:** ~10' S. of Edmond Marsh Trail
ELEVATION: **DRILLING CONTRACTOR:** Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log **START:** 12/12/02 0934 **FINISH:** 12/12/02 1228 **LOGGER:** S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		DM	10	16-38-50/6" (88/12")	**WELL GRAED SAND WITH GRAVEL (SW)** Gray, moist to wet, very dense, fine round to subround gravel, "clean", grades to **WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM)** 42' Gray, moist to wet, very dense, fine round to subround gravel, est. 15% gravel, 10-15% silt	
		DM	12	18-28-30 (58)	**POORLY GRADED SAND (SP)** Gray, moist to wet, fine to medium grained sand, trace fine to coarse round to subround gravel, est. 5% or less gravel	
45		DM	12	29-36-42 (78)	**POORLY GRADED SAND (SP)** -Similar to above, some gravels have brown staining surrounding the gravel and within the fine grained sand, fine gravel	
Qvr		DM	12	36-50/6" (50/6")	**POORLY GRADED SAND WITH GRAVEL (SP)** Gray, moist, very dense, fine to medium grained sand, fine to coarse round to subround gravel, gravel was packed in "tight", trace dark organics?, pockets/lenses of fine sand at 48'	48': Driller states it felt more compacted Bottom of boring at 51.7' at 1228 on 12-12-02
50		DM	6	(100/6")	**SILTY WELL GRADED SAND WITH GRAVEL (SM)** Gray, moist to wet, very dense, some is compact where the sand is finer grained, est. 20-25% gravel	**Deep Piezometer Construction (EM-2(D))** +2.55-0' Steel riser, locking monument 0-2' Concrete 2-36' Quick grout 36-38' Bentonite chips 38-51.7' Lapis Lustre 2/12 silica sand 0-40' Blank pvc 40-50' 0.020 machine slot screen and cap
Qvt		SS	6	(100/8")	**SILTY SAND WITH GRAVEL (SM)** Gray, moist, very dense, fine grained sand, fine round to subround gravel, est. 20-25% gravel, compacted looking	
55					BOTTOM OF BORING	**Shallow Piezometer Construction (EM-2(S))** Drilled and installed in a separate monument about 3 feet east of deep well 0-1' Concrete and riser 1-2' Bentonite chips 2-5' Lapis Lustre 2/12 silica sand 0-2.5' Blank pvc 2.5-5' 0.020 machine slot screen and cap
60						

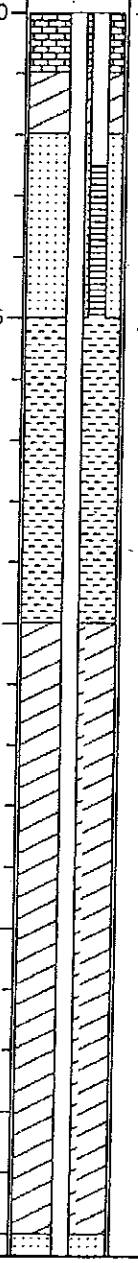
CH2MHILL

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-1
Sheet: 1 of 2

SOIL BORING LOG

GS elev = 207.3

PROJECT: N. Sequalitchew Creek Wetland **LOCATION:** ~100' S. of Edmond Marsh Trail
ELEVATION: **DRILLING CONTRACTOR:** Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log **START:** 12/11/02 1544 **FINISH:** 12/11/02 1620 **LOGGER:** S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0					Ground Surface	Drilled down to 24 feet bgs before first sample. Two piezometers installed in one monument. EM-1(S) is the shallow piezometer, and EM-1(D) is the deep piezometer 4': Driller states in gravel and a little water 12': Sounded gravelley to 14' while drilling, rig stopped in gravel 14': Loaded hole with water 14-16': Gravelly, smoother drilling below 16' 17': Driller states cobbles about 4" in diameter, then smaller sized gravels below 17' 17-24': Smooth drilling, loaded hole with water
5						
10						
15						
20						

CH2MHILL

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-1
Sheet: 2 of 2

SOIL BORING LOG

PROJECT: N. Sequalitchew Creek Wetland LOCATION: ~100' S. of Edmond Marsh Trail
ELEVATION: DRILLING CONTRACTOR: Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log START: 12/11/02 1544 FINISH: 12/11/02 1620 LOGGER: S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
25		DM	12	16-20-25 (45)	POORLY GRADED SAND WITH GRAVEL (SP) Gray, wet, medium dense, fine to medium grained sand, fine to coarse round to subround gravel, est. 15-20% gravel	
		DM	0	39-50/4" (50/4")	POORLY GRADED SAND WITH GRAVEL (SP) -similar to above but fine to medium gravel	Bottom of boring at 33.5' at 1620 on 12/11/02.
30		DM	12	34-35-35 (70)	No recovery -Slough	Measured groundwater at 6.10' (EM-1(S)) and 7.47' (EM-1 (D)) below top of steel on 12/11/02
		DM	6	50/6" (50/6")	POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM) Gray, wet, very dense, fine to medium grained sand, fine to coarse gravel, gets siltier toward bottom of sample, grades to SILTY SAND WITH GRAVEL (SM) at 32' Gray, wet, very dense, fine to medium grained sand, fine to medium round to subround gravel, est. 10-20% silt, 20-25% gravel	Piezometer Construction (EM-1(S) and EM-1(D)) +3.65-0' Steel riser, locking monument 3.xx-2.5' Blank PVC (EM-1(S)) 3.xx-22' Blank PVC (EM-1(D)) 0-1' Concrete 1-2' Bentonite chips 2-5' Lapis Lustre 2/12 silica sand 2.5-5' 0.020 machine slot screen and cap (EM-1(S)) 5-10' Cuttings 10-20' Bentonite chips 20-33.5' Lapis Lustre 2/12 silica sand 22-32' 0.020 machine slot screen and cap (EM-1(D)) Note: Both piezometers are in one steel, riser monument
35					BOTTOM OF BORING	
40						

CH2MHILL

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-1A
Sheet: 1 of 5

SOIL BORING LOG

PROJECT: N. Sequalitchew Creek Wetland **LOCATION:** ~100' S. of Edmond Marsh Trail
ELEVATION: **DRILLING CONTRACTOR:** Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log **START:** 12/11/02 **FINISH:** 12/11/02 **LOGGER:** S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0					Ground Surface	
		DM	18	1/12"-1/6" (2)	ORGANICS Dark brown, moist, very soft	
		DM	18	5-7-12 (19)	PEAT (PT) Dark brown, moist, very soft, fiberous	
		DM	8	43-40-40 (80)	SANDY SILTY GRAVEL (SM) Light brown, wet, loose, fine to coarse grained sand, coarse round to subround gravel	3': Driller states in gravel and a little water
5		DM	8	35-37-39 (76)	PEAT (PT) Dark brown, moist, very soft, fiberous, trace gravel mixed in	4.5': Sampler very wet, large gravel/small cobble jammed in shoe
					SANDY SILTY GRAVEL (GM) -Similar to above, light brown, wet, dense, fine to coarse grained sand, coarse round to subround gravel	6': Drilled in gravel from 4.5-6'.
					SILTY SAND WITH GRAVEL (SM) Gray, wet, dense, fine to coarse grained sand, fine to coarse round to subround gravel, trace round cobbles (TILL-LIKE)	
10		DM	10	28-35-39 (74)	SILTY GRAVEL WITH SAND (SM) Gray, wet, dense, fine to coarse gravel, fine to coarse grained sand, est. 30% silt, 20% sand (TILL-LIKE) In shoe: SANDY SILT (ML) Gray, moist, hard, fine to medium grained sand, est. 20-30% sand	
15		DM	12	42-35-38 (73) ?	SANDY WELL GRADED GRAVEL WITH SILT (GW-GM) Gray, wet, medium dense, fine to coarse round to subround gravel, fine to coarse sand, est. 30% sand, 10-15% fines	14': Sampler wet 17': Driller states not as much rock, large gravel 19': Water poured out of sampler 19.5': Measured groundwater through augers at 1406 on 12/11/02. Augers may be acting as a barrier.
20		DM	4	21-25-27 (52)		

CH2MHILL

PROJECT NUMBER: 151973.A4.WL **BORING NUMBER:** EM-1A
Sheet: 2 of 5

SOIL BORING LOG

PROJECT: N. Sequalitchew Creek Wetland **LOCATION:** ~100' S. of Edmond Marsh Trail
ELEVATION: **DRILLING CONTRACTOR:** Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log **START:** 12/11/02 **FINISH:** 12/11/02 **LOGGER:** S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
					GRAVELLY SAND (SW) Gray, wet, medium dense, fine to coarse grained sand, fine to coarse round to subround gravel, est. 30-40% gravel	
25		DM	10	42-33-30 (63)	**POORLY GRADED SAND WITH GRAVEL (SP** Gray, wet, medium dense, fine to medium grained sand, fine to coarse round to subround gravel, trace fine cobbles, est. 15-20% gravel	
30		DM	12	24-35-38 (73)	**WELL GRADED SAND WITH GRAVEL (SW)** Gray, wet, medium dense, fine to coarse grained sand, fine to medium round to subround gravel, trace fines, increased fines toward bottom of sampler, est. 20-30% gravel	
35		DM	6	50/6" (50/6")	**POORLY GRADED SAND WITH SILT AND GRAVEL TO SILTY SAND WITH GRAVEL (SP-SM/SM)** Gray, wet, very dense, fine to medium grained sand, fine to medium round to subround gravel, est. 10-20% fines, 20-25% gravel (TILL??)	34': Driller states back into a few cobbles
40		DM	4	50/4" (50/4")		

Qvt
Dof
d
Boring

CH2MHILL

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-1A
Sheet: 3 of 5

SOIL BORING LOG

PROJECT: N. Sequalitchew Creek Wetland **LOCATION:** ~100' S. of Edmond Marsh Trail
ELEVATION: **DRILLING CONTRACTOR:** Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log **START:** 12/11/02 **FINISH:** 12/11/02 **LOGGER:** S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
					POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM) Gray, wet, very dense, fine to medium grained sand, fine to coarse round to subround gravel, est. 10% fines, 10-15% gravel	
45		DM	4	50/5" (50/5")	POORLY GRADED SAND (SP) Gray, wet, very dense, fine to medium grained sand, trace fines	
50		DM	4	50/4" (50/4")	GRAVELLY WELL GRADED SAND WITH SILT (SW-SM) Gray, wet, very dense, fine to coarse round to subround gravel, est. 5-10% fines, 30-40% gravel	
55		DM	6	50/6" (50/6")	POORLY GRADED SAND (SP) Gray, wet, very dense, fine to medium grained sand	
60		DM	6	50/6" (50/6")		59': Driller states a little more gravel

CH2MHILL

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-1A
Sheet: 4 of 5

SOIL BORING LOG

PROJECT: N. Sequalitchew Creek Wetland **LOCATION:** ~100' S. of Edmond Marsh Trail
ELEVATION: **DRILLING CONTRACTOR:** Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log **START:** 12/11/02 **FINISH:** 12/11/02 **LOGGER:** S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
					POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM) Gray, wet, very dense, fine to medium grained sand, fine to medium round to subround gravel, est. 10-15% fines, 5-10% gravel	
65		DM	5	50/5" (50/5")	WELL GRADED SAND WITH GRAVEL TO WELL GRADED SAND WITH SILT AND GRAVEL (SW/SW-SM) Gray, wet, very dense, fine to coarse grained sand, fine to medium round to subround gravel, est. 5-10% fines, 20-30% gravel	
70		DM	5	50/5" (50/5")	POORLY GRADED SAND (SP) Gray, wet, very dense, medium to coarse grained round to subround sand, fine to medium round to subround gravel, est. <5% fines, 5-10% gravel	
75		DM	6	50/6" (50/6")	WELL GRADED SAND WITH GRAVEL TO WELL GRADED SAND WITH SILT AND GRAVEL (SW/SW-SM) Gray, wet, very dense, fine to coarse grained sand, fine round to subround gravel, est. 5-10% fines, 10-15% gravel	
80		DM	5	50/5" (50/5")		

CH2MHILL

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-1A
Sheet: 5 of 5

SOIL BORING LOG

PROJECT: N. Sequalitchew Creek Wetland LOCATION: ~100' S. of Edmond Marsh Trail
ELEVATION: DRILLING CONTRACTOR: Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log START: 12/11/02 FINISH: 12/11/02 LOGGER: S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
					POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM) Gray, wet, very dense, fine grained sand, fine to medium round to subround gravel, est. 10-15% fines, 20-30% gravel	
						83': Driller states into silts
85		DM	4	50/4" (50/4")	SILT (ML) Gray, moist to wet, hard	
90		DM	4	50/4" (50/4")	SILT (ML) -Similar to above, gray, moist to wet, hard, fine to medium sand seams	Bottom of boring at 89.3' at 1300 on 12/11/02.
					BOTTOM OF BORING	Driller states not much heave while drilling
						Backfilled boring with grout. Could not install piezometer in this boring. Had to move 3' north and redrill to the bottom of the piezometer installation.
95						
100						

RESOURCE PROTECTION WELL REPORT

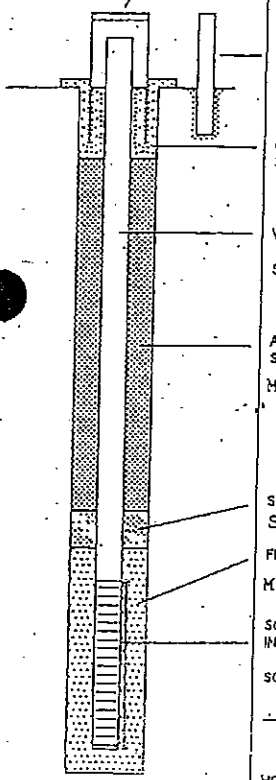
Close Demolition Waste Area - Ft. Lewis

START CARD NO. 17224

PROJECT NAME: Fort Lewis Public Works
WELL IDENTIFICATION NO. D-3
DRILLING METHOD: reverse circ. w/air
DRILLER: Charles E. Shorey, Jr.
FIRM: Layne Christensen Company
SIGNATURE:
CONSULTING FIRM: IMCO General Construction
REPRESENTATIVE: Roger Dudley

COUNTY: Pierce
LOCATION: ___ ¼ ___ ¼ SEC 26 TWN 19N R 1E
STREET ADDRESS OF WELL: Fort Lewis, WA 98433-9500
WATER LEVEL ELEVATION: 11' BGS
GROUND SURFACE ELEVATION: 216
DATE INSTALLED: 8-5-96
DATE DEVELOPED: 8-12-96, 8-14-96

AS-BUILT



OF BORING 24 FT.

WELL DATA

STEEL SURFACE MONUMENT
W/LOCK 3 FT. ABOVE G.L.
PROTECTIVE POSTS no
CONCRETE SURFACE SEAL 2' TO +4" FT.
WELL CASING 14 TO +3 FT.
SCHEDULE 80 TFJ PVC 2"
ANNULAR SEALANT 8 TO 2 FT.
Material: Cement
SEAL 10 TO 8 FT.
Silica sand 12'-10'
FILTER PACK 24 TO 12 FT.
Material: 10-20 sand
SCREEN INTERVAL 24 TO 14 FT.
SCHEDULE 80 TFJ PVC 2"
.02 FACTORY SLOTTED
HOLE DIAMETER
9 IN. 24 TO 0 FT.
___ IN ___ TO ___ FT.

FORMATION DESCRIPTION

0'-5' Coarse sand with medium gravel, brown in color

5'-10' Coarse to medium sand, with large and medium cobbles

10'-15' Fine silty sand, wet, light brown

11' Static water level

15'-20' Fine, dense sand with silt and uniform cobbles

20'-24' Fine silty sand, dense with uniform cobbles

WELL DEVELOPMENT DATA

8-12-96 Bailed 15 gallons from well to remove sediments
Temperature: 60 degrees F
pH: 6.0 Very silty, brown

8-14-96 Pumped 150 gallons from well to stabilize.
Temperature: 60 degrees F
pH; 6.0 Clear, no sediment

Layne Christensen Company
1401 E 26th Street - Tacoma WA 98421 (206) 572-4222 FAX (206) 572-4223

WELL COMPLETION REPORT

Project CELL 5, LFS, FT. LEWIS
Completion date 2/25/93
Contractor ANDREW WELL DRILLING SERVICE
Rig INGERSOLL RAND T-4W
Operator BOB DEWILD/MATT GILBERT
Inspector RICHARD SMITH
Depth 35.0 Datum GROUND SURFACE

HOLE DATA
Size: 6" in. to 35' ft.
____ in. to ____ ft.
____ in. to ____ ft.

CASING
Type 6" DIAMETER, 5' LONG STEEL SURFACE CASING
Mfr.
Ht. above gnd. surf. 3.0'
Drive shoe NO
Size: 6" in. to 3' AGS ft.
6" in. to 3' BGS ft.
____ in. to ____ ft.

SCREEN - 20' -30' (10') THREADED
Type PVC SCH 80 MONOFLEX 20 SLOT
Mfr. CAMPBELL
Composition PVC Dia. 2" ID

Fittings:	Length	Dia.
Riser	22.8'	2" ID
Tailpipe	0.2'	2" ID

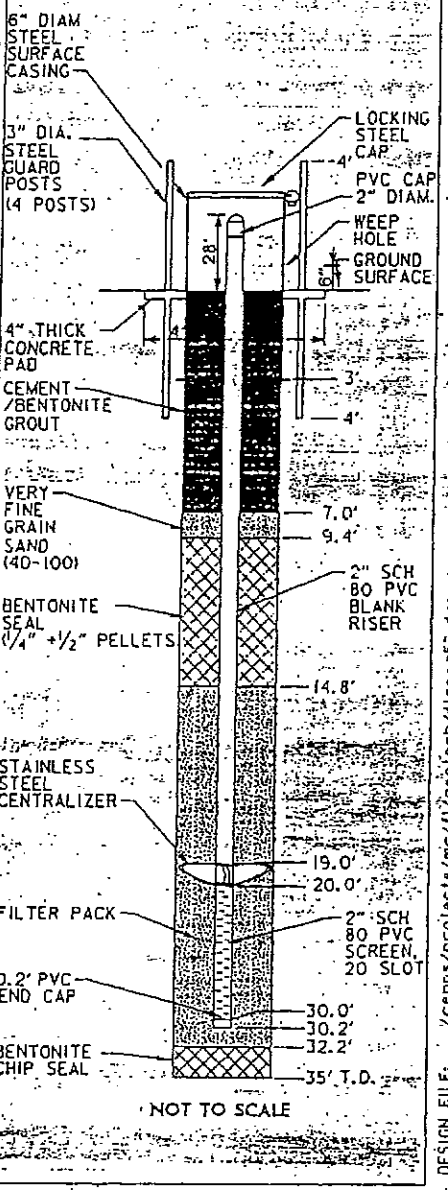
Centralizer- S.S. mounted on outside of PVC Riser 19' -20' BGS

FILTER
Source CSSI - ENVIRONMENTAL MEDIA
Composition SILICA SAND
Gradation 10-20
Inst. method POUR FROM SURFACE
Volume used 4 SACS (100 LB SAC)
Depth 14.8' to 32.2' ft.

GROUT
Composition CEMENT/BENT 5%/H20
Volume used 2-94 LBS BAGS CEMENT (12GAL)
Inst. method POUR DOWNHOLE W/BUCKET
Depth 0' to 7' ft.
____ to ____ ft.

REMARKS: BOTTOM PLUG BENT. CHIPS ½, 50 LB BAG
UPPER PLUG: BENT. PELLETS (⅜"), 2 - 50 LB
BUCKETS, VERY FINE SAND: ½ - 50 LB BAG.
FILLED CASING W/POTABLE WATER TO GROUND
SURFACE PRIOR TO INSTALLATION TO PREVENT
HEAVING AND AID IN PLACING BENT. PLUG.
GROUT RATIO: -1 SAC CEMENT (94 LBS)
6 GAL H20 - 5% BENT. BY WT

WELL DETAIL (AS BUILT)
93-MFS-C5-3



NOT TO SCALE

DESIGN FILE: /cenps/projects/mc/112geotech/11geoc53.dgn DATE AND TIME PLOTTED: 06-MAY-1993

DRILLING LOG	DIVISION NPO	INSTALLATION FORT LEWIS	SHEET 1 OF 1 SHEETS
1. PROJECT RCRA WELLS, CS, LF5		10. SIZE AND TYPE OF BIT 6" ODEX/6" ID TEMP CASING	
2. LOCATION (COORDINATES OR STATION) N 659,446.7 E 1,468,392.9		11. DATUM FOR ELEVATION SHOWN (TBM OR MSL) MSL	
3. DRILLING AGENCY ANDREW WELL DRILLING SERVICE		12. MANUFACTURER'S DESIGNATION OF DRILL INGERSOLL RAND T-4W	
4. HOLE NO. (AS SHOWN ON DRAWING TITLE AND FILE NUMBER) 93-WFS-CS-3		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 7; UNDISTURBED -0-	
5. NAME OF DRILLER BOB DEWILD, MATT GILBERT		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER 195.5	
7. THICKNESS OF OVERBURDEN +35'		16. DATE HOLE STARTED 930CT24 COMPLETED 930CT24	
8. DEPTH DRILLED INTO ROCK -0-		17. ELEVATION TOP OF HOLE 216.9	
9. TOTAL DEPTH OF HOLE 35'		18. TOTAL CORE RECOVERY FOR BORING	
		19. NAME AND SIGNATURE OF INSPECTOR BILL GOSS	

ELEVATION	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (DESCRIPTION)	% CORE RECOV-ERY	BOX OR SAMPLE NO.	REMARKS (DRILLING TIME, WATER LOSS, DEPTH OF WEATHERING, ETC., IF SIGNIFICANT)
	0		GP; POORLY GRADED SANDY GRAVEL; UNCONSOLIDATED, DRY, BROWN		A	DRILLED W/6; ODEX, 6" DRILLING CONCURRENT W/CASING, BIT LEADS CASING BY 6"
	10				B	SAMPLES TAKEN FROM DISCHARGE AT 5' INTERVALS
					C	AIR MONITORING WITH CGI AND PID - NO DETECT
	20		SWL 21.4'		D	
195.5			GP; POORLY GRADED SANDY GRAVEL; UNCONSOLIDATED, WET, BROWN		E	
	30				F	
	35		T.D. 35'		G	

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT RCRA WELLS, CS, LF5 HOLE NO. 93-WFS-CS-3

MAR 71
SEP 90 MODIFIED FOR CADD BY CEHQ

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 218.9 | Hole No. 93-MFS-CS-3

PROJECT RCRA WELLS, CS, LF5 | INSTALLATION FT LEWIS | SHEET 2 OF 4 SHEETS

ELEVATION	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (DESCRIPTION)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (DRILLING TIME, WATER LOSS, DEPTH OF WEATHERING, ETC., IF SIGNIFICANT)
	10		GP: POORLY GRADED SANDY GRAVEL; UNCONSOLIDATED, SAND FINE - COARSE, ROUNDED GRAVEL TO 1", DRY, BROWN		B	SAMPLE B @ 10'
	11					AIR MONITORING 10-15' PID (-0.8) PPM CGI 20.8%, 0.0.0
	12					
	13					
	14					
	15		GP: POORLY GRADED SANDY GRAVEL; UNCONSOLIDATED, SAND FINE - COARSE, ROUNDED GRAVEL TO 1½" - DRY, TO SLT. MOIST, BROWN		C	SAMPLE C @ 15'
	16					AIR MONITORING 15'-17' PID (-0.8)PPM CGI 20.8.0.0.0 - 1 9:25 - 10:15 @ 17' WELD CASING
	17					AIR MONITORING 17'-20' PID (-0.4)PPM CGI 21.0.1.0.0
	18					
	19					
	20					

ENG FORM 1836-A PREVIOUS EDITIONS ARE OBSOLETE. SEP 80 MODIFIED FOR CADD BY CEMPS

PROJECT RCRA WELLS, CS, LF5 | HOLE NO. 93-MFS-CS-3

DRILLING LOG	DIVISION: NPD	INSTALLATION: FORT LEWIS	SHEET 1 OF 4 SHEETS
1. PROJECT: RCRA WELLS, C5, LF5		10. SIZE AND TYPE OF BIT: 6" ODEX/6" ID TEMP. CASING	
2. LOCATION (COORDINATES OR STATION): N 659,446.7 E 1,368,392.9		11. DATUM FOR ELEVATION SHOWN: MSL	
3. DRILLING AGENCY: ANDREW WELL DRILLING SERVICE		12. MANUFACTURER'S DESIGNATION OF DRILL: INGERSOLL RAND T-4W	
4. HOLE NO. (AS SHOWN ON DRAWING) TITLE AND FILE NUMBER: 93-WFS-C5-3		13. TOTAL NO. OF OVERBURDEN & BEDROCK SAMPLES TAKEN: DISTURBED 7; UNDISTURBED -0-	
5. NAME OF DRILLER: BOB DEWILD, MATT GILBERT		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER: 195.5	
7. THICKNESS OF OVERBURDEN: ±35'		16. DATE HOLE: STARTED 930CT24; COMPLETED 930CT24	
8. DEPTH DRILLED INTO ROCK: -0-		17. ELEVATION TOP OF HOLE: 218.9	
9. TOTAL DEPTH OF HOLE: 35'		18. TOTAL CORE RECOVERY FOR BORING: 1	
		19. NAME AND SIGNATURE OF INSPECTOR: BILL GOSS	

ELEVATION	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (DESCRIPTION)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (DRILLING TIME, WATER LOSS, DEPTH OF WEATHERING, ETC., IF SIGNIFICANT)
	0		GP: POORLY GRADED SANDY GRAVEL; UNCONSOLIDATED. SAND FINE -COARSE ROUNDED GRAVEL TO 3". DRY. BROWN. OCCASIONAL COBBLE TO 6"			DRILLED W/6" ODEX, 6" CASING CONCURRENT W/DRILLING. BIT LEADS CASING BY 6" SAMPLES TAKEN FROM DISCHARGE LINE AT 5' INTERVALS AIR MONITORING W/PID & CGI AIR MONITORING @ 5' PID 1-0.4 PPM CGI 20,9,0,0,0
	5		GP: POORLY GRADED SANDY GRAVEL; UNCONSOLIDATED. SAND FINE - COARSE. ROUNDED GRAVEL TO 1". SLT. MOIST. BROWN		(1)	SAMPLE (1) @ 5'
	10					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. SEP 90 MODIFIED FOR CADD BY CEMPR

PROJECT: RCRA WELLS, C5, LF5 HOLE NO. 93-WFS-C5-3

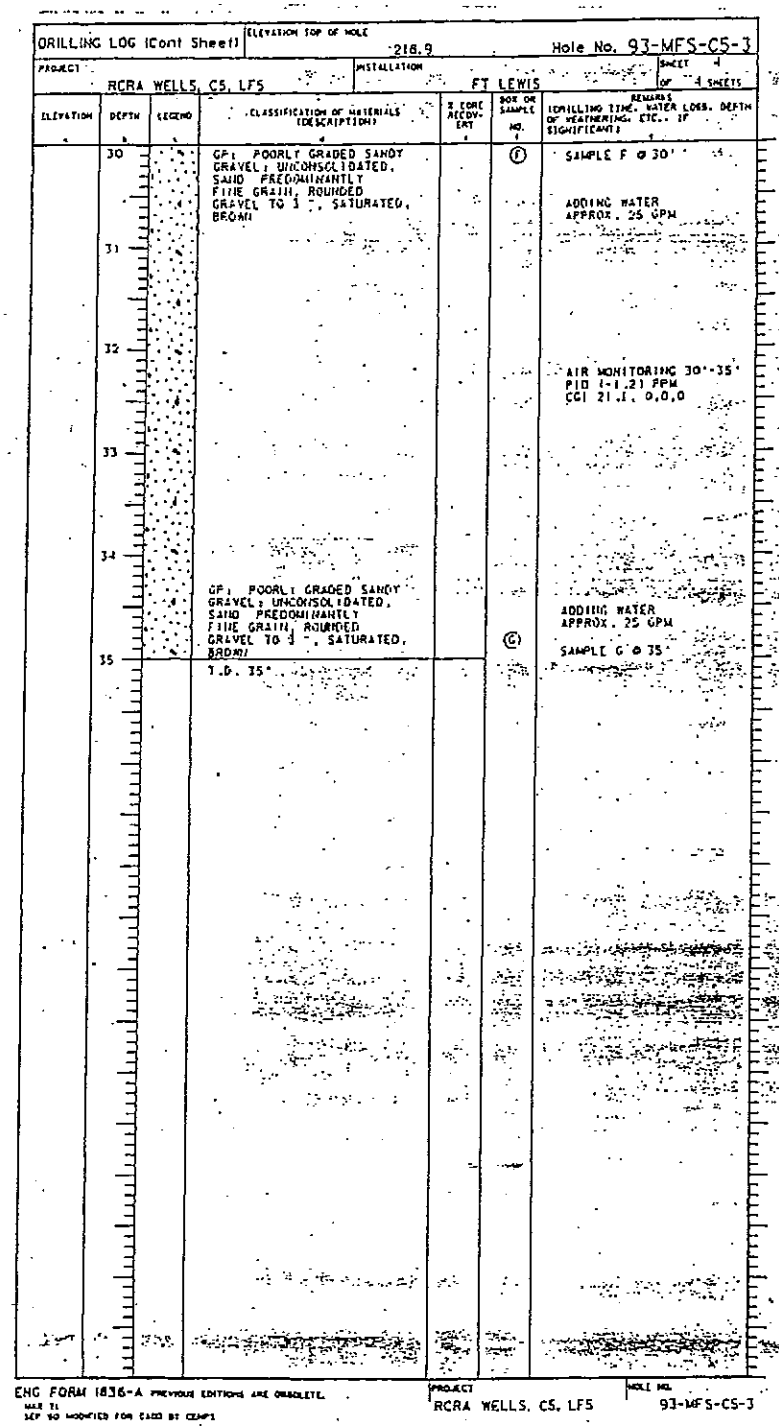
DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 216.9 | Hole No. 93-MFS-C5-3

PROJECT: RCRA WELLS, C5, LF5 | INSTALLATION: FT LEWIS | SHEET 3 OF 4 SHEETS

ELEVATION	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (DESCRIPTION)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (DRILLING TIME, WATER LOSS, DEPTH OF WEATHERING, ETC. - IF SIGNIFICANT)
	20		GP: POORLY GRADED SAND & GRAVEL; UNCONSOLIDATED, SAND FINE - COARSE, ROUNDED GRAVEL TO 1½", DRY, BROWN		(D)	SAMPLE D @ 20'
	21		@ 21' SAMPLE MOIST			AIR MONITORING 20'-25' PID (-0.4)PPM CGI 21, 1.0, 0
195.5			SWL 21.4			
	22					
	23					
	24					
	25		GP: POORLY GRADED SAND & GRAVEL; UNCONSOLIDATED, SAND FINE - COARSE, ROUNDED GRAVEL TO 1½", MOIST, BROWN		(E)	SAMPLE E @ 25'
						@ 25' ADD POTABLE WATER WHILE DRILLING APPROX. 2GPM
	26					FOOTEM LOSE FROZEN HOSE THAW HOSE & ADD WATER
	27					
	28					AIR MONITORING 25'-30' PID (-1.0) PPM CGI 21.0.0.0.1
	29		GP: AS ABOVE W/SAND PREDOMINANTLY FINE GRAIN			
	30					

ENG FORM 1836-A PREVIOUS EDITIONS ARE OBSOLETE. MAR 77 SEP 90 MODIFIED FOR CADD BY CEMPS

PROJECT: RCRA WELLS, C5, LF5 | HOLE NO. 93-MFS-C5-3



DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 218.9 | Hole No. 93-MFS-CS-3

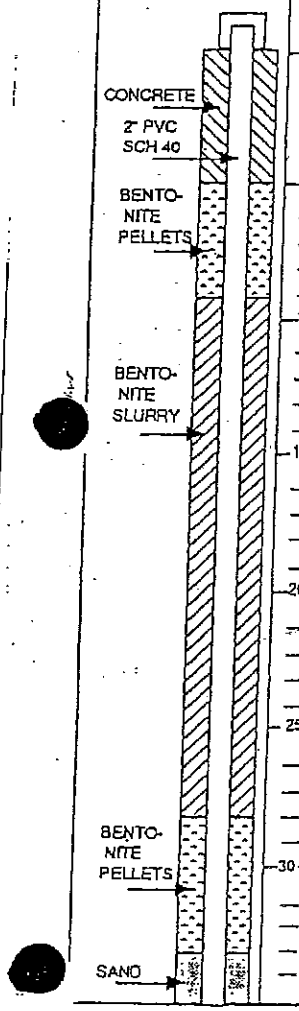
PROJECT: RCRA WELLS, CS, LF5 | INSTALLATION: FT LEWIS | SHEET 4 OF 4 SHEETS

ELEVATION	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (DESCRIPTION)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (DRILLING TIME, WATER LOSS, DEPTH OF WEATHERING, ETC., IF SIGNIFICANT)
	30		GP: POORLY GRADED SANDY GRAVEL; UNCONSOLIDATED, SAND PREDOMINANTLY FINE GRAIN, ROUNDED GRAVEL TO 3", SATURATED, BROWN		(F)	SAMPLE F @ 30'
						ADDING WATER APPROX. 25 GPM
	31					
	32					AIR MONITORING 30'-35' PID (-1.2) PPM CGI 21.1, 0.0,0
	33					
	34					
			GP: POORLY GRADED SANDY GRAVEL; UNCONSOLIDATED, SAND PREDOMINANTLY FINE GRAIN, ROUNDED GRAVEL TO 3", SATURATED, BROWN			ADDING WATER APPROX. 25 GPM
	35		T.D. 35'		(G)	SAMPLE G @ 35'

ENG FORM 1836-A PREVIOUS EDITIONS ARE OBSOLETE. MAR 71 SEP 80 MODIFIED FOR USED BY CEMP1

PROJECT: RCRA WELLS, CS, LF5 | HOLE NO. 93-MFS-CS-3

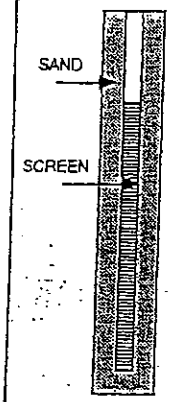
DRILLING LOG	PROJECT FT. LEWIS	PROJECT NUMBER 8820072A	SHEET 1 OF 2 SHEETS
LOCATION	LANDFILL #5	TOTAL NUMBER SAMPLES 0 (Sample Collected in Adjacent Hole)	
DRILLING AGENCY	HOLT	DEPTH TO WATER BELOW GRD SURFACE 22.06 FT	
HOLE NO.	88-2-VD	DATE HOLE STARTED 11/16/88	COMPLETED 11/17/88
NAME OF DRILLER	RANDY HOLT	ELEVATION AT REFERENCE POINT 220.03 FT	
TOTAL DEPTH OF HOLE	49.0 FT	SIGNATURE OF INSPECTOR	Warren Perkins William Deutsch



OPT (FT)	S T	B/FT	SAMP. NO.	% REC.	CLASSIFICATION OF MATERIALS (DESCRIPTION)	REMARKS Gals water added	
					Gravel with Sand		5
							5
					Yellow-gray, angular fragments	Bailed Material	5
							5
							5
							5
							5
					Yellow-gray, coarse sand with angular fragments, few 1-2" pebbles	Bailed Material	5
					Yellow-gray gravel with coarse sand fragments of some large cobbles to 5"	Bailed Material 11'10"	
					Yellow-gray gravel with some pebbles, not as many angular fragments	Bailed Material	5
					Yellow-gray pebbly gravel	Bailed Material	5
					Same as above, except more large angular fragments	Bailed Material	5
					As above, drilling harder at @ 18 ft similar to 88-1-SS	Bailed Material	
					Sandy gravel, yellow-gray, few 3-4" rock fragments; no pebbles	Vashon Recessional Gravel	5
						Bailed Material	5
					Sandy gravel, some silt, still hard drilling	Bailed Material	5
					As above		5
					Yellow-gray, sandy gravel, some silt; easier drilling	Water at 25' Bailed Material	5
					as above; drilling fairly hard	Bailed Material	2
					Yellow-gray, sandy gravel, angular fragments with some broken cobbles	Water bubbling into hole; drilling easier, able to drive casing ahead	
					Yellow-gray angular fragments	Vashon Till	7
					as above	Bailed sample; bailer full of water	7
					Sand/gravel, some silt	Hole making some water, not a lot	10
					as above	Hole making a little water	5

DRILLING LOG (Cont. Sheet) | HOLE NO. 88-2-VD

DIVISION | INSTALLATION FT. LEWIS | SHEET 2 OF 2 SHEETS



DPT (FT)	S T	B/FT	SAMP NO.	% REC.	CLASSIFICATION OF MATERIALS (DESCRIPTION)	REMARKS
						Water coming into
40					Well rounded coarse sand and gravel Some silt and crushed cobbles	hole in good quantity Vashon Advance Gravel Bailed sample
45					Slow drilling, large cobbles; cuttings all pulverized	Water at 28' below ground
					Heaving sand bottom 1 foot	
50					TOTAL DEPTH = 49 FT	

Woodward-Clyde Consultants

APPENDIX B

Field Data Sheets

DuPont Sampling and Analysis Plan

CalPortland -- Dupont, WA

Project Site/Location:	

Routine Station Maintenance			
Personnel:	Weather:	Arrival Date/Time:	
Station Battery Voltage:		Battery Changed? (Y/N -- New Voltage)	
Data Logger Desiccant OK? (Y/N)		Sensor(s) Cleaned & Secure? (Y/N)	
Flow Meter Desiccant OK? (Y/N)		Staff Plate Cleaned & Secure? (Y/N)	
Data Downloaded? (Y/N)		Rain Gage Cleaned & Secure? (Y/N)	
Water Level & Flow		**Water Quality Measurements & Observations (*In-Situ*)**	
Flow Meter Battery Voltage:		Data Logger Recorded Temp (°C) :	
Battery Changed? (Y/N -- New Voltage)		YSI Measured Temp (°C) :	
Date/time correct? (Y/N)		DO (mg/l) :	
Data Logger(s) Desiccant OK? (Y/N)		DO (% saturation) :	
Flow Meter Data Downloaded? (Y/N)		Salinity (ppt) :	
Staff Plate/Well Level (decimal-feet):		pH :	
Data Logger/Meter Recorded Level:		Turbidity (NTU) :	
Velocity (feet per second):		Water Color? (e.g., yellow, brown, grey)	
Flow Rate (CFS):		Floating Oil/Grease? (Y/N)	
Level Calibrated? (Y/N)		Floating Debris/Scum? (Y/N)	
Level Offset (Post-Calibration)		Potentially Harmful Materials? (Y/N)	
Level Offset (Post-Calibration)			

Notes, observations, and maintenance items for future visits. Include observations regarding channel/site conditions, such as: presence/absence of beaver dams; downed trees; streambed composition (e.g., embedded with sediment); vegetation; and particularly fast or slow flow velocities.

DuPont Sampling and Analysis Plan

CalPortland -- Dupont, WA

YSI Professional Handheld Multimeter Calibration Record	
CONDUCTIVITY and PH CALIBRATION*	DO CALIBRATION*
1. Press the Cal key. **2. Highlight the parameter you wish to calibrate and press enter. For Conductivity, a second menu will offer the option of calibrating Specific Conductance, Conductivity, or Salinity. Calibrating one automatically calibrates the other two. An additional sub-menu will require you to select the calibration units. For pH, auto-buffer recognition will determine which buffer the sensor is in and it will allow you to calibrate up to 6 points.** **3. Place the correct amount of calibration standard into a clean, dry or pre-rinsed container.** **4. Immerse the probe into the solution, making sure the sensor and thermistor are adequately immersed. Allow at least one minute for temperature to stabilize.** **5. For any of parameters, enter the calibration solution value by highlighting Calibration Value, pressing enter, and then using the alpha/numeric keypad to enter the known value. Once you have entered the value of the calibration standard, highlight <<<ENTER>>> and press enter.** **6. Wait for the readings to stabilize, highlight Accept Calibration and press enter to calibrate.** **7. For pH, continue with the next point by placing the probe in a second buffer and following the on-screen instructions or press Cal to complete the calibration.**	The Pro Plus offers four options for calibrating dissolved oxygen. The first is an air calibration method in % saturation. The second and third calibrates in mg/L or ppm to a solution with a known DO concentration (usually determined by a Winkler Titration). Calibration of any option (% or mg/L and ppm) will automatically calibrate the other. The fourth option is a zero calibration. If performing a zero calibration, you must perform a % or mg/L calibration following the zero calibration. For both ease of use and accuracy, YSI recommends performing the following 1-point DO % calibration: 1. Moisten the sponge in the cal/transport sleeve with a small amount of water and install it on the probe. The cal/transport sleeve ensures venting to the atmosphere. Disengage a thread or two to ensure atmospheric venting. Make sure the DO and temperature sensors are not immersed in the water. 2. Turn the instrument on. 3. Press the Cal key, highlight DO and press enter. 4. Highlight DO%, then press Enter. 5. Verify the barometric pressure and salinity displayed are accurate. Once DO and temperature are stable, highlight Accept Calibration and press enter.
*Additional calibration information can be found at: http://www.ysi.com/media/pdfs/605595-YSI-Pro-Plus-Quick-Start-Guide-RevB.pdf	

Date:	
Time:	
Staff:	

pH		
7	Initial	
	Calibration	
	Final	
4	Initial	
	Calibration	
	Final	
10	Initial	
	Calibration	
	Final	

Conductivity (Includes Salinity)		
Initial (µS/cm)	Calibration (µS/cm)	Final (µS/cm)

Dissolved Oxygen (1-Point DO Saturation Method)		
Initial (%)	Calibration (%)	Final (%)

APPENDIX C

Hydrologic Calculations

Western Washington Hydrology Model 2012

WWHM2012
PROJECT REPORT

Project Name: Basins C D
Site Name: Pioneer Aggregates
Site Address: Pioneer Avenue
City : DuPont
Report Date: 11/25/2020
Gage : 38 IN CENTRAL
Data Start : 10/01/1901
Data End : 09/30/2059
(adjusted) **Precip Scale:** 0.00
Version Date: 2019/09/13
Version : 4.2.17

Low Flow Threshold for POC 1 : 50 Percent of the 2 Year

High Flow Threshold for POC 1: 50 year

Low Flow Threshold for POC 2 : 50 Percent of the 2 Year

High Flow Threshold for POC 2: 50 year

PREDEVELOPED LAND USE

Name : Watershed C
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Lawn, Flat	19.2
A B, Lawn, Steep	14.4
C, Lawn, Flat	57.5
C, Lawn, Mod	49.3
C, Lawn, Steep	20.7
Pervious Total	161.1

Impervious Land Use	acre
DRIVEWAYS MOD	1
Impervious Total	1
Basin Total	162.1

Element Flows To:

Surface	Interflow	Groundwater

Name : Watershed D
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Lawn, Flat	4
A B, Lawn, Mod	41.5
C, Lawn, Flat	140
C, Lawn, Mod	15.9
C, Lawn, Steep	26.3
Pervious Total	227.7

Impervious Land Use	acre
Impervious Total	0
Basin Total	227.7

Element Flows To:

Surface	Interflow	Groundwater

MITIGATED LAND USE

Name : Basin C
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Lawn, Flat	19.2
A B, Lawn, Steep	14.4
C, Lawn, Flat	57.5
C, Lawn, Mod	49.3
C, Lawn, Steep	20.7
Pervious Total	161.1

Impervious Land Use	acre
DRIVEWAYS MOD	1
Impervious Total	1
Basin Total	162.1

Element Flows To:

Surface	Interflow	Groundwater
Infilt Pond C	Infilt Pond C	

Name : Basin D
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Lawn, Flat	4
A B, Lawn, Mod	41.5
C, Lawn, Flat	140
C, Lawn, Mod	15.9
C, Lawn, Steep	26.3
Pervious Total	227.7

Impervious Land Use	acre
Impervious Total	0
Basin Total	227.7

Element Flows To:

Surface	Interflow	Groundwater
Infilt Pond D	Infilt Pond D	

Name : Infilt Pond C
Bottom Length: 450.00 ft.
Bottom Width: 113.00 ft.
Depth: 6 ft.
Volume at riser head: 6.8406 acre-feet.
Infiltration On
Infiltration rate: 8.1
Infiltration safety factor: 1
Wetted surface area On
Total Volume Infiltrated (ac-ft.): 22322.842
Total Volume Through Riser (ac-ft.): 0
Total Volume Through Facility (ac-ft.): 22322.842
Percent Infiltrated: 100
Total Precip Applied to Facility: 0
Total Evap From Facility: 0
Side slope 1: 3 To 1
Side slope 2: 3 To 1
Side slope 3: 3 To 1
Side slope 4: 3 To 1
Discharge Structure

Riser Height: 5 ft.
Riser Diameter: 24 in.

Element Flows To:
Outlet 1 **Outlet 2**

Pond Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
0.0000	1.167	0.000	0.000	0.000
0.0667	1.172	0.078	0.000	9.576
0.1333	1.177	0.156	0.000	9.618
0.2000	1.182	0.235	0.000	9.661
0.2667	1.188	0.314	0.000	9.703
0.3333	1.193	0.393	0.000	9.746
0.4000	1.198	0.473	0.000	9.788
0.4667	1.203	0.553	0.000	9.831
0.5333	1.208	0.633	0.000	9.874
0.6000	1.214	0.714	0.000	9.916
0.6667	1.219	0.795	0.000	9.959
0.7333	1.224	0.877	0.000	10.00
0.8000	1.229	0.958	0.000	10.04
0.8667	1.235	1.041	0.000	10.08
0.9333	1.240	1.123	0.000	10.13
1.0000	1.245	1.206	0.000	10.17
1.0667	1.251	1.289	0.000	10.21
1.1333	1.256	1.373	0.000	10.26
1.2000	1.261	1.457	0.000	10.30
1.2667	1.266	1.541	0.000	10.34
1.3333	1.272	1.626	0.000	10.39
1.4000	1.277	1.711	0.000	10.43
1.4667	1.282	1.796	0.000	10.47
1.5333	1.288	1.882	0.000	10.52
1.6000	1.293	1.968	0.000	10.56
1.6667	1.298	2.054	0.000	10.60
1.7333	1.304	2.141	0.000	10.65
1.8000	1.309	2.228	0.000	10.69
1.8667	1.315	2.316	0.000	10.74
1.9333	1.320	2.403	0.000	10.78
2.0000	1.325	2.492	0.000	10.82
2.0667	1.331	2.580	0.000	10.87
2.1333	1.336	2.669	0.000	10.91
2.2000	1.342	2.758	0.000	10.96
2.2667	1.347	2.848	0.000	11.00
2.3333	1.352	2.938	0.000	11.04
2.4000	1.358	3.028	0.000	11.09
2.4667	1.363	3.119	0.000	11.13
2.5333	1.369	3.210	0.000	11.18
2.6000	1.374	3.302	0.000	11.22
2.6667	1.380	3.393	0.000	11.27
2.7333	1.385	3.486	0.000	11.31
2.8000	1.391	3.578	0.000	11.36
2.8667	1.396	3.671	0.000	11.40
2.9333	1.401	3.764	0.000	11.45

3.0000	1.407	3.858	0.000	11.49
3.0667	1.412	3.952	0.000	11.54
3.1333	1.418	4.046	0.000	11.58
3.2000	1.424	4.141	0.000	11.63
3.2667	1.429	4.236	0.000	11.67
3.3333	1.435	4.332	0.000	11.72
3.4000	1.440	4.428	0.000	11.76
3.4667	1.446	4.524	0.000	11.81
3.5333	1.451	4.620	0.000	11.85
3.6000	1.457	4.717	0.000	11.90
3.6667	1.462	4.815	0.000	11.94
3.7333	1.468	4.912	0.000	11.99
3.8000	1.474	5.011	0.000	12.03
3.8667	1.479	5.109	0.000	12.08
3.9333	1.485	5.208	0.000	12.13
4.0000	1.490	5.307	0.000	12.17
4.0667	1.496	5.407	0.000	12.22
4.1333	1.502	5.507	0.000	12.26
4.2000	1.507	5.607	0.000	12.31
4.2667	1.513	5.708	0.000	12.36
4.3333	1.518	5.809	0.000	12.40
4.4000	1.524	5.910	0.000	12.45
4.4667	1.530	6.012	0.000	12.49
4.5333	1.535	6.114	0.000	12.54
4.6000	1.541	6.217	0.000	12.59
4.6667	1.547	6.320	0.000	12.63
4.7333	1.552	6.423	0.000	12.68
4.8000	1.558	6.527	0.000	12.73
4.8667	1.564	6.631	0.000	12.77
4.9333	1.570	6.735	0.000	12.82
5.0000	1.575	6.840	0.000	12.87
5.0667	1.581	6.945	0.365	12.91
5.1333	1.587	7.051	1.030	12.96
5.2000	1.593	7.157	1.886	13.01
5.2667	1.598	7.263	2.883	13.05
5.3333	1.604	7.370	3.979	13.10
5.4000	1.610	7.477	5.134	13.15
5.4667	1.616	7.585	6.307	13.19
5.5333	1.621	7.693	7.456	13.24
5.6000	1.627	7.801	8.540	13.29
5.6667	1.633	7.910	9.523	13.34
5.7333	1.639	8.019	10.37	13.38
5.8000	1.644	8.128	11.08	13.43
5.8667	1.650	8.238	11.65	13.48
5.9333	1.656	8.348	12.09	13.53
6.0000	1.662	8.459	12.46	13.57
6.0667	1.668	8.570	13.01	13.62

Name : Infilt Pond D
Bottom Length: 1000.00 ft.
Bottom Width: 37.70 ft.
Depth: 6 ft.
Volume at riser head: 6.1485 acre-feet.
Infiltration On
Infiltration rate: 8.2
Infiltration safety factor: 1

Wetted surface area On
Total Volume Infiltrated (ac-ft.): 31272.175
Total Volume Through Riser (ac-ft.): 1.011
Total Volume Through Facility (ac-ft.): 31273.186
Percent Infiltrated: 100
Total Precip Applied to Facility: 0
Total Evap From Facility: 0
Side slope 1: 3 To 1
Side slope 2: 3 To 1
Side slope 3: 3 To 1
Side slope 4: 3 To 1
Discharge Structure
Riser Height: 5 ft.
Riser Diameter: 24 in.

Element Flows To:
Outlet 1 **Outlet 2**

Pond Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
0.0000	0.865	0.000	0.000	0.000
0.0667	0.875	0.058	0.000	7.234
0.1333	0.884	0.116	0.000	7.313
0.2000	0.894	0.176	0.000	7.392
0.2667	0.903	0.235	0.000	7.471
0.3333	0.913	0.296	0.000	7.550
0.4000	0.922	0.357	0.000	7.629
0.4667	0.932	0.419	0.000	7.709
0.5333	0.941	0.482	0.000	7.788
0.6000	0.951	0.545	0.000	7.867
0.6667	0.961	0.608	0.000	7.946
0.7333	0.970	0.673	0.000	8.026
0.8000	0.980	0.738	0.000	8.105
0.8667	0.990	0.803	0.000	8.185
0.9333	0.999	0.870	0.000	8.265
1.0000	1.009	0.937	0.000	8.344
1.0667	1.018	1.004	0.000	8.424
1.1333	1.028	1.073	0.000	8.504
1.2000	1.038	1.142	0.000	8.584
1.2667	1.047	1.211	0.000	8.664
1.3333	1.057	1.281	0.000	8.743
1.4000	1.067	1.352	0.000	8.824
1.4667	1.076	1.424	0.000	8.904
1.5333	1.086	1.496	0.000	8.984
1.6000	1.096	1.568	0.000	9.064
1.6667	1.106	1.642	0.000	9.144
1.7333	1.115	1.716	0.000	9.225
1.8000	1.125	1.791	0.000	9.305
1.8667	1.135	1.866	0.000	9.385
1.9333	1.144	1.942	0.000	9.466
2.0000	1.154	2.019	0.000	9.547
2.0667	1.164	2.096	0.000	9.627
2.1333	1.174	2.174	0.000	9.708

2.2000	1.183	2.252	0.000	9.789
2.2667	1.193	2.332	0.000	9.869
2.3333	1.203	2.412	0.000	9.950
2.4000	1.213	2.492	0.000	10.03
2.4667	1.223	2.573	0.000	10.11
2.5333	1.232	2.655	0.000	10.19
2.6000	1.242	2.738	0.000	10.27
2.6667	1.252	2.821	0.000	10.35
2.7333	1.262	2.905	0.000	10.43
2.8000	1.272	2.989	0.000	10.51
2.8667	1.282	3.074	0.000	10.60
2.9333	1.291	3.160	0.000	10.68
3.0000	1.301	3.247	0.000	10.76
3.0667	1.311	3.334	0.000	10.84
3.1333	1.321	3.421	0.000	10.92
3.2000	1.331	3.510	0.000	11.00
3.2667	1.341	3.599	0.000	11.09
3.3333	1.351	3.689	0.000	11.17
3.4000	1.361	3.779	0.000	11.25
3.4667	1.370	3.870	0.000	11.33
3.5333	1.380	3.962	0.000	11.41
3.6000	1.390	4.054	0.000	11.49
3.6667	1.400	4.147	0.000	11.58
3.7333	1.410	4.241	0.000	11.66
3.8000	1.420	4.335	0.000	11.74
3.8667	1.430	4.430	0.000	11.82
3.9333	1.440	4.526	0.000	11.91
4.0000	1.450	4.623	0.000	11.99
4.0667	1.460	4.720	0.000	12.07
4.1333	1.470	4.817	0.000	12.15
4.2000	1.480	4.916	0.000	12.24
4.2667	1.490	5.015	0.000	12.32
4.3333	1.500	5.114	0.000	12.40
4.4000	1.510	5.215	0.000	12.48
4.4667	1.520	5.316	0.000	12.57
4.5333	1.530	5.417	0.000	12.65
4.6000	1.540	5.520	0.000	12.73
4.6667	1.550	5.623	0.000	12.82
4.7333	1.560	5.727	0.000	12.90
4.8000	1.570	5.831	0.000	12.98
4.8667	1.580	5.936	0.000	13.06
4.9333	1.590	6.042	0.000	13.15
5.0000	1.600	6.148	0.000	13.23
5.0667	1.610	6.255	0.365	13.31
5.1333	1.621	6.363	1.030	13.40
5.2000	1.631	6.471	1.886	13.48
5.2667	1.641	6.580	2.883	13.57
5.3333	1.651	6.690	3.979	13.65
5.4000	1.661	6.800	5.134	13.73
5.4667	1.671	6.912	6.307	13.82
5.5333	1.681	7.023	7.456	13.90
5.6000	1.691	7.136	8.540	13.98
5.6667	1.702	7.249	9.523	14.07
5.7333	1.712	7.363	10.37	14.15
5.8000	1.722	7.477	11.08	14.24
5.8667	1.732	7.592	11.65	14.32
5.9333	1.742	7.708	12.09	14.40

6.0000	1.752	7.825	12.46	14.49
6.0667	1.763	7.942	13.01	14.57

ANALYSIS RESULTS

Stream Protection Duration

Predeveloped Landuse Totals for POC #1
Total Pervious Area:161.1
Total Impervious Area:1

Mitigated Landuse Totals for POC #1
Total Pervious Area:161.1
Total Impervious Area:1

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	7.15659
5 year	14.082833
10 year	20.66757
25 year	31.840733
50 year	42.64107
100 year	55.940025

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0
5 year	0
10 year	0
25 year	0
50 year	0
100 year	0

Stream Protection Duration
Annual Peaks for Predeveloped and Mitigated. POC #1

Year	Predeveloped	Mitigated
1902	4.799	0.000
1903	3.466	0.000
1904	25.520	0.000
1905	4.233	0.000
1906	1.571	0.000
1907	12.609	0.000
1908	5.300	0.000
1909	6.989	0.000
1910	14.200	0.000
1911	9.354	0.000
1912	55.963	0.000
1913	6.386	0.000
1914	39.323	0.000

1915	3.687	0.000
1916	8.055	0.000
1917	2.298	0.000
1918	4.539	0.000
1919	4.129	0.000
1920	9.261	0.000
1921	6.609	0.000
1922	17.117	0.000
1923	7.087	0.000
1924	3.338	0.000
1925	3.459	0.000
1926	6.149	0.000
1927	3.354	0.000
1928	4.887	0.000
1929	12.189	0.000
1930	4.365	0.000
1931	4.843	0.000
1932	5.332	0.000
1933	6.063	0.000
1934	20.863	0.000
1935	4.242	0.000
1936	6.076	0.000
1937	15.127	0.000
1938	5.018	0.000
1939	1.735	0.000
1940	6.513	0.000
1941	2.472	0.000
1942	13.789	0.000
1943	6.739	0.000
1944	19.359	0.000
1945	5.697	0.000
1946	10.648	0.000
1947	2.796	0.000
1948	10.617	0.000
1949	10.733	0.000
1950	3.312	0.000
1951	3.177	0.000
1952	36.522	0.000
1953	28.551	0.000
1954	5.398	0.000
1955	3.533	0.000
1956	2.073	0.000
1957	5.164	0.000
1958	19.341	0.000
1959	16.116	0.000
1960	3.516	0.000
1961	22.333	0.000
1962	5.470	0.000
1963	3.069	0.000
1964	31.433	0.000
1965	11.702	0.000
1966	3.930	0.000
1967	14.803	0.000
1968	5.405	0.000
1969	5.852	0.000
1970	12.098	0.000
1971	12.768	0.000

1972	52.820	0.000
1973	12.265	0.000
1974	12.727	0.000
1975	29.304	0.000
1976	21.674	0.000
1977	2.415	0.000
1978	19.844	0.000
1979	7.557	0.000
1980	15.201	0.000
1981	5.582	0.000
1982	3.596	0.000
1983	10.771	0.000
1984	11.121	0.000
1985	19.657	0.000
1986	5.284	0.000
1987	16.103	0.000
1988	5.029	0.000
1989	5.135	0.000
1990	7.297	0.000
1991	14.980	0.000
1992	11.209	0.000
1993	7.477	0.000
1994	11.829	0.000
1995	3.511	0.000
1996	14.451	0.000
1997	5.092	0.000
1998	11.456	0.000
1999	2.804	0.000
2000	6.273	0.000
2001	3.865	0.000
2002	28.697	0.000
2003	7.538	0.000
2004	9.171	0.000
2005	34.781	0.000
2006	3.283	0.000
2007	8.778	0.000
2008	6.181	0.000
2009	4.071	0.000
2010	4.942	0.000
2011	2.348	0.000
2012	6.803	0.000
2013	9.504	0.000
2014	5.199	0.000
2015	27.596	0.000
2016	2.758	0.000
2017	7.909	0.000
2018	18.018	0.000
2019	26.979	0.000
2020	12.928	0.000
2021	10.302	0.000
2022	8.336	0.000
2023	7.925	0.000
2024	45.967	0.000
2025	4.846	0.000
2026	7.863	0.000
2027	4.910	0.000
2028	2.945	0.000

2029	6.624	0.000
2030	15.307	0.000
2031	3.288	0.000
2032	2.451	0.000
2033	3.070	0.000
2034	4.192	0.000
2035	15.150	0.000
2036	6.795	0.000
2037	2.789	0.000
2038	15.705	0.000
2039	2.081	0.000
2040	4.681	0.000
2041	5.905	0.000
2042	13.736	0.000
2043	9.643	0.000
2044	9.191	0.000
2045	4.659	0.000
2046	5.399	0.000
2047	4.288	0.000
2048	5.191	0.000
2049	7.317	0.000
2050	7.509	0.000
2051	18.257	0.000
2052	3.570	0.000
2053	5.536	0.000
2054	32.862	0.000
2055	4.357	0.000
2056	2.675	0.000
2057	4.042	0.000
2058	4.312	0.000
2059	19.759	0.000

Stream Protection Duration
Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	55.9628	0.0000
2	52.8202	0.0000
3	45.9668	0.0000
4	39.3227	0.0000
5	36.5224	0.0000
6	34.7813	0.0000
7	32.8623	0.0000
8	31.4326	0.0000
9	29.3037	0.0000
10	28.6966	0.0000
11	28.5509	0.0000
12	27.5956	0.0000
13	26.9794	0.0000
14	25.5195	0.0000
15	22.3329	0.0000
16	21.6736	0.0000
17	20.8633	0.0000
18	19.8441	0.0000
19	19.7590	0.0000
20	19.6570	0.0000
21	19.3587	0.0000

22	19.3413	0.0000
23	18.2573	0.0000
24	18.0179	0.0000
25	17.1166	0.0000
26	16.1156	0.0000
27	16.1032	0.0000
28	15.7052	0.0000
29	15.3068	0.0000
30	15.2014	0.0000
31	15.1501	0.0000
32	15.1265	0.0000
33	14.9802	0.0000
34	14.8030	0.0000
35	14.4510	0.0000
36	14.1996	0.0000
37	13.7890	0.0000
38	13.7363	0.0000
39	12.9282	0.0000
40	12.7680	0.0000
41	12.7266	0.0000
42	12.6087	0.0000
43	12.2648	0.0000
44	12.1890	0.0000
45	12.0982	0.0000
46	11.8294	0.0000
47	11.7016	0.0000
48	11.4560	0.0000
49	11.2090	0.0000
50	11.1213	0.0000
51	10.7712	0.0000
52	10.7328	0.0000
53	10.6481	0.0000
54	10.6173	0.0000
55	10.3024	0.0000
56	9.6433	0.0000
57	9.5038	0.0000
58	9.3535	0.0000
59	9.2609	0.0000
60	9.1913	0.0000
61	9.1712	0.0000
62	8.7780	0.0000
63	8.3359	0.0000
64	8.0547	0.0000
65	7.9255	0.0000
66	7.9088	0.0000
67	7.8633	0.0000
68	7.5570	0.0000
69	7.5383	0.0000
70	7.5089	0.0000
71	7.4765	0.0000
72	7.3171	0.0000
73	7.2970	0.0000
74	7.0873	0.0000
75	6.9892	0.0000
76	6.8032	0.0000
77	6.7951	0.0000
78	6.7392	0.0000

79	6.6238	0.0000
80	6.6086	0.0000
81	6.5127	0.0000
82	6.3864	0.0000
83	6.2726	0.0000
84	6.1810	0.0000
85	6.1495	0.0000
86	6.0758	0.0000
87	6.0626	0.0000
88	5.9047	0.0000
89	5.8516	0.0000
90	5.6973	0.0000
91	5.5818	0.0000
92	5.5361	0.0000
93	5.4705	0.0000
94	5.4054	0.0000
95	5.3989	0.0000
96	5.3978	0.0000
97	5.3317	0.0000
98	5.3001	0.0000
99	5.2844	0.0000
100	5.1989	0.0000
101	5.1912	0.0000
102	5.1638	0.0000
103	5.1346	0.0000
104	5.0924	0.0000
105	5.0292	0.0000
106	5.0183	0.0000
107	4.9417	0.0000
108	4.9104	0.0000
109	4.8875	0.0000
110	4.8459	0.0000
111	4.8429	0.0000
112	4.7986	0.0000
113	4.6807	0.0000
114	4.6594	0.0000
115	4.5394	0.0000
116	4.3648	0.0000
117	4.3568	0.0000
118	4.3121	0.0000
119	4.2875	0.0000
120	4.2417	0.0000
121	4.2333	0.0000
122	4.1918	0.0000
123	4.1287	0.0000
124	4.0712	0.0000
125	4.0416	0.0000
126	3.9304	0.0000
127	3.8653	0.0000
128	3.6866	0.0000
129	3.5958	0.0000
130	3.5696	0.0000
131	3.5328	0.0000
132	3.5163	0.0000
133	3.5109	0.0000
134	3.4661	0.0000
135	3.4587	0.0000

136	3.3542	0.0000
137	3.3382	0.0000
138	3.3115	0.0000
139	3.2884	0.0000
140	3.2832	0.0000
141	3.1770	0.0000
142	3.0697	0.0000
143	3.0686	0.0000
144	2.9449	0.0000
145	2.8037	0.0000
146	2.7957	0.0000
147	2.7891	0.0000
148	2.7581	0.0000
149	2.6753	0.0000
150	2.4716	0.0000
151	2.4511	0.0000
152	2.4155	0.0000
153	2.3485	0.0000
154	2.2981	0.0000
155	2.0808	0.0000
156	2.0730	0.0000
157	1.7348	0.0000
158	1.5711	0.0000

Stream Protection Duration
POC #1
The Facility PASSED

The Facility PASSED.

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
3.5783	17484	0	0	Pass
3.9729	12565	0	0	Pass
4.3674	8897	0	0	Pass
4.7620	6343	0	0	Pass
5.1566	4656	0	0	Pass
5.5512	3562	0	0	Pass
5.9457	2785	0	0	Pass
6.3403	2182	0	0	Pass
6.7349	1561	0	0	Pass
7.1295	1210	0	0	Pass
7.5240	978	0	0	Pass
7.9186	780	0	0	Pass
8.3132	638	0	0	Pass
8.7078	535	0	0	Pass
9.1023	424	0	0	Pass
9.4969	343	0	0	Pass
9.8915	293	0	0	Pass
10.2860	261	0	0	Pass
10.6806	239	0	0	Pass
11.0752	223	0	0	Pass
11.4698	205	0	0	Pass
11.8643	193	0	0	Pass
12.2589	181	0	0	Pass
12.6535	170	0	0	Pass
13.0481	161	0	0	Pass

13.4426	152	0	0	Pass
13.8372	142	0	0	Pass
14.2318	133	0	0	Pass
14.6264	127	0	0	Pass
15.0209	116	0	0	Pass
15.4155	111	0	0	Pass
15.8101	108	0	0	Pass
16.2046	99	0	0	Pass
16.5992	97	0	0	Pass
16.9938	92	0	0	Pass
17.3884	88	0	0	Pass
17.7829	79	0	0	Pass
18.1775	73	0	0	Pass
18.5721	68	0	0	Pass
18.9667	66	0	0	Pass
19.3612	63	0	0	Pass
19.7558	60	0	0	Pass
20.1504	57	0	0	Pass
20.5450	55	0	0	Pass
20.9395	49	0	0	Pass
21.3341	46	0	0	Pass
21.7287	44	0	0	Pass
22.1232	44	0	0	Pass
22.5178	39	0	0	Pass
22.9124	39	0	0	Pass
23.3070	39	0	0	Pass
23.7015	38	0	0	Pass
24.0961	35	0	0	Pass
24.4907	34	0	0	Pass
24.8853	33	0	0	Pass
25.2798	31	0	0	Pass
25.6744	30	0	0	Pass
26.0690	30	0	0	Pass
26.4636	30	0	0	Pass
26.8581	29	0	0	Pass
27.2527	27	0	0	Pass
27.6473	26	0	0	Pass
28.0419	25	0	0	Pass
28.4364	24	0	0	Pass
28.8310	21	0	0	Pass
29.2256	21	0	0	Pass
29.6201	20	0	0	Pass
30.0147	20	0	0	Pass
30.4093	20	0	0	Pass
30.8039	20	0	0	Pass
31.1984	20	0	0	Pass
31.5930	18	0	0	Pass
31.9876	18	0	0	Pass
32.3822	18	0	0	Pass
32.7767	18	0	0	Pass
33.1713	16	0	0	Pass
33.5659	16	0	0	Pass
33.9605	16	0	0	Pass
34.3550	16	0	0	Pass
34.7496	16	0	0	Pass
35.1442	15	0	0	Pass
35.5387	15	0	0	Pass

35.9333	14	0	0	Pass
36.3279	14	0	0	Pass
36.7225	12	0	0	Pass
37.1170	12	0	0	Pass
37.5116	12	0	0	Pass
37.9062	12	0	0	Pass
38.3008	12	0	0	Pass
38.6953	12	0	0	Pass
39.0899	12	0	0	Pass
39.4845	11	0	0	Pass
39.8791	10	0	0	Pass
40.2736	10	0	0	Pass
40.6682	9	0	0	Pass
41.0628	9	0	0	Pass
41.4573	9	0	0	Pass
41.8519	9	0	0	Pass
42.2465	9	0	0	Pass
42.6411	9	0	0	Pass

Water Quality BMP Flow and Volume for POC #1
On-line facility volume: 6.0805 **acre-feet**
On-line facility target flow: 3.3931 **cfs.**
Adjusted for 15 min: 3.3931 **cfs.**
Off-line facility target flow: 1.9045 **cfs.**
Adjusted for 15 min: 1.9045 **cfs.**

LID Report

LID Technique	Used for Water Quality	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft.)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality Treated	Percent Treatment?	Comment
Infilt Pond C POC	N	20313.78			N	100.00			
Total Volume Infiltrated		20313.78	0.00	0.00		100.00	0.00	0%	No Treat. Credit

Compliance with LID Standard 8
Duration Analysis Result = Passed

Stream Protection Duration

Predeveloped Landuse Totals for POC #2
Total Pervious Area:227.7
Total Impervious Area:0

Mitigated Landuse Totals for POC #2
Total Pervious Area:227.7
Total Impervious Area:0

Flow Frequency Return Periods for Predeveloped. POC #2

Return Period	Flow(cfs)
2 year	9.453983
5 year	18.751269
10 year	27.642348
25 year	42.801569
50 year	57.51558
100 year	75.693112

Flow Frequency Return Periods for Mitigated. POC #2

Return Period	Flow(cfs)
2 year	0
5 year	0
10 year	0
25 year	0
50 year	0
100 year	0

Stream Protection Duration
Annual Peaks for Predeveloped and Mitigated. POC #2

Year	Predeveloped	Mitigated
1902	6.246	0.000
1903	4.718	0.000
1904	33.939	0.000
1905	5.808	0.000
1906	2.062	0.000
1907	16.843	0.000
1908	6.764	0.000
1909	9.046	0.000
1910	19.255	0.000
1911	12.085	0.000
1912	77.843	1.755
1913	8.817	0.000
1914	50.844	0.000
1915	4.788	0.000
1916	10.048	0.000
1917	3.156	0.000
1918	6.084	0.000
1919	5.382	0.000
1920	12.020	0.000
1921	8.763	0.000
1922	22.619	0.000
1923	9.530	0.000
1924	4.652	0.000
1925	4.536	0.000
1926	8.035	0.000
1927	4.560	0.000
1928	6.400	0.000
1929	15.813	0.000
1930	5.877	0.000
1931	6.424	0.000
1932	6.832	0.000
1933	7.918	0.000
1934	27.707	0.000
1935	5.633	0.000

1936	7.878	0.000
1937	20.521	0.000
1938	6.479	0.000
1939	2.219	0.000
1940	8.440	0.000
1941	3.360	0.000
1942	18.130	0.000
1943	8.634	0.000
1944	25.406	0.000
1945	7.749	0.000
1946	14.041	0.000
1947	3.803	0.000
1948	14.258	0.000
1949	14.446	0.000
1950	4.515	0.000
1951	4.113	0.000
1952	50.783	7.074
1953	39.109	0.000
1954	6.849	0.000
1955	4.901	0.000
1956	2.873	0.000
1957	7.121	0.000
1958	26.457	0.000
1959	21.858	0.000
1960	4.398	0.000
1961	29.737	0.000
1962	7.022	0.000
1963	4.264	0.000
1964	42.383	0.000
1965	15.609	0.000
1966	4.977	0.000
1967	19.613	0.000
1968	7.449	0.000
1969	7.567	0.000
1970	15.844	0.000
1971	17.325	0.000
1972	71.605	0.000
1973	16.472	0.000
1974	17.212	0.000
1975	40.503	0.000
1976	28.810	0.000
1977	3.358	0.000
1978	27.189	0.000
1979	9.606	0.000
1980	19.926	0.000
1981	6.878	0.000
1982	4.449	0.000
1983	14.229	0.000
1984	14.551	0.000
1985	26.318	0.000
1986	6.950	0.000
1987	21.177	0.000
1988	6.670	0.000
1989	6.826	0.000
1990	9.281	0.000
1991	18.716	0.000
1992	14.449	0.000

1993	9.817	0.000
1994	15.884	0.000
1995	4.476	0.000
1996	19.610	0.000
1997	6.542	0.000
1998	15.149	0.000
1999	3.625	0.000
2000	8.159	0.000
2001	4.976	0.000
2002	38.857	0.000
2003	9.870	0.000
2004	11.896	0.000
2005	46.782	0.000
2006	4.233	0.000
2007	11.111	0.000
2008	8.046	0.000
2009	5.271	0.000
2010	6.874	0.000
2011	3.144	0.000
2012	9.224	0.000
2013	12.376	0.000
2014	6.602	0.000
2015	37.780	0.000
2016	3.159	0.000
2017	10.697	0.000
2018	25.208	0.000
2019	35.795	0.000
2020	17.250	0.000
2021	13.365	0.000
2022	9.977	0.000
2023	9.850	0.000
2024	64.683	0.000
2025	6.669	0.000
2026	10.472	0.000
2027	6.313	0.000
2028	4.045	0.000
2029	8.691	0.000
2030	20.644	0.000
2031	4.446	0.000
2032	3.072	0.000
2033	4.250	0.000
2034	5.863	0.000
2035	20.444	0.000
2036	9.044	0.000
2037	3.865	0.000
2038	20.483	0.000
2039	2.184	0.000
2040	5.955	0.000
2041	7.500	0.000
2042	18.567	0.000
2043	12.694	0.000
2044	12.165	0.000
2045	5.930	0.000
2046	7.032	0.000
2047	5.805	0.000
2048	7.202	0.000
2049	9.679	0.000

2050	9.773	0.000
2051	24.509	0.000
2052	4.830	0.000
2053	7.495	0.000
2054	44.017	0.000
2055	5.437	0.000
2056	3.707	0.000
2057	5.563	0.000
2058	5.827	0.000
2059	26.461	0.000

Stream Protection Duration
Ranked Annual Peaks for Predeveloped and Mitigated. POC #2

Rank	Predeveloped	Mitigated
1	77.8432	7.0742
2	71.6051	1.7552
3	64.6825	0.0000
4	50.8441	0.0000
5	50.7834	0.0000
6	46.7818	0.0000
7	44.0168	0.0000
8	42.3826	0.0000
9	40.5026	0.0000
10	39.1091	0.0000
11	38.8567	0.0000
12	37.7802	0.0000
13	35.7950	0.0000
14	33.9390	0.0000
15	29.7370	0.0000
16	28.8097	0.0000
17	27.7067	0.0000
18	27.1888	0.0000
19	26.4609	0.0000
20	26.4572	0.0000
21	26.3176	0.0000
22	25.4058	0.0000
23	25.2078	0.0000
24	24.5093	0.0000
25	22.6185	0.0000
26	21.8582	0.0000
27	21.1771	0.0000
28	20.6440	0.0000
29	20.5208	0.0000
30	20.4827	0.0000
31	20.4438	0.0000
32	19.9258	0.0000
33	19.6128	0.0000
34	19.6103	0.0000
35	19.2545	0.0000
36	18.7158	0.0000
37	18.5671	0.0000
38	18.1296	0.0000
39	17.3248	0.0000
40	17.2504	0.0000
41	17.2121	0.0000
42	16.8432	0.0000

43	16.4715	0.0000
44	15.8843	0.0000
45	15.8442	0.0000
46	15.8125	0.0000
47	15.6093	0.0000
48	15.1494	0.0000
49	14.5511	0.0000
50	14.4486	0.0000
51	14.4460	0.0000
52	14.2582	0.0000
53	14.2287	0.0000
54	14.0408	0.0000
55	13.3653	0.0000
56	12.6935	0.0000
57	12.3759	0.0000
58	12.1649	0.0000
59	12.0851	0.0000
60	12.0203	0.0000
61	11.8959	0.0000
62	11.1114	0.0000
63	10.6974	0.0000
64	10.4724	0.0000
65	10.0477	0.0000
66	9.9772	0.0000
67	9.8699	0.0000
68	9.8497	0.0000
69	9.8169	0.0000
70	9.7728	0.0000
71	9.6795	0.0000
72	9.6063	0.0000
73	9.5297	0.0000
74	9.2813	0.0000
75	9.2245	0.0000
76	9.0458	0.0000
77	9.0442	0.0000
78	8.8167	0.0000
79	8.7634	0.0000
80	8.6914	0.0000
81	8.6343	0.0000
82	8.4400	0.0000
83	8.1594	0.0000
84	8.0462	0.0000
85	8.0351	0.0000
86	7.9177	0.0000
87	7.8778	0.0000
88	7.7495	0.0000
89	7.5670	0.0000
90	7.4996	0.0000
91	7.4949	0.0000
92	7.4485	0.0000
93	7.2023	0.0000
94	7.1209	0.0000
95	7.0316	0.0000
96	7.0221	0.0000
97	6.9501	0.0000
98	6.8783	0.0000
99	6.8739	0.0000

100	6.8494	0.0000
101	6.8321	0.0000
102	6.8264	0.0000
103	6.7636	0.0000
104	6.6703	0.0000
105	6.6692	0.0000
106	6.6022	0.0000
107	6.5422	0.0000
108	6.4785	0.0000
109	6.4237	0.0000
110	6.3999	0.0000
111	6.3135	0.0000
112	6.2460	0.0000
113	6.0841	0.0000
114	5.9555	0.0000
115	5.9305	0.0000
116	5.8765	0.0000
117	5.8631	0.0000
118	5.8265	0.0000
119	5.8080	0.0000
120	5.8054	0.0000
121	5.6331	0.0000
122	5.5632	0.0000
123	5.4370	0.0000
124	5.3821	0.0000
125	5.2706	0.0000
126	4.9766	0.0000
127	4.9760	0.0000
128	4.9015	0.0000
129	4.8297	0.0000
130	4.7881	0.0000
131	4.7176	0.0000
132	4.6524	0.0000
133	4.5602	0.0000
134	4.5358	0.0000
135	4.5146	0.0000
136	4.4764	0.0000
137	4.4486	0.0000
138	4.4460	0.0000
139	4.3984	0.0000
140	4.2645	0.0000
141	4.2498	0.0000
142	4.2333	0.0000
143	4.1134	0.0000
144	4.0452	0.0000
145	3.8650	0.0000
146	3.8025	0.0000
147	3.7072	0.0000
148	3.6252	0.0000
149	3.3602	0.0000
150	3.3581	0.0000
151	3.1587	0.0000
152	3.1562	0.0000
153	3.1436	0.0000
154	3.0717	0.0000
155	2.8726	0.0000
156	2.2190	0.0000

157	2.1836	0.0000
158	2.0622	0.0000

Stream Protection Duration
POC #2
The Facility PASSED

The Facility PASSED.

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
4.7270	21074	5	0	Pass
5.2602	15174	3	0	Pass
5.7934	11041	3	0	Pass
6.3266	7806	2	0	Pass
6.8599	5656	1	0	Pass
7.3931	4265	0	0	Pass
7.9263	3345	0	0	Pass
8.4595	2653	0	0	Pass
8.9927	2048	0	0	Pass
9.5260	1494	0	0	Pass
10.0592	1178	0	0	Pass
10.5924	947	0	0	Pass
11.1256	758	0	0	Pass
11.6588	624	0	0	Pass
12.1920	508	0	0	Pass
12.7253	404	0	0	Pass
13.2585	331	0	0	Pass
13.7917	284	0	0	Pass
14.3249	245	0	0	Pass
14.8581	229	0	0	Pass
15.3914	210	0	0	Pass
15.9246	196	0	0	Pass
16.4578	187	0	0	Pass
16.9910	172	0	0	Pass
17.5242	157	0	0	Pass
18.0574	152	0	0	Pass
18.5907	145	0	0	Pass
19.1239	132	0	0	Pass
19.6571	125	0	0	Pass
20.1903	122	0	0	Pass
20.7235	114	0	0	Pass
21.2568	105	0	0	Pass
21.7900	100	0	0	Pass
22.3232	98	0	0	Pass
22.8564	93	0	0	Pass
23.3896	88	0	0	Pass
23.9228	85	0	0	Pass
24.4561	83	0	0	Pass
24.9893	73	0	0	Pass
25.5225	66	0	0	Pass
26.0557	64	0	0	Pass
26.5889	61	0	0	Pass
27.1222	57	0	0	Pass
27.6554	54	0	0	Pass
28.1886	51	0	0	Pass
28.7218	50	0	0	Pass

29.2550	45	0	0	Pass
29.7882	41	0	0	Pass
30.3215	40	0	0	Pass
30.8547	39	0	0	Pass
31.3879	38	0	0	Pass
31.9211	38	0	0	Pass
32.4543	38	0	0	Pass
32.9875	36	0	0	Pass
33.5208	34	0	0	Pass
34.0540	31	0	0	Pass
34.5872	30	0	0	Pass
35.1204	29	0	0	Pass
35.6536	29	0	0	Pass
36.1869	28	0	0	Pass
36.7201	28	0	0	Pass
37.2533	28	0	0	Pass
37.7865	28	0	0	Pass
38.3197	26	0	0	Pass
38.8529	26	0	0	Pass
39.3862	22	0	0	Pass
39.9194	22	0	0	Pass
40.4526	21	0	0	Pass
40.9858	19	0	0	Pass
41.5190	19	0	0	Pass
42.0523	19	0	0	Pass
42.5855	18	0	0	Pass
43.1187	18	0	0	Pass
43.6519	18	0	0	Pass
44.1851	16	0	0	Pass
44.7183	16	0	0	Pass
45.2516	16	0	0	Pass
45.7848	16	0	0	Pass
46.3180	16	0	0	Pass
46.8512	15	0	0	Pass
47.3844	15	0	0	Pass
47.9177	15	0	0	Pass
48.4509	15	0	0	Pass
48.9841	15	0	0	Pass
49.5173	15	0	0	Pass
50.0505	15	0	0	Pass
50.5837	15	0	0	Pass
51.1170	12	0	0	Pass
51.6502	12	0	0	Pass
52.1834	10	0	0	Pass
52.7166	10	0	0	Pass
53.2498	10	0	0	Pass
53.7831	10	0	0	Pass
54.3163	10	0	0	Pass
54.8495	10	0	0	Pass
55.3827	9	0	0	Pass
55.9159	9	0	0	Pass
56.4491	9	0	0	Pass
56.9824	9	0	0	Pass
57.5156	9	0	0	Pass

Water Quality BMP Flow and Volume for POC #2
On-line facility volume: 8.5564 **acre-feet**
On-line facility target flow: 4.7648 **cfs.**
Adjusted for 15 min: 4.7648 **cfs.**
Off-line facility target flow: 2.6759 **cfs.**
Adjusted for 15 min: 2.6759 **cfs.**

LID Report

LID Technique	Used for Water Quality Treatment?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft.)	Cumulative Infiltration Credit	Percent Volume Infiltrated	Water Quality Percent Treated	Comment
Infilt Pond D POC	N	28458.60			N	100.00		
Total Volume Infiltrated		28458.60	0.00	0.00		100.00	0.00	0% No Treat. Credit

Compliance with LID Standard 8
Duration Analysis Result = Passed

POC #3 was not reported because POC must exist in both scenarios and both scenarios must have been run.**Perlnd and Implnd Changes**
No changes have been made.

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WWHM2012
PROJECT REPORT

Project Name: Basin E GW
Site Name: Pioneer Aggregates
Site Address: Pioneer Avenue
City : DuPont
Report Date: 11/25/2020
Gage : 38 IN CENTRAL
Data Start : 10/01/1901
Data End : 09/30/2059
Precip Scale: 1.00
Version Date: 2019/09/13
Version : 4.2.17

Low Flow Threshold for POC 1 : 50 Percent of the 2 Year

High Flow Threshold for POC 1: 50 year

PREDEVELOPED LAND USE

Name : Basin E Pre
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Lawn, Flat	3.5
A B, Lawn, Steep	72.1
C, Lawn, Flat	12.7
SAT, Forest, Flat	4.3
Pervious Total	92.6

Impervious Land Use	acre
Impervious Total	0
Basin Total	92.6

Element Flows To:

Surface	Interflow	Groundwater

MITIGATED LAND USE

Name : Watershed E
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Lawn, Flat	3.5
A B, Lawn, Steep	72.1
C, Lawn, Flat	12.7
SAT, Forest, Flat	4.3
Pervious Total	92.6

Impervious Land Use	acre
Impervious Total	0
Basin Total	92.6

Element Flows To:

Surface	Interflow	Groundwater
Trapezoidal Pond 3	Trapezoidal Pond 3	

Name : Trapezoidal Pond 3
Bottom Length: 600.00 ft.
Bottom Width: 96.00 ft.
Depth: 7 ft.
Volume at riser head: 9.8477 acre-feet.
Infiltration On
Infiltration rate: 8.1
Infiltration safety factor: 1
Wetted surface area On
Total Volume Infiltrated (ac-ft.): 1091797
Total Volume Through Riser (ac-ft.): 0
Total Volume Through Facility (ac-ft.): 1091797
Percent Infiltrated: 100
Total Precip Applied to Facility: 0
Total Evap From Facility: 0
Side slope 1: 3 To 1
Side slope 2: 3 To 1
Side slope 3: 3 To 1
Side slope 4: 3 To 1
Discharge Structure
Riser Height: 6 ft.
Riser Diameter: 24 in.

Element Flows To:

Outlet 1	Outlet 2

Pond Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
0.0000	1.322	0.000	0.000	0.000
0.0778	1.329	0.103	0.000	10.86
0.1556	1.337	0.206	0.000	10.92
0.2333	1.344	0.311	0.000	10.98
0.3111	1.352	0.416	0.000	11.04
0.3889	1.359	0.521	0.000	11.10
0.4667	1.367	0.627	0.000	11.16
0.5444	1.374	0.734	0.000	11.22
0.6222	1.382	0.841	0.000	11.29
0.7000	1.389	0.949	0.000	11.35
0.7778	1.397	1.057	0.000	11.41
0.8556	1.404	1.166	0.000	11.47
0.9333	1.412	1.276	0.000	11.53
1.0111	1.420	1.386	0.000	11.59
1.0889	1.427	1.497	0.000	11.66
1.1667	1.435	1.608	0.000	11.72
1.2444	1.442	1.720	0.000	11.78
1.3222	1.450	1.832	0.000	11.84
1.4000	1.458	1.945	0.000	11.90
1.4778	1.465	2.059	0.000	11.97
1.5556	1.473	2.174	0.000	12.03
1.6333	1.481	2.288	0.000	12.09
1.7111	1.488	2.404	0.000	12.16
1.7889	1.496	2.520	0.000	12.22
1.8667	1.504	2.637	0.000	12.28
1.9444	1.511	2.754	0.000	12.34
2.0222	1.519	2.872	0.000	12.41
2.1000	1.527	2.990	0.000	12.47
2.1778	1.535	3.109	0.000	12.53
2.2556	1.542	3.229	0.000	12.60
2.3333	1.550	3.349	0.000	12.66
2.4111	1.558	3.470	0.000	12.72
2.4889	1.566	3.592	0.000	12.79
2.5667	1.573	3.714	0.000	12.85
2.6444	1.581	3.837	0.000	12.91
2.7222	1.589	3.960	0.000	12.98
2.8000	1.597	4.084	0.000	13.04
2.8778	1.605	4.208	0.000	13.10
2.9556	1.612	4.334	0.000	13.17
3.0333	1.620	4.459	0.000	13.23
3.1111	1.628	4.586	0.000	13.30
3.1889	1.636	4.713	0.000	13.36
3.2667	1.644	4.840	0.000	13.43
3.3444	1.652	4.968	0.000	13.49
3.4222	1.660	5.097	0.000	13.55
3.5000	1.668	5.227	0.000	13.62
3.5778	1.675	5.357	0.000	13.68
3.6556	1.683	5.487	0.000	13.75
3.7333	1.691	5.619	0.000	13.81
3.8111	1.699	5.751	0.000	13.88
3.8889	1.707	5.883	0.000	13.94
3.9667	1.715	6.016	0.000	14.01
4.0444	1.723	6.150	0.000	14.07
4.1222	1.731	6.284	0.000	14.14
4.2000	1.739	6.419	0.000	14.20
4.2778	1.747	6.555	0.000	14.27

4.3556	1.755	6.691	0.000	14.33
4.4333	1.763	6.828	0.000	14.40
4.5111	1.771	6.965	0.000	14.47
4.5889	1.779	7.104	0.000	14.53
4.6667	1.787	7.242	0.000	14.60
4.7444	1.795	7.382	0.000	14.66
4.8222	1.803	7.522	0.000	14.73
4.9000	1.811	7.662	0.000	14.79
4.9778	1.820	7.803	0.000	14.86
5.0556	1.828	7.945	0.000	14.93
5.1333	1.836	8.088	0.000	14.99
5.2111	1.844	8.231	0.000	15.06
5.2889	1.852	8.375	0.000	15.13
5.3667	1.860	8.519	0.000	15.19
5.4444	1.868	8.664	0.000	15.26
5.5222	1.876	8.810	0.000	15.33
5.6000	1.885	8.956	0.000	15.39
5.6778	1.893	9.103	0.000	15.46
5.7556	1.901	9.251	0.000	15.53
5.8333	1.909	9.399	0.000	15.59
5.9111	1.917	9.548	0.000	15.66
5.9889	1.926	9.697	0.000	15.73
6.0667	1.934	9.847	0.365	15.79
6.1444	1.942	9.998	1.161	15.86
6.2222	1.950	10.15	2.205	15.93
6.3000	1.959	10.30	3.421	16.00
6.3778	1.967	10.45	4.745	16.06
6.4556	1.975	10.60	6.112	16.13
6.5333	1.983	10.76	7.456	16.20
6.6111	1.992	10.91	8.711	16.27
6.6889	2.000	11.07	9.823	16.33
6.7667	2.008	11.22	10.75	16.40
6.8444	2.017	11.38	11.48	16.47
6.9222	2.025	11.54	12.02	16.54
7.0000	2.033	11.69	12.46	16.61
7.0778	2.042	11.85	13.07	16.68

Name : Groundwater
Time Series number 400 is connected to:

Element Flows To:
Outlet 1 **Outlet 2**
Trapezoidal Pond 3

ANALYSIS RESULTS

Stream Protection Duration

Predeveloped Landuse Totals for POC #1
Total Pervious Area:92.6

Total Impervious Area:0

Mitigated Landuse Totals for POC #1
Total Pervious Area:92.6
Total Impervious Area:0

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	0.694472
5 year	1.66554
10 year	2.813589
25 year	5.188279
50 year	7.936065
100 year	11.870051

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0
5 year	0
10 year	0
25 year	0
50 year	0
100 year	0

Stream Protection Duration
Annual Peaks for Predeveloped and Mitigated. POC #1

Year	Predeveloped	Mitigated
1902	0.422	0.000
1903	0.344	0.000
1904	2.209	0.000
1905	0.399	0.000
1906	0.155	0.000
1907	1.106	0.000
1908	0.457	0.000
1909	0.639	0.000
1910	1.746	0.000
1911	0.792	0.000
1912	21.409	0.000
1913	0.870	0.000
1914	3.061	0.000
1915	0.347	0.000
1916	0.654	0.000
1917	0.215	0.000
1918	0.519	0.000
1919	0.392	0.000
1920	0.782	0.000
1921	0.601	0.000
1922	1.760	0.000
1923	0.892	0.000
1924	0.305	0.000
1925	0.344	0.000
1926	0.536	0.000
1927	0.323	0.000
1928	0.407	0.000

1929	2.441	0.000
1930	0.424	0.000
1931	0.436	0.000
1932	0.432	0.000
1933	0.512	0.000
1934	6.870	0.000
1935	0.403	0.000
1936	0.500	0.000
1937	1.364	0.000
1938	0.463	0.000
1939	0.161	0.000
1940	0.532	0.000
1941	0.249	0.000
1942	1.173	0.000
1943	0.548	0.000
1944	1.641	0.000
1945	0.514	0.000
1946	0.956	0.000
1947	0.253	0.000
1948	0.945	0.000
1949	0.947	0.000
1950	0.314	0.000
1951	0.307	0.000
1952	5.349	0.000
1953	3.215	0.000
1954	0.428	0.000
1955	0.335	0.000
1956	0.199	0.000
1957	0.541	0.000
1958	6.176	0.000
1959	5.202	0.000
1960	0.314	0.000
1961	3.901	0.000
1962	0.472	0.000
1963	0.284	0.000
1964	2.773	0.000
1965	3.175	0.000
1966	0.321	0.000
1967	1.279	0.000
1968	0.515	0.000
1969	0.479	0.000
1970	1.122	0.000
1971	1.544	0.000
1972	4.786	0.000
1973	1.154	0.000
1974	2.271	0.000
1975	3.088	0.000
1976	1.880	0.000
1977	0.219	0.000
1978	5.034	0.000
1979	0.600	0.000
1980	1.310	0.000
1981	0.430	0.000
1982	0.282	0.000
1983	0.920	0.000
1984	0.934	0.000
1985	1.721	0.000

1986	0.451	0.000
1987	1.370	0.000
1988	0.474	0.000
1989	0.476	0.000
1990	0.572	0.000
1991	1.181	0.000
1992	1.981	0.000
1993	1.047	0.000
1994	1.154	0.000
1995	0.296	0.000
1996	3.899	0.000
1997	0.422	0.000
1998	0.986	0.000
1999	0.289	0.000
2000	0.517	0.000
2001	0.314	0.000
2002	2.726	0.000
2003	0.648	0.000
2004	0.911	0.000
2005	8.312	0.000
2006	0.415	0.000
2007	0.681	0.000
2008	0.513	0.000
2009	0.335	0.000
2010	0.458	0.000
2011	0.229	0.000
2012	0.590	0.000
2013	0.800	0.000
2014	0.422	0.000
2015	2.610	0.000
2016	0.203	0.000
2017	0.955	0.000
2018	6.725	0.000
2019	4.625	0.000
2020	1.171	0.000
2021	1.569	0.000
2022	0.471	0.000
2023	0.769	0.000
2024	8.879	0.000
2025	0.456	0.000
2026	0.943	0.000
2027	0.402	0.000
2028	0.279	0.000
2029	0.789	0.000
2030	2.756	0.000
2031	0.302	0.000
2032	0.222	0.000
2033	0.291	0.000
2034	0.387	0.000
2035	1.379	0.000
2036	0.785	0.000
2037	0.253	0.000
2038	1.637	0.000
2039	0.152	0.000
2040	0.391	0.000
2041	0.478	0.000
2042	1.236	0.000

2043	1.078	0.000
2044	2.978	0.000
2045	0.461	0.000
2046	0.530	0.000
2047	0.428	0.000
2048	0.491	0.000
2049	0.625	0.000
2050	0.631	0.000
2051	1.624	0.000
2052	0.330	0.000
2053	0.486	0.000
2054	2.995	0.000
2055	0.346	0.000
2056	0.256	0.000
2057	0.394	0.000
2058	0.479	0.000
2059	4.711	0.000

Stream Protection Duration
Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	21.4094	0.0000
2	8.8787	0.0000
3	8.3120	0.0000
4	6.8704	0.0000
5	6.7252	0.0000
6	6.1764	0.0000
7	5.3485	0.0000
8	5.2023	0.0000
9	5.0335	0.0000
10	4.7860	0.0000
11	4.7110	0.0000
12	4.6246	0.0000
13	3.9014	0.0000
14	3.8987	0.0000
15	3.2147	0.0000
16	3.1751	0.0000
17	3.0876	0.0000
18	3.0614	0.0000
19	2.9947	0.0000
20	2.9781	0.0000
21	2.7732	0.0000
22	2.7561	0.0000
23	2.7264	0.0000
24	2.6097	0.0000
25	2.4414	0.0000
26	2.2706	0.0000
27	2.2091	0.0000
28	1.9806	0.0000
29	1.8805	0.0000
30	1.7598	0.0000
31	1.7465	0.0000
32	1.7205	0.0000
33	1.6411	0.0000
34	1.6368	0.0000
35	1.6236	0.0000

36	1.5692	0.0000
37	1.5440	0.0000
38	1.3790	0.0000
39	1.3702	0.0000
40	1.3637	0.0000
41	1.3103	0.0000
42	1.2793	0.0000
43	1.2355	0.0000
44	1.1814	0.0000
45	1.1732	0.0000
46	1.1709	0.0000
47	1.1540	0.0000
48	1.1538	0.0000
49	1.1223	0.0000
50	1.1055	0.0000
51	1.0782	0.0000
52	1.0465	0.0000
53	0.9860	0.0000
54	0.9556	0.0000
55	0.9546	0.0000
56	0.9466	0.0000
57	0.9454	0.0000
58	0.9428	0.0000
59	0.9338	0.0000
60	0.9199	0.0000
61	0.9109	0.0000
62	0.8924	0.0000
63	0.8699	0.0000
64	0.8001	0.0000
65	0.7922	0.0000
66	0.7890	0.0000
67	0.7853	0.0000
68	0.7816	0.0000
69	0.7695	0.0000
70	0.6807	0.0000
71	0.6538	0.0000
72	0.6477	0.0000
73	0.6389	0.0000
74	0.6309	0.0000
75	0.6251	0.0000
76	0.6011	0.0000
77	0.5999	0.0000
78	0.5899	0.0000
79	0.5717	0.0000
80	0.5483	0.0000
81	0.5405	0.0000
82	0.5358	0.0000
83	0.5318	0.0000
84	0.5302	0.0000
85	0.5191	0.0000
86	0.5171	0.0000
87	0.5151	0.0000
88	0.5143	0.0000
89	0.5127	0.0000
90	0.5122	0.0000
91	0.4998	0.0000
92	0.4915	0.0000

93	0.4862	0.0000
94	0.4794	0.0000
95	0.4792	0.0000
96	0.4776	0.0000
97	0.4759	0.0000
98	0.4742	0.0000
99	0.4718	0.0000
100	0.4713	0.0000
101	0.4629	0.0000
102	0.4608	0.0000
103	0.4584	0.0000
104	0.4566	0.0000
105	0.4561	0.0000
106	0.4511	0.0000
107	0.4364	0.0000
108	0.4317	0.0000
109	0.4305	0.0000
110	0.4285	0.0000
111	0.4277	0.0000
112	0.4236	0.0000
113	0.4222	0.0000
114	0.4218	0.0000
115	0.4216	0.0000
116	0.4151	0.0000
117	0.4072	0.0000
118	0.4033	0.0000
119	0.4024	0.0000
120	0.3992	0.0000
121	0.3940	0.0000
122	0.3919	0.0000
123	0.3911	0.0000
124	0.3872	0.0000
125	0.3469	0.0000
126	0.3465	0.0000
127	0.3445	0.0000
128	0.3440	0.0000
129	0.3351	0.0000
130	0.3348	0.0000
131	0.3297	0.0000
132	0.3228	0.0000
133	0.3213	0.0000
134	0.3139	0.0000
135	0.3138	0.0000
136	0.3138	0.0000
137	0.3066	0.0000
138	0.3054	0.0000
139	0.3020	0.0000
140	0.2963	0.0000
141	0.2907	0.0000
142	0.2892	0.0000
143	0.2844	0.0000
144	0.2815	0.0000
145	0.2794	0.0000
146	0.2564	0.0000
147	0.2530	0.0000
148	0.2527	0.0000
149	0.2494	0.0000

150	0.2290	0.0000
151	0.2219	0.0000
152	0.2188	0.0000
153	0.2150	0.0000
154	0.2027	0.0000
155	0.1985	0.0000
156	0.1609	0.0000
157	0.1552	0.0000
158	0.1521	0.0000

Stream Protection Duration
POC #1
The Facility PASSED

The Facility PASSED.

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.3472	19041	0	0	Pass
0.4239	9872	0	0	Pass
0.5005	5518	0	0	Pass
0.5772	3457	0	0	Pass
0.6539	2213	0	0	Pass
0.7305	1451	0	0	Pass
0.8072	1034	0	0	Pass
0.8838	745	0	0	Pass
0.9605	558	0	0	Pass
1.0371	456	0	0	Pass
1.1138	381	0	0	Pass
1.1904	332	0	0	Pass
1.2671	306	0	0	Pass
1.3437	275	0	0	Pass
1.4204	253	0	0	Pass
1.4971	230	0	0	Pass
1.5737	213	0	0	Pass
1.6504	197	0	0	Pass
1.7270	178	0	0	Pass
1.8037	161	0	0	Pass
1.8803	155	0	0	Pass
1.9570	146	0	0	Pass
2.0336	138	0	0	Pass
2.1103	134	0	0	Pass
2.1870	126	0	0	Pass
2.2636	119	0	0	Pass
2.3403	110	0	0	Pass
2.4169	105	0	0	Pass
2.4936	99	0	0	Pass
2.5702	95	0	0	Pass
2.6469	91	0	0	Pass
2.7235	89	0	0	Pass
2.8002	84	0	0	Pass
2.8768	83	0	0	Pass
2.9535	81	0	0	Pass
3.0302	78	0	0	Pass
3.1068	76	0	0	Pass
3.1835	72	0	0	Pass
3.2601	68	0	0	Pass

3.3368	66	0	0	Pass
3.4134	65	0	0	Pass
3.4901	62	0	0	Pass
3.5667	61	0	0	Pass
3.6434	58	0	0	Pass
3.7200	55	0	0	Pass
3.7967	55	0	0	Pass
3.8734	55	0	0	Pass
3.9500	52	0	0	Pass
4.0267	51	0	0	Pass
4.1033	48	0	0	Pass
4.1800	46	0	0	Pass
4.2566	43	0	0	Pass
4.3333	41	0	0	Pass
4.4099	37	0	0	Pass
4.4866	37	0	0	Pass
4.5633	34	0	0	Pass
4.6399	31	0	0	Pass
4.7166	28	0	0	Pass
4.7932	26	0	0	Pass
4.8699	25	0	0	Pass
4.9465	24	0	0	Pass
5.0232	24	0	0	Pass
5.0998	22	0	0	Pass
5.1765	22	0	0	Pass
5.2531	21	0	0	Pass
5.3298	18	0	0	Pass
5.4065	17	0	0	Pass
5.4831	17	0	0	Pass
5.5598	17	0	0	Pass
5.6364	17	0	0	Pass
5.7131	17	0	0	Pass
5.7897	17	0	0	Pass
5.8664	17	0	0	Pass
5.9430	17	0	0	Pass
6.0197	15	0	0	Pass
6.0963	15	0	0	Pass
6.1730	14	0	0	Pass
6.2497	11	0	0	Pass
6.3263	11	0	0	Pass
6.4030	11	0	0	Pass
6.4796	11	0	0	Pass
6.5563	11	0	0	Pass
6.6329	11	0	0	Pass
6.7096	11	0	0	Pass
6.7862	9	0	0	Pass
6.8629	9	0	0	Pass
6.9396	8	0	0	Pass
7.0162	8	0	0	Pass
7.0929	8	0	0	Pass
7.1695	8	0	0	Pass
7.2462	8	0	0	Pass
7.3228	8	0	0	Pass
7.3995	8	0	0	Pass
7.4761	8	0	0	Pass
7.5528	8	0	0	Pass
7.6294	8	0	0	Pass

7.7061	8	0	0	Pass
7.7828	8	0	0	Pass
7.8594	8	0	0	Pass
7.9361	8	0	0	Pass

Water Quality BMP Flow and Volume for POC #1
On-line facility volume: 7.31 **acre-feet**
On-line facility target flow: 4.0677 **cfs.**
Adjusted for 15 min: 4.0677 **cfs.**
Off-line facility target flow: 2.2884 **cfs.**
Adjusted for 15 min: 2.2884 **cfs.**

LID Report

LID Technique	Used for Water Quality	Total Volume Percent Treatment?	Volume Needs Treatment (ac-ft)	Infiltration Through Facility (ac-ft)	Cumulative Volume Infiltration (ac-ft.)	Comment
Trapezoidal Pond 3	POC	N	993535.27			N
100.00						
Total Volume Infiltrated			993535.27	0.00	0.00	
100.00	0.00	0%	No Treat. Credit			

Compliance with LID Standard 8
Duration Analysis Result = Passed

POC #2 was not reported because POC must exist in both scenarios and both scenarios must have been run. POC #3 was not reported because POC must exist in both scenarios and both scenarios must have been run.**Perlnd and Implnd Changes**
No changes have been made.

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APPENDIX D

Stormwater Design Calculations

Table 1. Wetpond Design Summary

Project No. 040010-016-01, CalPortland
Pioneer Aggregates South Parcel Project, DuPont, WA

Basin C WQ Pond										
Required Pond Volume	6.08	ac-ft								
Required Pond Volume	264844.8	cu ft								
Number of Ponds Wanted:	1									
Total Volume Required Per Pond:	264,845	cu ft								
Pond Design Based on Number of Pond Wanted:										
% Total Volume for Cell 1	0.3									
Total Volume for Cell 1	79,453	cu ft								
Depth Cell 1	6	ft	Length to Width Ratio:	3	Length:	162	ft	Total Bottom Area:	8,748	sq ft
Side Slopes XH:1V	3				Width:	54	ft	Total Top Area:	17,820	sq ft
								Volume Calculated:	79,704	Good? YES
Total Volume Required for Cell 2	185,391.4	cu ft								
Depth Cell 2	7	ft	Length to Width Ratio:	3.00	Length:	240	ft	Total Bottom Area:	19,200	sq ft
Side Slopes XH:1V	3				Width:	80	ft	Total Top Area:	34,404	sq ft
								Volume Calculated:	187,614	Good? YES
Basin D WQ Pond										
Required Pond Volume	8.55	ac-ft								
Required Pond Volume	372,438	cu ft								
Number of Ponds Wanted:	1									
Total Volume Required Per Pond:	372,438	cu ft								
Pond Design Based on Number of Pond Wanted:										
% Total Volume for Cell 1	0.3									
Total Volume for Cell 1	111,731	cu ft								
Depth Cell 1	6	ft	Length to Width Ratio:	3.03	Length:	200	ft	Total Bottom Area:	13,200	sq ft
Side Slopes XH:1V	3				Width:	66.0	ft	Total Top Area:	24,072	sq ft
								Volume Calculated:	111,816	Good? YES
Total Volume Required for Cell 2	260,706.6	cu ft								
Depth Cell 2	7	ft	Length to Width Ratio:	3.16	Length:	300	ft	Total Bottom Area:	28,500	sq ft
Side Slopes XH:1V	3				Width:	95	ft	Total Top Area:	46,854	sq ft
								Volume Calculated:	263,739	Good? YES

Notes

Yellow shading represents user input

Gray shading prepresents volume check for capacity

ac = acres, ac-ft = acre-feet, cu ft = cubic feet, ft = feet, sq ft = square feet

Table 2. Infiltration Calculations

Project No. 040010-016-01 CalPortland
Pioneer Aggregates South Parcel Project, DuPont,WA

Infiltration Pond C		Boring	15	15		18	18		
Original Ground Elevation	200	depth	168-178	178-188		168-778	178-188		
Existing Surface	25	D10	0.297	0.297		0.594	0.297		
Depth (bgs)	175	D60	12.7	9.525		12.7	4.75		
Analysis depth	12.5	D90	38.1	38.1		38.1	25.4		
		Fines	0.02	0.03		0.02	0.02		
	log (Ksat)		-1.35	-1.42		-0.79	-1.31		
	Ksat	cm/sec	0.04	0.04		0.16	0.05		
		in/hr	63.31	54.34		228.83	69.68		
			2.5 feet	10 feet		2.5	10		
		KsatAvg	55.92			KsatAvg	80.94		
	CFv	1	0.5	0.33	CFv	1	0.5	0.33	
	Correction Factor	0.36	0.18	0.1188		0.36	0.18	0.12	
	Ksat (in/hr)	20.132	10.066	6.644		29.140	14.570	9.62	8.13
								Ksat Final	8.1
Infiltration Pond D		Boring	8	8		7	7		
Original Ground Elevation	200	depth	168-178	178-188		168-180	180-185		
Existing Surface	25	D10	0.15	0.297		0.297	0.297		
Depth (bgs)	175	D60	4.75	12.7		9.525	12.7		
Analysis depth	12.5	D90	12.7	38.1		25.4	25.4		
		Fines	0.08	0.03		0.02	0.03		
	log (Ksat)		-1.53	-1.37		-1.23	-1.21		
	Ksat	cm/sec	0.03	0.04		0.06	0.06		
		in/hr	41.36	60.84		83.37	86.58		
		depth (ft)	2.5	10		5.0	7.5		
	KsatAvg	55.6033				KsatAvg	85.268		
	CFv	1	0.5	0.33	CFv	1	0.5	0.33	
	Correction Factor	0.36	0.18	0.1188		0.36	0.18	0.12	
	Ksat Design (in/hr)	20.02	10.01	6.61		30.70	15.35	10.13	8.37
								Ksat Final	8.2

Notes

Purple shading represents boring numbers

Pink shading represents Infiltration capacity calculations

bgs = below ground surface, cm/sec = centimeters per second, in/hr = inches per hour

Table 3. Infiltration Basin Design Summary

Project No. 040010-016-01, CalPortland
Pioneer Aggregates South Parcel Project, DuPont, WA

Basin C Designed Infiltration Pond:				
Length of bottom area (ft)	450			
Width of bottom area (ft)	113	Total Bottom Area:	50,762 sq ft	
Depth (ft)	5			
Side Slope X:1V	3	Total Top Area:	66,748 sq ft	(no freeboard - water surface)
Total Provided Volume (cu ft)	293,775			
Basin D Designed Infiltration Pond:				
Length of bottom area (ft)	1000			
Width of bottom area (ft)	37.7	Total Bottom Area:	37,655 sq ft	37655
Depth (ft)	5			
Side Slope X:1V	3	Total Top Area:	68,755 sq ft	(no freeboard - water surface)
Total Provided Volume (cu ft)	266,025			68755
Basin E Designed Infiltration Pond:				
Length of bottom area (ft)	600			
Width of bottom area (ft)	96.345	Total Bottom Area:	57,807 sq ft	
Depth (ft)	6			
Side Slope X:1V	3	Total Top Area:	82,120 sq ft	(no freeboard - water surface)
Total Provided Volume (cu ft)	419,781			

Appendix E

Groundwater Model Update

GROUNDWATER MODEL UPDATE

DuPont Mine South Parcel Expansion Area

Project No. 040001-014 • June 2017

Aspect CONSULTING

earth + water

GROUNDWATER MODEL UPDATE

DuPont Mine South Parcel Expansion Area

Project No. 040001-014 • June 2017

Aspect Consulting, LLC

Steve Germiat, LHG
Principal Hydrogeologist
sgermiat@aspectconsulting.com

Peter Bannister, PE
Associate Groundwater Resources Engineer
pbannister@aspectconsulting.com

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1 Introduction

This report documents the updated analysis used to predict groundwater levels during and after the proposed dewatering and mining of the South Parcel at CalPortland's Pioneer Aggregate facility in DuPont, Washington.

The South Parcel is a proposed 171-acre mining expansion located west of the existing mine and south of the processing area (see Figure 1). Groundwater saturates the gravels of the South Parcel to within 20 feet of the ground surface. Mining will require pumping groundwater to dewater the gravels that are currently saturated. Dewatering and removal of the gravel will result in localized changes in groundwater elevations around the South Parcel.

The foundation of the groundwater analysis is a numerical groundwater model (DuPont model) developed specifically for the project. The DuPont model is based on the conceptual model for the groundwater system developed from extensive analysis of project-specific borings and investigations, as well as compilation and review of other geologic and hydrogeologic investigations in the DuPont area. After development, the model was calibrated to historically observed groundwater levels, then validated against additional historical data. Once the model was able to reliably reproduce historical conditions, the calibrated and validated model was then used to predict the changes in groundwater levels during and after the proposed expansion of mining.

This model represents an update to previous groundwater modeling analysis developed for the South Parcel (CH2M Hill 2003, Aspect 2004a, Aspect 2009a, Aspect 2009b, and Aspect 2014). It incorporates revisions to the mining plan, expansion of the model area, inclusion of seasonal and annual variability in climate and groundwater levels, and elements of the USGS groundwater model for the Chambers-Clover Creek watershed, including model boundary conditions and hydrogeologic layers at depth (Savoca et al., 2010; Johnson et al., 2011).

The model was first developed and calibrated to match existing measured conditions between 2004 and 2010, and then validated to the monitoring data collected through 2015. The model simulation of existing conditions formed the baseline from which changes in future groundwater levels under proposed scenarios can be measured. The model was then used in a series of predictive runs to simulate groundwater conditions at four different steps of dewatering during the proposed mining plan.

This report is organized into the following sections to reflect the process of model development, calibration, and use:

- Section 2 summarizes the groundwater modeling process.
- Section 3 presents a summary of the hydrogeologic conceptual model.
- Section 4 describes the model setup.
- Section 5 describes the model calibration and validation.

- Section 6 describes the DuPont model predictive analysis.
- Section 7 presents model predictions for future mining conditions.

2 Overview of Groundwater Modeling

This section provides an overview of general groundwater modeling methods and terminology, based on multiple sources (Fetter, 1994; Anderson and Woessner, 1992; Hill and Tiedeman, 2007).

Groundwater models are tools used to simulate and predict what cannot be measured directly. Groundwater models quantitatively simulate groundwater flow and groundwater levels using mathematical equations based on the well-established mechanics of fluid flow in porous media.

Generally, the process of developing and testing a robust groundwater model involves the following steps:

1) Monitor groundwater and surface water levels and compile information about area geology and hydrology from numerous sources.
2) Develop a conceptual model of area hydrogeology by interpreting the existing information.
3) Develop a numerical hydrogeologic model that represents the conceptual model.
4) Calibrate the numerical model to observed groundwater measurements.
5) Validate the numerical model with additional groundwater measurements.
6) Predict future groundwater conditions by simulating anticipated changes (e.g., adding pumping wells or changes in topography).
7) Update the model as new information is collected, and refine the model if necessary.

The foundation of a groundwater model is the “conceptual model” that describes the hydrogeologic system based on data collected during field investigations. The reliability of a groundwater model depends on the appropriate translation of the conceptual model into mathematical terms. For example, natural hydrogeologic systems typically include geologic layers with differing hydraulic characteristics (e.g., hydraulic conductivity, storage coefficient). A numerical groundwater model includes a three-dimensional (3-D) grid of cells. Layers with differing hydraulic parameters can be established within the 3-D model grid to best match the natural geologic layering. The influence of surface water features (e.g., creeks, lakes), and flow between groundwater and surface water, can also be simulated within the numerical groundwater model. Because natural hydrologic systems are always variable (heterogeneous) in both space and time, mathematic models are always simplifications of the natural system.

Groundwater models are evaluated based on how well they can reproduce historical observations. Adjustments to groundwater models are made during calibration to improve the comparison between observed and model-calculated conditions. In addition to the calibration process, there is a validation step that compares observed and model-calculated conditions outside the calibration timeframe. For a calibrated and validated

model, the remaining differences between observed and model-calculated conditions are attributed to model bias and uncertainty, which are quantified using statistics.

Once calibrated and validated, the groundwater model is used to forecast conditions after incorporating anticipated hydrogeologic changes. The results of predictive models are interpreted within the context of the calibrated model bias and uncertainty. Post-modeling evaluation is used to provide more accurate forecasts of groundwater conditions, accounting for model bias to the extent practical, and identifying remaining prediction uncertainty.

The DuPont model is developed to predict groundwater level changes in response to the proposed mining plan, which includes active dewatering to accommodate mining, followed by cessation of pumping and establishment of a new hydrologic equilibrium condition. The results from the DuPont model are used for environmental evaluations and for design of the Monitoring Plan that will be followed during mining to directly measure groundwater level changes and thus allow ongoing assessment of, and adaptive response to, potential impacts. As described in this report, the DuPont model is a robust predictive tool developed based on hydrogeologic measurements collected from 2004 to 2015.

2.1 Model Setup

For three-dimensional, finite-difference groundwater models (like the DuPont model), the simulated aquifer system is digitized into a block of cells, including vertical layers of horizontal grids. Each cell is assigned information on cell dimensions, hydraulic conductivity, aquifer storage, and boundary conditions defined below:

- Cell dimensions are the length, width, and vertical thickness of the cell, which may vary with neighboring cells;
- Hydraulic conductivity describes the rate at which water can move through soils represented by the cell, typically distinguishing the horizontal and vertical values (in stratified soils, hydraulic conductivity is typically higher in the horizontal direction, along bedding, than vertically across the bedding);
- Aquifer storage describes the amount of water that can be stored in (or drained from) soils within the cell, typically distinguishing the confined and unconfined values; and
- Boundary conditions are the assigned mechanisms that result in cell-specific flux of water into or out of the model, and can change over time. Boundary conditions may include recharge from precipitation, groundwater underflow from outside the model domain, infiltration from surface water into the groundwater system, drainage from groundwater to surface water, well discharge, etc. Along the sides of a model domain that are parallel to the regional groundwater flow direction, no-flow boundary conditions can be established in a model; where used, no-flow boundary conditions are positioned far enough from areas within the model domain that are of primary interest for a project so that they do not artificially affect the model simulations in that area.

A “steady-state” model simulates average groundwater flow and levels assuming average hydrologic conditions over a specified time period without a change in aquifer storage –

it does not simulate changes over time. Conversely, a "transient" model simulates changes in aquifer storage, groundwater flow, and groundwater levels over time, based on specified changes in boundary conditions. Transient groundwater models are composed of multiple stress periods, and each boundary condition is specified for the length of each stress period. For example, each monthly stress period may specify a groundwater recharge rate based on the monthly rates of incident precipitation, runoff, and evapotranspiration.

A numerical groundwater model calculates a water balance for each cell within the model. For transient models, the water balance is calculated for each cell in each stress period. Because of the large number of calculations involved, groundwater models rely on numerical methods. These numerical methods allow for some small degree of approximation to provide a solution within a reasonable time. For example, a groundwater model may achieve a solution when the difference between calculated groundwater level changes is less than 0.01 foot, and the change in aquifer storage is less than 0.1 percent of the total calculated water balance.

2.2 Calibration

Model calibration is a standard component of groundwater modeling involving a systematic adjustment of cell-specific values assigned for less certain or spatially variable hydraulic parameters (such as hydraulic conductivity) to yield model-calculated groundwater levels that best match observed groundwater levels and minimize model bias. During calibration, adjusted parameter values should remain within a range that is considered reasonable based on the conceptual model.

When further parameter adjustment does not improve the model calibration, the remaining difference between calculated and observed groundwater levels, also called "residual," is attributed to model bias. The uncertainty in model results are quantified using residual statistics, such as the mean residual, the standard deviation of residuals, and the root mean square error of residuals. These statistics may be applied to the entire set of available data to describe the overall model calibration, or applied to groups of available data to describe spatial and temporal differences in model calibration.

Calibrated model results may be further refined using residual statistics to offset model bias. Deterministic regression methods (e.g., well-specific trend-line analysis) may be used where there is sufficient observation data.

Model bias in a calibrated groundwater model is typically due to a combination of causes. These potential causes of model bias are described below.

Conceptual Model. A groundwater model is a mathematical representation of the conceptual model. Elements missing from the conceptual model are not simulated, and may present as potential model bias during calibration.

Model Discretization. A groundwater model is a collection of cells and stress periods, and the properties within these units are averaged over space and time. The cell size defines the "averaging volume", while the stress period length defines the "averaging period". Differences within an averaging volume or averaging period are not simulated, and may present as potential model bias during calibration.

Assumptions. A groundwater model requires assumptions beyond the available data. For example, a model requires information on subsurface conditions between and beyond a network of wells. Making informed hydrogeologic assumptions based on available data is an important element of the modeling process, and may present as potential model bias during calibration.

2.3 Validation

Model validation involves testing a calibrated model for a set of conditions outside the calibration period. The purpose of model validation is to demonstrate the reliability of model results and analysis.

During groundwater model validation, the cell dimensions, hydraulic conductivity, and aquifer storage parameters remain the same as determined in the calibration process. The boundary conditions are modified to reflect changes in recharge rates, groundwater underflow, and surface water infiltration. Then, the calculated and observed groundwater levels are compared to assess model bias, and model bias is evaluated for consistency between the calibration period and the validation period. If the residual statistics are sufficiently similar, then the model is considered validated for those conditions tested.

2.4 Model Bias and Uncertainty

A groundwater model is necessarily a simplified mathematical representation of complex subsurface physical conditions and does not perfectly represent the real-world groundwater behavior. As such, the use of any model introduces bias and uncertainty that the numeric results are exactly correct.

One measure of the uncertainty of a groundwater model is its ability to reproduce the observed data set used for validation. Systematic differences between observed and calculated conditions are due to model bias. For example, model bias helps explain why groundwater levels are generally calculated higher than observed at a given location, and we can objectively adjust model results to account for model bias. Model uncertainty is defined as the “random” differences between observed and model-calculated conditions. For example, model uncertainty helps explain why groundwater levels were calculated higher than observed during some periods, and lower during others. We don’t attempt to adjust model results for uncertainty, but it helps qualify the results. Model uncertainty can be expressed as a range around a specific model result that we can expect the actual groundwater levels to be within.

Additional uncertainty occurs when the model is used for predicting scenarios outside the range of observed baseline conditions. Some examples are:

- Spatial distance – there is greater uncertainty in model predictions for locations at greater distance from existing wells.
- Climatic conditions – there is greater uncertainty when climate conditions are different from those experienced in the calibration and validation periods.
- Decrease in water levels with dewatering – there is greater uncertainty where the decrease in water levels resulting from dewatering is beyond the range of observed water levels.

2.5 Predictive Analysis

Predictive groundwater models use the calibrated and validated model to forecast groundwater conditions associated with a change in hydrogeologic conditions. Some forecasted conditions, such as groundwater levels, can eventually be measured whereas others, such as surface water infiltration, cannot be directly measured. The results of the calibrated/validated model establish “baseline” conditions, and are compared with results from predictive models. This type of difference analysis is typically sufficient for most groundwater model applications (e.g., Johnson et al, 2011). Predictive model results should be interpreted within the context of model bias and uncertainty to make fully-informed decisions.

Predictive model results may be refined to offset model bias. Modified well-specific trend-line analysis, based on the calibrated and validated model refinement and informed by additional constraints, may be used to improve prediction accuracy. Model uncertainty may be quantified based on the calibrated and validated model residual statistics. When a predictive model calculates conditions outside the range of those observed, the model uncertainty increases.

3 Hydrogeologic Conceptual Model

The conceptual model describes the physical geologic and hydrologic conditions understood to exist around the proposed mine expansion. It forms the basis for the numerical model developed to predict groundwater changes as a result of the proposed mining project.

The following sections describe the conceptual understanding of the surface and groundwater system in the project area as it relates to the groundwater model development and predictive analyses. Figures 1, 2 and 3 provide, respectively, a plan map, geologic map and hydrogeologic cross-section for the project area.

3.1 Vashon Outwash Aquifer

The South Parcel expansion lies within a thick glacial outwash sequence near Puget Sound, just north of the Sequalitchew Creek canyon, and east-southeast of the existing mine (Figure 2). The outwash includes the surficial, coarse-grained Steilacoom Gravel flood deposits, overlying older Vashon outwash; the outwash sequence overlies the low-permeability Olympia Beds (Qob) interglacial unit.

The underlying Qob is absent west of a line (termed Qob Truncation and shown in purple on Figures 1 and 2) located on the order of 1,500 to 3,000 feet inland from the current Puget Sound shoreline. During the time of the Vashon glaciation, the Qob's western extent was the shoreline. The shoreline was extended westward to the current configuration during the waning stages of the Vashon glaciation, when glacial outburst flooding deposited a thick deltaic sequence of Steilacoom Gravels into ancestral Puget Sound. Consequently, Steilacoom Gravels extend from ground surface to below sea level west of the Qob Truncation.

The occurrence/non-occurrence of the Qob creates a unique hydrogeologic condition. Groundwater in the outwash east of the Qob Truncation is held up by the occurrence of the thick, low permeability Qob deposits. The cross section (Figure 3) illustrates the steep hydraulic gradient that occurs where the groundwater drops over this feature within the current mine site. As the groundwater flows westerly over the Qob Truncation, it drops roughly 160 feet in 800 feet (0.2 ft/ft) through the permeable gravels to near sea level. Therefore, the water table is found at relatively shallow depths of 15 to 25 feet in the South Parcel area. West of the Qob Truncation, the water table is found at a depth of roughly 190 feet in the existing mine.

Monitoring of groundwater levels began in 2000 with a series of groundwater monitoring wells installed within and around the South Parcel. Groundwater levels in the Vashon Aquifer typically fluctuate 6 to 8 feet in response to seasonal precipitation patterns and annual variations. However, groundwater levels in the central marsh area fluctuate over a more limited range of 2 to 3 feet, whereas monitoring well CHMW-3S, on the south end of the South Parcel, fluctuates greater than 15 feet of seasonally (Aspect 2007). In addition, monitoring conducted for the adjacent Fort Lewis Landfill 5 and DuPont Works Consent Decree area indicate groundwater level variations on the order of 10 feet (URS 2000; URS 2003).

Five pumping tests were conducted along the east side of the proposed South Parcel mine expansion area to determine hydraulic properties of the outwash aquifer throughout its depth (CH2M Hill, 2000). These testing data, along with studies conducted for Fort Lewis Landfill 5 (Woodward-Clyde Consultants, 1991) and the Former DuPont Works site (URS, 2003), provide baseline hydraulic parameters for the Vashon Aquifer used as a starting point in development of the numerical groundwater flow model.

The surficial Steilacoom Gravels are highly permeable and are known to rapidly infiltrate precipitation and stormwater; the veneer of topsoil covering the Gravels is finer grained (can contain volcanic ash) and thus has lower infiltration capacity. The gravels form a relatively flat outwash plain in the area, in the center of which is a series of large wetlands—referred to as Bell, McKay, Hamer, and Edmond Marshes (Figure 1). These wetlands occur in areas where large ice blocks, stranded during the glacial flood outbursts, later melted forming kettle depressions lined with finer-grained, lower-permeability materials. These features store water for a much longer time relative to the rapidly infiltrating gravel outwash around these features. The wetland sediments from throughout the wetland complex were sampled and lab tested for permeability, and these data were used for simulating the wetland areas in the numerical groundwater model.

For purposes of developing the numerical groundwater model, the Vashon Aquifer is represented by two principal zones with distinct permeabilities, separated by a relatively lower permeability zone. The upper zone is comprised of the Steilacoom Gravel, which occurs from groundwater surface to an elevation of approximately 180 to 168 feet above mean sea level and, based on model calibration, has a hydraulic conductivity ranging from 35 to 3,900 feet/day within the model area. At that elevation, there is a lithologic change sometimes indicated by a slightly siltier zone or a slight increase in density during drilling. Below this siltier zone lies the deeper portion of the Vashon Aquifer, comprised of sand and gravel that, based on model calibration, has a lower average permeability, ranging between 0.3 and 49 feet/day. The deeper outwash zone occurs to the depth of the Qob, which occurs at an average elevation of 110 to 120 feet. The two aquifer zones are differentiated on Figure 3 by a dashed line within the Vashon Aquifer in the area of the mine site.

3.2 Connection of Aquifer with Wetlands and Springs

The principal drainage features in the Sequalitchew Creek watershed include Sequalitchew Creek, the Fort Lewis Diversion Canal, and the series of interconnected wetlands through which these drainages flow (see Figure 1). The bulk of the surface water originates at Sequalitchew Lake and from several Fort Lewis stormwater facilities located on the southeast project boundary. The Diversion Canal drains excess surface water from Sequalitchew Lake and the upper marshes (Bell, Hamer and McKay) to Puget Sound, and Sequalitchew Creek provides additional drainage of Edmond Marsh and, to a limited degree, the upper marshes during high-precipitation periods.

Since 2000, monitoring data have been collected to understand the hydraulic connection of the groundwater system with the area wetlands and Sequalitchew Creek system. The monitoring data indicate hydraulic connection between surface water and groundwater through the wetland complex within the upper Sequalitchew Creek drainage. Hydraulic connection is observed by similar water elevations, fluctuations, and time-trends at paired

surface water and groundwater monitoring stations. Hydraulic connection is also indicated in the middle reaches of Sequalitchew Creek where springs (groundwater) discharge to the ravine throughout most of the year. Sequalitchew Creek infiltrates water to the groundwater system in its lowermost reaches.

The monitoring data also indicate that the core wetland areas are generally underlain by fine-grained, low-permeability peat and silt deposits that hold water (Aspect, 2004). Where these peat deposits occur, the amount and rate of surface water that can leak into the groundwater system due to potential future groundwater drawdown would be limited by the natural low permeability of the underlying silts and peats. In other areas, development has removed the naturally low-permeability soils from historical wetland areas; the removal of peat and/or the natural heterogeneity of the soil materials, can create an avenue for greater hydraulic connection and thus wetland response to groundwater change. A summary of our understanding of the hydraulic connection of the groundwater system with the upstream marsh areas is provided below.

3.2.1 Sequalitchew Lake and East Edmond Marsh

The Sequalitchew Lake level is believed to be an expression of the water table, and the monitoring data at the outlet indicates year-round hydraulic connection between the surface water and groundwater in this area.

The principal water supply for Joint Base Lewis-McChord (JBLM) occurs on the eastern side of Sequalitchew Lake where Sequalitchew Springs are located, which are reported to yield as much as 9,000 gallons per minute (gpm) (approximately 20 cubic feet per second [cfs]). Most of the time the springs provide more flow that needed by JBLM for water supply, resulting in surface water outflow from the Lake passing over the Diversion Weir and into the Diversion Canal.

3.2.2 Upstream Marshes—Bell, Hamer and McKay

Surface water levels higher than groundwater levels indicate an influx of surface water in the wet season, with dropping surface water and groundwater levels in the dry season.

3.2.3 Edmond Marsh

Throughout Edmond Marsh, there is connection between surface water and groundwater; however, the connection is greater in the more easterly monitoring stations than in the west marsh area. In the central and eastern areas, stations EM-3 and EM-2 are located adjacent to roadways that, during their construction, may have excavated out the peat deposits. In addition, the creation and maintenances of a channel for Sequalitchew Creek through Edmond Marsh during the years when a fish hatchery operated in Sequalitchew Lake likely disturbed or removed portions of the peat deposits. The westernmost station EM-1 has the least amount of hydraulic connection, presumably because the underlying peat materials are still in place.

These monitoring data indicate an influx of stormwater in the wet season fills the wetland area. Beaver dams help to maintain marsh surface water levels higher than groundwater levels beneath the marshes during the wet season. During the dry season, the surface water and groundwater levels drop. The west end of Edmond Marsh completely dries each year by late spring.

3.2.4 Southern Lakes

A group of lakes (e.g., Grant Lake, Pond Lake, Old Fort Lake and several others) are located in the southwestern most study area. Monitoring data indicates these are water table lakes whose surfaces fluctuate with the groundwater level.

3.2.5 Groundwater Discharges to Sequalitchew Creek Ravine

Groundwater discharges from the Vashon Aquifer as springs in the Sequalitchew Creek ravine below elevations of approximately 195 feet down to the top elevation of the Qob deposits at elevation between approximately 100 to 120 feet, which spans a creek reach of approximately 0.7 miles. Based on stream gaging data, this groundwater discharge varies between approximately 0.5 cfs in the summer to 1.5 cfs in the winter. Progressing downstream past the Qob Truncation, Sequalitchew Creek becomes a losing stream as the water table drops through the outwash to near sea level.

3.3 Deeper Aquifers

Beneath the Qob is the regionally extensive and highly productive Sea Level Aquifer, which occurs throughout the DuPont area between elevations of roughly 50 and -100 feet relative to mean sea level. The Sea Level Aquifer is generally confined beneath the Qob aquitard, and has very limited hydraulic connection with the shallower Vashon Aquifer. West of the Qob Truncation, the Sea Level Aquifer becomes unconfined and its groundwater merges with flow from the Vashon Aquifer in the accumulation of Steilacoom Gravels extending below mean sea level (sometimes referred to as the unconfined Sea Level Aquifer; URS, 2003). Groundwater in the Sea Level Aquifer discharges to Puget Sound via intertidal and subtidal seeps. The Sea Level Aquifer is the City of DuPont's primary water supply source, with their Bell Hill wells No. 1 and No. 3 and Hoffman Hill wells No. 1 and No. 2 completed in it.

Below the Sea Level Aquifer and underlying aquitard unit is a deeper glacial aquifer unit, sometimes termed the Lakewood Aquifer, in which the City of DuPont's Bell Hill No. 2 is completed.

Below the Lakewood Aquifer, two deeper glacial aquifer units separated by interglacial aquitard units were observed during drilling of CalPortland's 1,000-foot-deep water well for the aggregate processing plant. CalPortland's well is completed in the deepest observed aquifer unit, screened between elevations of -685 and -770 feet.

4 Setup of Updated Model

The DuPont model represents a significant update to previous numerical groundwater models used on this project (CH2M Hill 2003, Aspect 2004a, Aspect 2009b)). The updates include changes to the model time period, structure and extent, calibration process, and mining plan scenarios.

Previous models were calibrated to an average "steady-state" condition. The updated model is a transient model calibrated to monthly hydrologic measurements collected from March 2004 through December 2010, and validated to measurements collected through December 2015. The model extent was also expanded to include the area west of the Olympia Beds (Qob) Truncation to Puget Sound to allow for simulation of groundwater discharges in the western portion of the project area. The model also now incorporates deeper geologic layers including the Sea Level Aquifer.

In 2010 and 2011, the USGS published a regional groundwater model that provides additional information outside the boundaries of the prior model, allowing us to supplement our site-specific hydrogeologic data with data from the greater Chambers-Clover Creek watershed (Savoca et al., 2010; Johnson et al., 2011). Elements of the USGS model were spatially correlated and numerically transcribed to the DuPont model.

The DuPont model was calibrated to groundwater conditions based on monitoring data from 2004 to 2010, and validated based on monitoring data through 2015. Overall, these 2004 to 2015 groundwater conditions are referred to as the "baseline." The calibration process used a state-of-the-science parameter estimate program (PEST) and is discussed in Section 5.

The DuPont model was then used to predict groundwater conditions during and after mining. Predictive scenarios representing the major steps in mining and dewatering were developed based on the current mining plan, which differs from prior models in that it no longer includes construction of a north fork of Sequalitchew Creek. Four predictive scenarios representing the planned mining steps (hereafter referred to as Steps 1, 2, 3, and 4) were developed and simulated.

4.1 Model Code

Groundwater flow equations were calculated using the program MODFLOW-SURFACT, version 3 (Hydrogeologic, 2012). This program is better suited than traditional MODFLOW programs for simulating the partially saturated flow conditions that are anticipated will be caused by the proposed mining of the South Parcel. An earlier version of the same software was used for previous modeling efforts.

The DuPont model was developed using an industry-standard computer program, Groundwater Vistas, version 6 (ESI, 2011), as a pre- and post-processor. An earlier version of the same software was used for previous modeling efforts.

The DuPont model was setup to minimize numerical error and provide for a practical computational run time. The head convergence criterion was set to 0.01 feet, which is a setting typical for groundwater models. The cumulative mass balance error was limited to 0.02 percent, which is more stringent than the 0.1 percent criterion for an "ideal" model

(Anderson and Woessner, 1992). The DuPont model requires up to 18 hours for a computational run.

4.2 Model Extent and Grid

Relative to earlier versions of the model, the DuPont model was expanded to simulate boundaries further from the South Parcel, so as to reduce the effects of model boundaries on the central area of interest. The model extent is shown on Figure 4 and the inset shows the DuPont model extent within the context of the regional USGS model extent. Compared to previous models, the DuPont model was expanded to the northwest to include the area beyond (downgradient of) the Qob Truncation. Inactive cells along the northeast and southeast model extents were converted to active cells to include a portion of American Lake as a well-defined surface water boundary condition. Model results for areas closer to the model extents are considered less accurate due to the proximity of model boundaries.

The DuPont model grid coordinate system was updated to be consistent with the project coordinate system and to provide quality assurance for model construction and interpretation of model results. The model horizontal datum is NAD 83 State Plane South in feet. The model vertical datum is NGVD 29 in feet. The model was rotated and offset to better align with the predominant groundwater flow direction. The grid was rotated 44.45 degrees counter-clockwise; and model x,y coordinates were offset 1,097,483 feet east and 653,755 feet north, respectively. The model coordinate, elevation, and offset information allows for georeferencing of model results.

The grid in the DuPont model was refined to reduce potential numerical error and allow greater spatial resolution in results. Grid spacing in the DuPont model was halved from previous models, with a range from 50-foot spacing across the mine property up to a maximum of 250-foot spacing at the model boundaries. This spacing resulted in 268 rows and 198 columns across the DuPont model domain, creating 53,064 cells in each layer and a total of 477,576 cells in the model.

4.3 Model Layers

The DuPont model was constructed with nine layers to simulate five hydrostratigraphic units, which is consistent with the upper five hydrostratigraphic units identified in the USGS model (Johnson et al., 2011). The five hydrostratigraphic units simulated in the DuPont model are, from the surface down:

- Steilacoom Gravel;
- Upper Confining Unit;
- Vashon Outwash;
- Olympia Beds; and
- Sea Level Aquifer.

Table 1 provides a brief description of the hydrostratigraphic units simulated in the model. Figure 7a through 7e provides the thickness and extent of the five

hydrostratigraphic units. Other reports provide a more detailed description of the hydrogeologic conceptual model for the project area, including the hydrostratigraphic units (Aspect, 2004a; Savoca et al., 2010; Johnson et al., 2011). Each hydrostratigraphic unit was simulated as two layers in the model, except the Upper Confining Unit, which was simulated with one layer. Using two model layers allowed integrating the information from co-located monitoring wells into the calibration of vertical hydraulic conductivity within a hydrostratigraphic unit.

4.3.1 Model Top Elevation

The ground surface elevation, shown on Figure 5, was based on available LiDAR surveys and represents the top elevation used in the DuPont model. This surface topography was used in the baseline and predictive simulations of future mining Steps 1 through 3. For future mining Step 4, the surface topography was modified within the South Parcel as shown in Figure 6 to reflect the changes from mining.

4.3.2 Hydrostratigraphic Units

The hydrostratigraphic units and their contact elevations were inferred from the network of mine exploration borings, off-property monitoring well logs, and area-wide cross sections including those developed for the DuPont Mine (Aspect 2004b) and the USGS model (Savoca et al., 2010; Johnson et al., 2011). Where a hydrostratigraphic unit is simulated using two layers, each layer is of equal thickness.

Model Layers 1 and 2 generally simulated the Steilacoom Gravel across the model extent, except where it was inferred to be absent. The areas of greater hydraulic conductivities in Layers 1 and 2 reflect Steilacoom Gravel, whereas areas of lesser hydraulic conductivities reflect glacial till deposits at the surface (Burke Hill, for example) or erosion through deeper hydrostratigraphic units (Sequalitchew Ravine, for example) (Figure 7a). The Steilacoom Gravel was simulated in all layers west of the Qob Truncation, where the main flow channel for the glacial outburst floods was inferred to have discharged.

East of the Qob Truncation, Layer 3 generally simulates a thin layer of finer-grained material (relative to the Steilacoom Gravel above and Vashon Outwash below), and is referred to as the Upper Confining Unit in this report. The lack of obvious till in the borings from the DuPont Mine led us to infer that the Steilacoom Gravel flood outwash may have eroded away most, if not all, of the till within the main flow channel. This is consistent with the hydrogeologic interpretation established for Parcel 1 of the Former DuPont Works Site located south of Sequalitchew Creek (URS, 2003). The USGS mapped till deposits on either side of the main flow channel, and we included that till in our model (see Figure 21 in Johnson et al., 2011). During model calibration, the model did not replicate observed water levels in the Steilacoom Gravel without a finer-grained layer within the flow channel, consistent with the USGS geologic interpretation. Figure 7b shows the Upper Confining Unit east of the Qob Truncation, and Steilacoom Gravel west of the Qob Truncation.

Layers 4 and 5 simulate the Vashon Outwash east of the Qob Truncation, as shown in Figure 7c. Layers 6 and 7 simulate the Olympia Beds east of the Qob Truncation, as shown in Figure 7d. Layers 8 and 9 simulate the Sea Level Aquifer east of the Qob Truncation, as shown in Figure 7e.

The Sequalitchew Creek ravine is an erosional feature created after deposition of the Steilacoom Gravel. As such, the ravine was simulated as cutting through the hydrostratigraphic layers as it descends toward sea level.

In the predictive model simulating the post-mining condition, the hydrostratigraphic units are modified to reflect the effects of mining as described in Section 5.

4.4 Aquifer Parameters

An initial range in aquifer parameter values (including horizontal hydraulic conductivity, vertical hydraulic conductivity, specific yield, and specific storage) was defined for each hydrostratigraphic unit based on data developed in previous studies (Aspect, 2004a; Aspect, 2004b). Aquifer parameter values for the model layers were calibrated using the process described in Section 5 to minimize the difference between observed and model-calculated groundwater levels. The calibrated average values are provided in Table 1.

The DuPont model was updated to allow spatial differences in hydraulic conductivity within a hydrostratigraphic unit. Allowing hydraulic conductivity to vary in this updated model permitted better calibration to the observed transient conditions (note that prior models were steady state and assumed homogeneous hydraulic conductivity within each hydrostratigraphic unit). The spatial distribution of final calibrated hydraulic conductivity is shown for the Steilacoom Gravel hydrostratigraphic unit, the Upper Confining Unit hydrostratigraphic unit, and the deeper Vashon Outwash hydrostratigraphic unit on Figure 8a through 8d.

Other parameters (specific yield, specific storage, and vertical anisotropy—the ratio of vertical to horizontal hydraulic conductivity) were held spatially constant within a hydrostratigraphic unit, as they had been in prior models. Vertical conductivity is calculated based on the horizontal conductivity, which varies spatially, and the vertical anisotropy, which does not. As such, vertical conductivity varies spatially within a hydrostratigraphic unit.

4.5 Model Calibration and Validation Timeframes

The DuPont model calibration timeframe was updated to simulate the period of monitoring from March 2004 through December 2010. The DuPont model simulates 82 monthly stress periods[1], preceded by one “lead-in” period of average conditions for the entire period. The first stress period was included to simulate steady-state average conditions, similar to previous models, and improve the model calibration process.

The roughly 6-year model calibration timeframe is robust in comparison with prior versions of the model and the recent work by USGS. The transient USGS model simulated the 24-month period from September 2006 to August 2008, which was preceded by a 3-year lead-in period.

[1] Stress periods are a time interval within the model when conditions change. Stress periods include multiple time steps for computational purposes, but conditions such as precipitation, pumping rates, or lake water levels only change at the beginning of the stress period.

The DuPont model validation timeframe was updated to simulate the period of monitoring from March 2004 through December 2015, or 142 monthly stress periods. This longer timeframe provided the baseline groundwater conditions for predictive analysis.

The validation timeframe overlaps the calibration timeframe because of a change in the precipitation data source. The model was calibrated using precipitation data from McMillin Reservoir, but beginning in 2012 this data source became unreliable, with significant gaps in coverage. For model validation, the precipitation data source was changed to the PRISM estimates for the McMillin Reservoir (details are presented in Section 4.6.1) for the entire validation period (2004-2015). Using the full period of record for validation allows for validation of the change in precipitation source as well as validating the model in additional years.

The validation period reflects a range of weather conditions, including both relatively wet and relatively dry years, as shown on Figure 9. Figure 9 shows the DuPont model timeframe compared to the USGS model timeframe, within the context of historical annual precipitation. The predictive models used the same 2004 to 2015 timeframe as the baseline model, but with different boundary conditions as noted below. Predictive models simulated dewatering and/or surface drainage during the initial stress period, so as to provide the maximum predicted change in groundwater levels for each phase of mining.

4.6 Boundary Conditions

Model boundary conditions were assigned to best simulate the observed or inferred hydrogeologic conditions, as described below. The predictive models used boundary conditions identical to the baseline model, except as noted below.

4.6.1 Recharge—Net Precipitation

Monthly-variable and spatially-variable recharge values were based on values assigned in the USGS transient model (see Figures 4 and 6 in Johnson et al., 2011; Savoca et al., 2010), which included net precipitation recharge after accounting for runoff, evapotranspiration, and other surficial processes. Figure 10 shows the distribution of average recharge rates across the model extent.

For the calibration time periods outside the USGS model timeframe, recharge values were correlated with precipitation data at the McMillin Reservoir (NWS station 455224), the nearest long-term weather station with a long-term record (active since 1941). The precipitation record for McMillin Reservoir became less reliable in 2012, with more frequent breaks in data collection.

Since the McMillin Reservoir observations no longer had good coverage for the entire model timeframe, a predicted monthly time series for the McMillin Reservoir location from the Oregon State University PRISM Climate Group (OSU 2017) was used instead of the actual weather station observations.

Figure 9 shows a collection of graphs with the following information:

- Annual precipitation (upper left): compares the annual precipitation at McMillin Reservoir with PRISM data, and shows the average annual precipitation with PRISM data and the groundwater model timeframes;

- Annual precipitation exceedance plot (lower left): shows the probability distribution of annual precipitation, highlighting the years during the validation period;
- Monthly precipitation and recharge (upper right): compares the monthly precipitation (bars) and recharge (lines) during the validation period, and shows the model timeframes; and
- Precipitation by month (lower right): shows the range in historical (1942 to 2015) monthly precipitation (high/low lines) and the monthly precipitation during the validation period (scatter plot).

The McMillin Reservoir and PRISM precipitation data sets compare closely with each other, and the switch to using PRISM data for modeling was seamless. The validation period for the DuPont model represents a wide-range in the precipitation recharge, including both relatively wet and relatively dry years and months.

4.6.2 Groundwater Inflow

Groundwater inflow to the model domain was simulated as occurring in three locations: 1) from American Lake, 2) across a portion of the northeast model boundary, and 3) across the southeast model boundary. Figure 11 shows the location of model boundary conditions, including groundwater inflow. The American Lake boundary was defined by monthly-variable specified head cells based on reported and/or precipitation-correlated water levels (Johnson et al., 2011). Groundwater underflow across the northeast model boundary occurs in the Steilacoom Gravel hydrostratigraphic unit (Layer 2) and was defined in the model by monthly-variable specified head cells based USGS model results (Johnson et al., 2011). Groundwater underflow across the southeast model boundary occurs in the Sea Level Aquifer (Layer 9) and was defined by monthly-variable specified head cells based on USGS model results (Johnson et al., 2011). For the period after the USGS model timeframe, specified heads were assigned based on correlations with precipitation patterns. Figure 12 shows a graph of specified heads over time assigned to the groundwater inflow boundaries of the DuPont model.

4.6.3 Infiltration from Wetlands

Wetlands simulated in the DuPont model include Bell Marsh, McKay Marsh, Hamer Marsh, and the Edmond Marsh complex (Table 2). In addition, the channel flowing through East Edmond Marsh was simulated distinctly from the surrounding wetland areas to reflect the “cookie cutter” dredging that occurred in the 1970s to 1990s.

Each wetland area, including the Sequalitchew Creek channel, was treated as a distinct head-dependent boundary condition within the model, as shown on Figure 11.

In a few areas, wetland soils have been removed during historical development activities within the Edmond Marsh complex. Specifically, it was assumed that wetland soils were removed and replaced with sand and gravel fill at the former railroad grade at the Robinson Trail, and along the DuPont-Steilacoom Road. These areas were not included as wetland boundary conditions.

Wetland boundary conditions (drains and rivers) used monthly-variable and spatially-variable heads based on observed staff gage readings during the period of monitoring. Graphs of wetland water depths over time are shown on Figure 13, calculated from observed staff gage readings and the estimated bottom elevation of the wetland. When wetland stages were observed to be dry, the model simulated no water depth. Perched wetland conditions, where the wetland may have surface water ponded above the groundwater table (see Figure 15; Aspect, 2004a), were not simulated with the DuPont model because that water is not in direct hydraulic connection with the groundwater system being simulated.

The connection between the wetlands and the aquifer was defined by river cells with calibrated conductance values simulating a 5-foot-thick layer of peat forming the wetland bottom (see Figure 15; Aspect, 2004a). The wetland properties assigned in the model are summarized in Table 2. Wetland conductance values[2] were calibrated such that the area-weighted average vertical hydraulic conductivity was 0.034 feet per day. This value was consistent with previous peat testing results, which averaged in the range of 0.03 to 0.08 feet per day.

For predictive modeling, the wetland stages were maintained at baseline conditions.

4.6.4 Discharge to Surface Water

Groundwater-to-surface water discharge was simulated for the Joint Base Lewis-McChord (JBLM) water supply overflow, Sequalitchew Lake, the Diversion Canal and drainage, the wetlands complex, and the Sequalitchew Creek ravine. The locations of these boundary conditions are shown on Figure 11, and each is described below. The groundwater model simulates groundwater discharge to surface water, and does not simulate surface water flow due to runoff.

We assumed that groundwater discharged to surface water travels directly to Puget Sound, without potential for re-infiltration to the groundwater system. This assumption may result in the model overestimating drawdown effects from mine dewatering, especially in the area of the Diversion Canal and the Sequalitchew Creek ravine.

4.6.4.1 Joint Base Lewis-McChord Water Supply Overflow

Overflow from the spring water supply for JBLM at the east end of Sequalitchew Lake was simulated to evaluate changes in overflow throughout the mining process. The overflow was defined with a drain cell based on the overflow elevation. Groundwater discharged to this drain cell was assumed to subsequently discharge to Puget Sound via Sequalitchew Lake and the Diversion Canal, without potential for re-infiltration to the groundwater system.

4.6.4.2 Sequalitchew Lake

Sequalitchew Lake was simulated as a reflection of the groundwater table, and was defined by drain cells with monthly-variable heads based on observed lake levels at

[2] Wetland conductance (C) is a model-specific value that depends on the cell dimensions, as shown in the following equation: C = Kv*L*W/m, where Kv is vertical hydraulic conductivity (ft/d), L is cell length (ft), W is cell width (ft), and m is the peat thickness (ft). A higher conductance value allows greater hydraulic connection between wetland surface water and underlying groundwater, and vice versa.

monitoring well MW-SL-1, which is located at the west shore of Sequalitchew Lake. Groundwater discharging to Sequalitchew Lake was assumed to travel directly to Puget Sound via the Diversion Canal, without potential for re-infiltration to the groundwater system.

4.6.4.3 Diversion Canal and Drainage

The Diversion Canal, and the drainage associated with JBLM North were defined by drain cells with heads assigned at the elevation of the ground surface. Losing reaches of the Diversion Canal to the aquifer were not simulated with the DuPont model because that water is not in direct hydraulic connection with the groundwater system being simulated. Except near Sequalitchew Lake, the bottom of the Diversion Canal is generally above the water table, and proposed mining will not affect the flow in the canal or the seepage rates from the canal.

Groundwater model results indicate a shallow water table in the vicinity of JBLM North. We assumed that groundwater discharging to channels or other surface water features on JBLM North travels via the Diversion Canal directly to Puget Sound, without potential for re-infiltration to the groundwater system.

4.6.4.4 Wetlands Complex

Surface water discharge from the wetlands was defined by drain cells with conductance values greater than values for the river cells simulating wetland infiltration. We assumed that surface water discharged from the wetlands was subsequently discharged to Puget Sound via the Diversion Canal or the Sequalitchew Creek ravine, without re-infiltration within the wetlands. Re-infiltration of water to the aquifer from the losing reach of Sequalitchew Creek near Edmonds Marsh was not simulated because of the complexity of surface water/groundwater interaction in this area. This is a conservative assumption because it reduces the amount of water infiltrating to the aquifer along the losing reach, and may result in overestimating the effects of mine dewatering in the vicinity of the losing reach.

Infiltration from the wetlands is discussed in Section 4.6.3.

4.6.4.5 Sequalitchew Creek Ravine

Seepage within the Sequalitchew Creek ravine was defined by drain cells with heads assigned to ground surface to simulate gaining conditions. We assumed that groundwater discharged to these drain cells was subsequently discharged to Puget Sound via Sequalitchew Creek.

4.6.5 Discharge from Dewatering Wells

Dewatering wells were included in the predictive scenarios for future mining Steps 1 through 3. These mining steps represent the phased increase in dewatering efforts through planning, preparation, and execution of mining:

- Step 1 – Initial Dewatering Test
- Step 2 – Preparation for Mining/Expanded Dewatering Test
- Step 3 – Active Dewatering During Mining

Dewatering wells are not included in Step 4 – Cessation of Active Dewatering – because, at that point, all dewatering wells will have been turned off allowing groundwater seeps to develop at the toe of the mined slope. Additional detail about the dewatering plan is presented in the main body of the Monitoring Plan (Aspect, 2017).

The DuPont model was used to simulate the effects of dewatering as though each dewatering step occurred throughout the 11-year baseline period. This approach simulates the effects of the dewatering activities under the range of weather conditions represented by the baseline period.

The DuPont model simulated 10, 24, and 66 dewatering wells along the eastern mine property boundary for Steps 1, 2, and 3, respectively. Figure 14 shows the locations of the proposed dewatering wells during the progressive mining Steps. The simulated wells were screened across multiple model layers for the aquifer above the Olympia Beds, with pumping rates of up to 1 cfs per well. The MODFLOW-SURFACT model code automatically re-allocates pumping to lower layers as upper layers are dewatered, and automatically reduces the pumping rate as the water level approaches the bottom of the well.

Planned re-infiltration of pumped water to the floor of the existing mine will discharge to Puget Sound via the Sea Level Aquifer, and thus will not influence upgradient effects of dewatering and mining in the Vashon Outwash. Simulation of the re-infiltration of the dewatering discharge was not included in the DuPont model as it would occur west of the truncation of the Olympia Beds and thus would not affect water levels in the Vashon Aquifer.

4.6.6 Discharge to the Mined Slope

Groundwater discharge along the toe of the newly mined slope in the South Parcel was simulated for future mining Step 4, and was defined by drain cells with heads assigned at the elevation of the toe of the proposed mine slope (see Figure 5 for post-mining elevations).

4.6.7 Groundwater Outflow

Submarine groundwater outflow to Puget Sound was simulated using drain cells with heads assigned to mean sea level. The locations of boundary conditions, including groundwater outflow, is provided on Figure 11.

4.6.8 No-Flow Boundaries

No-flow boundaries were assigned at the edges of the DuPont model where groundwater flow was inferred to be relatively parallel with the model boundary (Figure 4). This included the bottom of the model (bottom of Sea Level Aquifer), and the sides of the model perpendicular to the shore of Puget Sound, except in layers where information was available to specify head.

5 Model Calibration and Validation

The DuPont model was calibrated by adjusting parameter values to minimize the difference between observed and calculated hydrogeologic conditions. The DuPont model was calibrated to the monitoring data from March 2004 through December 2010. The DuPont model was then updated with monitoring data from January 2011 through December 2015 and validated to the entire March 2004 to December 2015 period.

Similar to the USGS model, the DuPont model was calibrated using a specialized program called PEST, version 12 (Dougherty, 2011), which optimizes a parameter estimation method to provide the best fit within the limits of the available data and assumptions used in the numerical model. Jim Rumbaugh, the software developer for Groundwater Vistas, assisted Aspect with calibrating the DuPont model.

The raw calibration results statistically indicated a good calibration, and were further refined using trend-line analysis to improve matching observed and calculated water levels. The model calibration process is described below, including establishing calibration targets, defining the calibration method, providing the calibration and validation results, and post-processing the model results.

5.1 Calibration Targets

Observed groundwater levels were assigned to the DuPont model as transient calibration targets at the mid-point elevation of the monitoring well screen. Head targets, drawdown targets, and head-difference targets were set up using the same observed water levels, but provide different information to PEST during model calibration. Targets, and their primary calibration parameters, are summarized below:

- Head targets (1,467 total during calibration; 2,503 total during validation) primarily informed the calibration of horizontal hydraulic conductivity values. Head targets were used during validation to calculate residual statistics.
- Drawdown targets (1,467 total) primarily informed the calibration of aquifer storage parameters. In this case, “drawdown targets” applied the same information used for head targets to reflect seasonal changes in water levels (not drawdown due to a pumping well). Drawdown targets were calculated as the arithmetic average water level minus the observed water level on a given date. Drawdown targets were not used during validation.
- Head-difference targets (414 total) primarily informed the calibration of vertical hydraulic conductivity where shallow and deep wells were co-located. In this case, head-difference targets applied the same information used for head targets to reflect the vertical hydraulic gradient. Head-difference targets were not used during validation.

Observed and calculated groundwater levels over time at monitoring wells are presented on Figure 15 (top graphs). Wells with more observations had greater influence on model calibration than those with fewer observations.

Select single-observation targets in the area south of Sequalitchew Creek were used to inform model calibration. These calibration data were assigned for the first stress period to represent average conditions and included the following:

- Groundwater level data from 1994 at monitoring wells that were part of the Remedial Investigation of the Former DuPont Works Site (URS, 2003); and
- Surface water levels from August 2004 at Wetland 8, Wetland 10, Strickland Lake, Grant Lake, and Old Fort Lake (Aspect, 2004b).

5.2 Calibration Methods

Calibration methods followed the guidance provided for highly parameterized inversion (Doherty and Hunt, 2010; Doherty, et al., 2010). Essentially, this guidance allows back-calculating multiple model parameters to result in a best-fit with observed data, while maintaining parameter values within an expected range.

Table 3 provides a list of the model parameters adjusted during the calibration process. The DuPont model calibration was conducted in two stages, as described below:

- The first stage of model calibration refined aquifer parameters and wetland conductance values using zones or reaches of piecewise constancy. Calibration results were used to focus efforts on the most sensitive parameters. Calibrated aquifer parameters included horizontal and vertical hydraulic conductivities, and unconfined and confined aquifer storage values.
- The second stage of model calibration involved refinements to the spatial distribution of hydraulic conductivity within the Steilacoom Gravel, the Upper Confining Unit, and the deeper Vashon Outwash. Calibration methods included the following:
  - Regularization with pilot points, allowing hydraulic conductivity values to vary one order of magnitude from the value determined during the first stage. Previously determined vertical: horizontal anisotropy was maintained. As shown in Table 1, the maximum and minimum calibrated hydraulic conductivity values for a hydrostratigraphic unit are within two orders of magnitude.
  - Singular value decomposition, which internalized sensitivity analysis and reduced the time required for calibration. The calibration process was concluded when successive iterations showed limited improvement in residual statistics (discussed below).

5.3 Calibration Results

The calibrated DuPont model provided a good “fit” between calculated and observed groundwater levels. Consistent with model calibration guidance (Anderson and Woessner, 1992; Hill and Tiedemann, 2007), we evaluated the sufficiency of DuPont model calibration based on comparing observed and calculated groundwater levels from multiple perspectives. First, we evaluated the overall model calibration. Then, we evaluated the transient model calibration for potential trends. Last, we evaluated the

model calibration for each monitoring well. Additional discussion of each step is provided below.

5.3.1 Overall Groundwater Level Calibration

We characterized the DuPont model as calibrated when additional adjustment in model parameters did not improve overall residual statistics, within the constraints of the model setup (Section 3) and the calibration targets and methods (Section 4.1 and 4.2).

A quantitative calibration evaluation, based on statistical analysis, met accepted industry standards for overall model comparison. The overall groundwater level calibration for the DuPont model was quantitatively evaluated using residual statistics for head targets (Table 4). Overall residual statistics were also calculated for drawdown (i.e., seasonal change in water levels) and head-difference targets, and we describe the level of calibration for these targets within the context of head targets for clarity and consistency. A description of common residual statistics is provided below:

- The overall **mean** residual reflects that calculated groundwater levels were 1.8 feet less than observed, on average.
- The overall **standard deviation** of residuals reflects that calibrated water levels were generally within 2.7 feet of the observed value.
- The **sum of squared** residuals is used for identification of specific targets which affect the overall model calibration, discussed further in Section 5.3.3.
- The overall **root mean square error** incorporates information on both the mean and standard deviation, and reflects that calibrated groundwater levels were generally within 3.2 feet of the observed value.

Thus, a broad interpretation of the mean and standard deviation is that the model-calculated groundwater levels across the entire model domain were 1.8 feet less than observed groundwater levels on average, and were usually within 2.7 feet of observed groundwater levels.

Consistent with model calibration guidance, selected residual statistics were scaled to the range of observed groundwater levels to compare with industry standards. The DuPont model calibration focused on groundwater conditions east of the Qob truncation, where the difference between the maximum and minimum observed groundwater levels was approximately 31 feet. The range in simulated groundwater elevations spanned approximately 230 feet (from American Lake to Puget Sound). The scaled standard deviation and root mean square error "*should be less than 10 to 15 percent for a good calibration*" (ESI, 2011). A description of the scaled residual statistics is provided below:

- The scaled standard deviation of residuals was less than 9 percent (2.7 feet / 31 feet) of the observed range.
- The scaled root mean square error of residuals was less than 11 percent (3.2 feet / 31 feet) of the observed range.

Thus, we interpreted the DuPont model as meeting industry standards, and as having a good calibration over the 6 years of observations covering a range of climatic conditions.

Residual statistics were calculated for drawdown (i.e. seasonal change in water levels) and head-difference targets (Table 4). Low values of scaled standard deviation indicate a good model fit. The overall scaled standard deviation of residuals for drawdown was 12 percent of the observed range, and for head-difference was 14 percent of the observed range.

A qualitative evaluation of the overall model calibration showed good agreement between calculated and observed groundwater levels and ranges based on mapped comparisons (Figures 16 and 17). The map on Figure B-13 compares measured to model-calculated water table elevation contours for May 2010. This qualitative calibration evaluation shows good agreement between water table elevation contours across most of the model domain within the context of seasonal variability, with the best agreement in the vicinity of the wetlands that are areas of primary interest for the project. The map on Figure 17 compares the seasonal range in model-calculated and observed groundwater levels. The range in model-calculated groundwater levels (contours) were approximately 86 percent of the observed values (posted values), on average.

5.3.2 Calibration of Groundwater Levels over Time

The DuPont model head calibration results were consistently good during seasonal and annual hydrologic cycles. Transient head calibration results were evaluated over two time scales, monthly and annual, as listed in Table 4, to evaluate if there were temporal trends in the accuracy of the model calibration.

The time-related residual statistics indicate a good annual model calibration with the scaled standard deviation between 8 to 12 percent. There is no discernible trend in the annual residual statistics, which suggests that the model calibration is consistently good during dry and wet years. The monthly residual statistics also indicate a consistently good calibration during dry and wet months, with the scaled standard deviation between 8 and 11 percent.

5.3.3 Calibration of Groundwater Levels at Individual Wells

Overall, individual monitoring wells selected for DuPont model calibration showed good model fit. The calibration was evaluated at individual wells to determine if there were spatial trends in model performance. Calibration at individual wells is summarized in a scatter plot (Figure 18, upper graph), which compares the observed and calibrated groundwater level elevations. Most wells fall close to the 1:1 line that represents the “perfect” model fit.

Based on the validation model results, head target residual statistics for individual wells are provided in Table 5, and are described in more detail below:

- Monitoring wells with fewer observations provided less information for the PEST calibration than other wells. These wells included 88-2-VD and MW-PL-1.
- All monitoring wells had mean residuals that were less than the range of observed values, except 88-2-VD.
- The standard deviation of residuals at any individual well was less than approximately 1.7 feet.

- The sum of squared residuals clearly identifies those wells most influencing the overall model calibration. The shallow and deep monitoring wells at MW-EM-1, CHMW-2, and CHMW-3 have greater mean residuals, and greater sum of squared residuals, than other locations. Although the offset at 88-2-VD is larger than other monitoring wells, the sum of squared residuals is limited by the relatively small number of observations.
- The root mean square error combines the mean and standard deviation of residuals. Based on this statistic, the calibration is better at monitoring wells MW-EM-3, MW-EM-2s and -2d, MW-SRC-2, and MW-HM-1 than at other locations.

The potential causes for poorer calibration at selected wells, identified by greater mean residual, are as follows:

- MW-EM-1S and MW-EM-1D appear to be sensitive to the groundwater and wetland interactions at the discharge point of West Edmond Marsh. Re-infiltration of surface water was not simulated at this location based on limited information for flow rates; ignoring re-infiltration is a conservative assumption with respect to predicting hydrogeologic impacts (see Section 4.6.4.5). Also, surface water was inferred to be seasonally perched above the water table (see Figure 15, Aspect 2004a), and the groundwater model was setup to simulate typical groundwater conditions.
- The shallow and deep monitoring wells at CHMW-2 and CHMW-3 are close to the Qob truncation, and are in areas with greater hydraulic gradients (inferred and calculated) than other monitoring wells. Groundwater levels at these monitoring wells appear to be sensitive where the curving water table crosses hydrostratigraphic contacts near the Qob truncation.

In summary, areas with the best model fit are the central portion of the Edmond Marsh Complex (MW-EM-2s, MW-EM-2d, and MW-EM-3) and the eastern boundary of the South Parcel (CHMW-1 and CHMW-4d) based on the residual statistics shown in Table 5. These areas are also the focus of attention for predicting the effects of proposed mining activities, and model predictions in these areas are considered more reliable than areas with poorer calibration.

5.4 Validation Results

Model validation was conducted, without changing the model construction (model grid/layering and aquifer parameters, to demonstrate that the validity of using PRISM data to assign recharge distribution. We characterized the DuPont model as validated because of the similarity between the calibration and validation residual statistics, as explained in further detail below.

5.4.1 Overall Groundwater Level Validation

The summary table below compares overall residual statistics between model calibration and model validation.

Type (Period)	Mean Residual (feet)	Standard Deviation of Residuals (feet)
Calibration (2004 to 2010)	1.8	2.7
Validation (2004 to 2010)	1.9	2.7
Validation (2011 to 2015)	1.8	2.5

The calibration and validation residual statistics for the period 2004 to 2010 compare closely, and demonstrate that the use of the PRISM data source, in place of the McMillin Reservoir data, was valid. The residual statistics for the period from 2011 to 2015 compares closely to the earlier period, and validates the model results for the conditions simulated.

Table 6 shows the residual statistics for head targets during model validation, and can be compared to Table 4 which provides statistics for head targets during model calibration. Specifically, the residual statistics for the model validation meets the industry standard for a reliable groundwater model.

5.4.2 Validation of Groundwater Levels over Time

Similar to calibration evaluation, the DuPont model head results were consistently validated over two time scales, monthly and annual, as listed in Table 6. Similar residual statistics over time indicated no temporal trends, and validated the model accuracy.

5.4.3 Validation of Groundwater Levels at Individual Wells

Overall, individual monitoring wells in the DuPont model showed good model fit for the validation period. Based on the validation model results, head target residual statistics for individual wells are provided in Table 7. The validation results provided similar well-specific residual statistics as the model calibration results.

The top graphs on Figure 15 show observed and calculated groundwater levels over time at individual monitoring wells. The middle graphs on Figure 15 compare the calculated and observed groundwater levels at individual wells. These graphs illustrate the offset and scatter described in the residual statistics, as well as the ranges in observed and calculated groundwater levels.

5.5 Further Refinement of Model Results

During calibration, the DuPont model was updated by including additional hydrologic complexity to better simulate the observed groundwater conditions. Some real-world complexity could not be incorporated in the model, and resulted in model bias quantified in the residual statistics. Therefore, the raw model results were refined to reduce model bias in groundwater levels calculated at individual wells using deterministic regression methods (Hill and Tiedeman, 2007). Similar methods were also used to improve the accuracy of the predicted groundwater levels (Xu et al., 2012; Doherty and Cristensen, 2011) for individual wells discussed in Section 6.

The trend-line analysis used to refine the model-calculated groundwater levels is shown on Figure 15 for each monitoring well (except 88-2-VD). To avoid introducing additional bias by refining groundwater level results for only wells with poorer calibration, trend-line analysis was performed for all wells. The top plot for each well on Figure 15 shows observed and validated groundwater water levels over time. The middle plot for each well on Figure 15 shows the trend-line analysis for observed and calculated water levels to determine the best-fit line, or "refinement trend line". The best-fit line also accounts for local hydrogeology by establishing a control point at elevation 120 feet NGVD29, which is the approximate contact elevation between the Vashon Outwash and the Olympia Beds. This allows for correlation of model-predicted results outside the range of observed water levels, and is most applicable for wells CHMW-1, CHMW-2, CHMW-3, and CHMW-4. The refined baseline groundwater levels have been corrected for the offset and slope in the refinement trend line, but do not account for the scatter around the 1:1 line. The bottom plot for each well on Figure 15 shows the observed and refined baseline groundwater levels.

Post-model refinement statistics for individual wells are provided in Table 7, and are described in more detail below:

- The refined mean residual was zero for all monitoring wells because the refinement method accounts for the well-specific offset.
- The refined standard deviation of residuals for all monitoring wells was similar to, and less than, the raw calibrated value.
- The refined sum of squared residuals was less than the calibrated value.
- The refined root mean square error was less than the calibrated value, and similar to the refined standard deviation of residuals.

Table 7 provides the refined range in groundwater levels, for comparison with the validation results and observed values. The trend-line analysis results in a range in groundwater levels of approximately 104 percent of observed values, on average.

In summary, the refinement method greatly improves the accuracy of model results, as measured by mean residual and other residual statistics. The refinement method is limited to the model-calculated groundwater levels at head targets, and does not extend to other model results such as groundwater balance analysis.

5.6 Groundwater Balance Analysis

The groundwater balance for the calibrated DuPont model provides baseline conditions to be used for comparison with the predictive future mining. The groundwater balance provides information on water inputs, outputs, and changes in aquifer storage during the model timeframe. Analysis of the components of the DuPont model groundwater balance allows comparison of baseline conditions to predicted conditions during the mining process.

The average values from the models (not including the first stress period) were used for the analysis. The results of the water balance analysis are presented below for the overall

model and for the wetland complex. Observed flows in the Diversion Canal and Sequalitchew Creek ravine were compared to model results.

The trend-line analysis used to refine model-calculated groundwater levels was not applied to the model-calculated groundwater balance. Groundwater balance elements were not monitored directly, and did not serve as model calibration targets.

5.6.1 Overall Groundwater Balance Analysis

The overall groundwater balance is consistent with the description of model boundary conditions above, and is expressed by the following equation:

$$R + GWin + WLinf = Dsw + Dwell + Dmine + GWout + \Delta S$$

Where:

R is recharge to groundwater from precipitation;

GWin is groundwater inflow to the model area;

WLinf is wetland infiltration to groundwater;

Dsw is groundwater discharge to surface water;

Dwell is groundwater discharge from dewatering wells (future mining Steps 1, 2, and 3 only);

Dmine is groundwater discharge into the mine (future mining Step 4 only);

GWout is groundwater outflow from the model area; and

ΔS is change in aquifer storage.

All terms in the water balance equation have units of cubic feet per second (cfs).

Time-averaged groundwater balances are presented on Figure 19, which shows a column chart and a table with rates provided in cfs. For the baseline model:

- Recharge and groundwater inflow represented approximately 13 and 83 percent of all model inflows, on average.
- The average infiltration from the wetland complex was approximately 5 cfs, and represented approximately 3.4 percent of all model inflows.
- The average change in aquifer storage was slightly positive, reflecting the transient boundary conditions assigned in the model, and represented 0.2 percent of all model inflows.
- Average groundwater outflow along the Puget Sound shoreline represented approximately 91 percent of all model outflows.
- Discharge to surface water (e.g., Sequalitchew Lake, wetlands, Sequalitchew Creek, Diversion Canal) represented the balance of model outflows (approximately 9 percent, on average). Dewatering wells were not simulated in the baseline model.

Figure 20 shows a line chart of the baseline model groundwater balance over the model timeframe, with rates provided in cfs. The monthly variability in recharge is largely balanced by changes in aquifer storage and discharge to surface water.

5.6.2 Wetland Complex Groundwater Balance Analysis

For the purposes of the groundwater balance analysis, wetlands were grouped consistent with the previous water balance analysis (Aspect, 2004a) as follows:

- Bell, Hamer, and McKay (BHM) Marshes
- East Edmond Marsh (East EM)
- West Edmond Marsh (West EM)

Time-averaged infiltration and discharge rates for the wetland complex are presented on Figure 21. For the baseline model:

- Infiltration in BHM Marshes represented approximately 29 percent of the total wetland infiltration, on average.
- Average infiltration in East EM, with the peat removed from the “cookie cutter” channel, represented approximately 68 percent of the total wetland infiltration.
- Average infiltration in West EM represented approximately 3 percent of the total wetland infiltration.
- For the combined wetlands, the average groundwater-to-surface water discharge was approximately 19 percent of infiltration from the wetlands.
- Average groundwater-to-surface water discharge rates to the BHM Marshes, East EM, and West EM were approximately 66, 26, and 7 percent, respectively, of total groundwater-to-surface water discharge within the wetlands.

Figure 22 shows a line chart of the infiltration and discharge for the wetland groups under baseline conditions, as well as the net wetland flow. Infiltration rates at the West EM were the lowest, occurred with the lowest frequency, and were the least sensitive to seasonal precipitation patterns, compared to the other wetland groups.

6 Model Predictions for Future Mining Conditions

Following calibration and validation, the DuPont model was used to predict decreases in groundwater conditions during the four sequential future steps of proposed dewatering and mining activity in the South Parcel. As described in Section 4.6.5, dewatering Steps 1, 2, and 3 simulated 10, 24, and 66 active dewatering wells, respectively. Step 4 simulated the post-mining condition with pumping terminated and groundwater passively discharging at the toe of the newly mined slope. For direct comparison with baseline model results, predictive models used the same baseline boundary conditions as the validation model, except for pumping at active dewatering wells.

Model results indicate that pumping rates will equilibrate within one month, and water levels will largely equilibrate within 60 days of a change in pumping rates. For the purposes of this modeling effort, we assumed surface water levels in the wetlands will be similar to historical conditions.

Results of the predictive models are discussed below by dewatering phase, in terms of predicted decreases in groundwater levels. To support the discussion, predicted decreases in groundwater levels are presented in a table, graphs, and maps. Baseline groundwater levels are sensitive to seasonal and longer-term precipitation patterns (e.g., see Figure 15), and groundwater levels during the four dewatering phases are predicted to likewise remain sensitive to precipitation patterns.

For each of the monitoring wells and each of the dewatering steps, Table 8 provides the maximum decrease in groundwater level based on refined model results, with and without including model uncertainty. For the purposes of communicating refined model results, we focus on the maximum decrease in groundwater level without including model uncertainty represented by the values on the left half of Table 8. Additional discussion of model uncertainty is provided in Section 6.5.

Figure 23 provides a collection of graphs comparing groundwater levels (elevations) for each dewatering step by well. The upper graphs on Figure 23 compare baseline groundwater levels and predicted groundwater levels for each of the four dewatering phases. The error bars illustrate the minimum groundwater levels at the 95-percent confidence interval, as a measure of model uncertainty. The 95-percent confidence interval was calculated using the 1-tailed test and the well-specific standard deviation of residuals from the residual statistics for the entire 11-year model validation period. For predictive model results, the 95-percent confidence interval was increased proportional to the average water level decrease at that location. Additional discussion of model uncertainty is provided in Section 6.5.

The middle graphs on Figure 23 show the ranges in monthly groundwater level elevations for baseline conditions and each of the four dewatering phases. The color bars reflect the potential effects of annual hydrologic variability. As described above, the error bars illustrate the minimum groundwater level at the 95-percent confidence interval, as a measure of model uncertainty.

The lower graphs on Figure 23 show the range in monthly groundwater levels decrease from baseline for each of the four dewatering steps. The color bars reflect the potential effects of annual hydrologic variability. As described above, the error bars illustrate the minimum groundwater level at the 95-percent confidence interval, as a measure of model uncertainty.

Figure 24a through Figure 24d shows maps of predicted maximum groundwater level decreases from baseline conditions for each of the four dewatering steps. The contour lines on Figure 24a through Figure 24d are lines of equal groundwater level decrease. Predicted groundwater level decreases during the planned four mining steps are described below.

6.1 Future Mining Step 1: Initial 10-well Dewatering Test

Step 1 dewatering will include 10 active wells located in the northern portion of the South Parcel, as shown on Figure 14. To simulate Step 1, the validated model was modified by adding 10 wells screened across the Steilacoom Gravels and Vashon Outwash. Wells were simulated to pump up to 1 cfs each unless the available drawdown in the well limited the pumping rate. After the first month of pumping all 10 wells, the combined pumping rate is predicted to be approximately 3.6 cfs, on average, and up to approximately 5.5 cfs during the wet season.

Groundwater level decreases are predicted to stabilize within approximately 60 days after pumping starts based on model results. During Step 1, the model-predicted decreases in groundwater levels are most evident at monitoring wells CHMW-2s and CHMW-2D, which are the closest monitoring wells to the proposed location of the Step 1 dewatering wells (see Figure 24a through Figure 24d; monitoring well locations are depicted on Figure 4). At more distant monitoring wells, the predicted groundwater level decreases are less than half the observed range in baseline groundwater levels. The maximum groundwater level decrease at CHMW-2D is predicted to be approximately 8.8 feet. The maximum groundwater level decrease at upgradient monitoring well MW-D-3 (adjacent to the Diversion Canal east of the mine expansion) is predicted to be approximately 1.8 feet. The maximum groundwater level decrease at monitoring wells MW-EM-1D and MW-EM-2D (in Edmonds Marsh) is predicted to be approximately 0.5 foot and 0.1 foot, respectively.

During Step 1, little or no effects on wetlands or groundwater discharge to Sequalitchew Creek were predicted by the model. The overall average wetland infiltration rate is predicted to remain similar to baseline conditions (Figure 19). The predicted average rates of wetland infiltration to groundwater, and discharge from wetland to surface water, are similar to baseline conditions (Figure 21). The timing of net wetland flow (wetland infiltration to groundwater and discharge from the wetland to surface water) is predicted to be approximately the same as baseline conditions (Figure 22). During Step 1, the JBLM water supply overflow showed no significant change in flow rates compared to baseline conditions.

6.2 Future Mining Step 2: Active Dewatering In Preparation for Mining

During Step 2, the dewatering well network will be expanded to the south along the South Parcel mine perimeter as well as adding a few wells in the interior as shown in Figure 14. To simulate Step 2, the validated model was modified by adding 24 wells screened across the Steilacoom Gravels and Vashon Outwash. The dewatering wells are arranged in two lines on either side of the initial mine trough, with 19 boundary wells and 5 inner wells. Wells were simulated to pump up to 1 cfs each unless the available drawdown in the well limited the pumping rate. After the first month of pumping all 24 wells, the combined pumping rate is predicted to be approximately 5.2 cfs, on average, and up to approximately 8.8 cfs during the wet season.

Groundwater level decreases at upgradient monitoring wells are predicted to stabilize within approximately 60 days after pumping starts based on model results. During Step 2, the maximum groundwater level decreases at CHMW-2D and CHMW-1 are predicted to be approximately 45 feet and 5.2 feet, respectively (see Table 8 and Figures 23 and 24). At this step, monitoring well CHMW-2D will be interior to the dewatering well network. The maximum groundwater level decrease at upgradient monitoring well MW-D-3 is predicted to be approximately 4.3 feet. The maximum groundwater level decreases at MW-EM-1D and MW-EM-2D are predicted to be approximately 1.5 feet and 0.2 feet, respectively.

During Step 2, the predicted overall wetland infiltration rate will be approximately 0.2 cfs greater than baseline conditions (Figure 19), assuming wetland water levels are maintained. Most of the predicted changes in infiltration will occur in the East Edmond Marsh area (Figure 21). The predicted timing of net wetland flow will remain approximately the same as baseline conditions (Figure 22). Groundwater discharge to Sequalitchew Creek during Step 2 is predicted to remain similar to baseline conditions. During Step 2, the JBLM water supply overflow showed no significant change in flow rates compared to baseline conditions.

6.3 Future Mining Step 3: Active Dewatering During Mining

Step 3 dewatering was simulated with 66 active wells along the eastern and southern South Parcel mine boundary, as shown in Figure 14. The dewatering wells are arranged in two lines on either side of the initial mine trough, with 54 boundary wells and 12 interior wells. The combined pumping rate is predicted to be approximately 6.9 cfs, on average, and up to approximately 12.2 cfs during the wet season. It may not be necessary to operate all dewatering wells as the final mine trough progresses, once an alternative (passive) dewatering system is in place. However, for the purposes of evaluating the maximum effects of dewatering during Step 3, the DuPont model simulated all dewatering wells operating simultaneously as a conservative assumption.

Groundwater level decreases are predicted to stabilize within approximately 60 days after pumping starts based on model results. During Step 3, the maximum groundwater level decreases at CHMW-2D, CHMW-1, CHMW-4D, and CHMW-3D are predicted to be approximately 51 feet, 60 feet, 15 feet, and 57 feet, respectively (see Table 8 and Figures 23 and 24). The maximum groundwater level decreases at MW-EM-1D and MW-EM-2D are predicted to be approximately 5.1 feet and 0.4 feet, respectively. The maximum groundwater level decreases at upgradient monitoring wells MW-D-3 and MW-93-MFS-C-5 are predicted to be approximately 7.7 feet and 4.2 feet, respectively. The groundwater levels during Step 3 are predicted to be approximately 10 to 20 feet above the Olympia Beds along the mine trough.

During Step 3, the predicted overall wetland infiltration rate will be approximately 0.6 cfs greater than baseline conditions (Figure 19), assuming wetland water levels are constant. Most of the predicted changes in infiltration will occur in the East Edmond Marsh area (Figure 21). Based on model results, the lower groundwater levels under West Edmond Marsh will reduce groundwater discharge to surface water during Step 3 (Figure 22). Groundwater discharge to Sequalitchew Creek during Step 3 is predicted to be 0.5 cfs less than baseline conditions, on average, with the greatest decreases during the wet

season. As with Steps 1 and 2, the JBLM water supply overflow showed no significant change in flow rates in Step 3 compared to baseline conditions.

6.4 Future Mining Step 4: Post-Mining Conditions

During Step 4, pumping from the dewatering well network will cease, groundwater will emanate from the toe of the mined slope, forming wetlands along the toe of the slope and on portions of the mine floor of the South Parcel. Overflow from the wetlands will be collected and conveyed to an infiltration pond on the floor of the existing mine, . As described in Section 4.3.1, the Step 4 ground surface (model top) elevation was modified to reflect the final mine grade (Figure 6) to simulate passive groundwater discharge into the mine. The flow rate of groundwater discharging into the mine is predicted to be 6.9 cfs, on average, and up to 13.7 cfs during the wet season. Collected groundwater discharging into the mine will be re-infiltrated in the western portion of the mine area. The re-infiltration of collected groundwater seeping into the mine will recharge the Sea Level Aquifer and will not affect groundwater levels in the Vashon Outwash aquifer. As such, re-infiltration was not simulated in the DuPont model.

Groundwater level decreases are predicted to stabilize within approximately 60 days after pumping stops based on model results. Groundwater levels will recover slightly relative to the active pumping of Step 3. During Step 4, the maximum groundwater level decreases at monitoring wells along the mine trough (CHMW-2D, CHMW-1, CHMW-4D, and CHMW-3S), are predicted to be approximately 32 feet, 30 feet, 14.0 feet, and 50 feet, respectively. The maximum groundwater level decreases at upgradient monitoring wells MW-D-3 and MW-93-MFS-C-5 are predicted to be approximately 6.6 feet and 3.6 feet, respectively. The maximum groundwater level decreases at MW-EM-1D and MW-EM-2D are predicted to be approximately 4.7 feet and 0.4 feet, respectively (see Figures 23 and 24).

During Step 4, the predicted overall wetland infiltration rate will be approximately 0.5 cfs greater than baseline conditions (Figure 19), assuming stream restoration efforts maintain wetland water levels. Most of the predicted changes in infiltration will occur in East Edmond Marsh area (Figure 21). Based on model results, the result of lower groundwater levels under West EM will reduce groundwater discharge to surface water during Step 4 than during Baseline conditions (Figure 22). Groundwater discharge to Sequalitchew Creek during Step 4 is predicted to be 0.5 cfs less than baseline conditions, on average, with the greatest decreases during the wet season.

During Step 4, the JBLM water supply overflow showed no significant change in flow rates compared to baseline conditions (Figure 19).

6.5 Quantifying Model Uncertainty

All predictions of any groundwater model, including the DuPont model, are subject to uncertainty – for example, in the model parameters and boundary conditions, conceptual model construction, and future conditions. While these some of these uncertainties can be controlled through the robustness of the data collection, calibration, and validation process, they cannot be eliminated and some uncertainties, particularly related to future conditions, are not knowable.

One method for acknowledging uncertainty in model predictions is to quantify the knowable components (i.e., model bias) and incorporate it into the evaluation of future conditions. We can calculate a lower confidence limit on the predicted groundwater levels, then perform environmental evaluations based on those lower limits. If the environmental analyses are still favorable, then we can have increased confidence in the groundwater model and a smaller chance of an adverse outcome.

We calculated a measure of overall model bias based on the scaled standard deviation of the differences between the validated model water levels and the measured water levels at each groundwater monitoring location over the validation period. The scaled standard deviation is the standard deviation divided by the range in the observed water levels. This analysis used the raw validation results, before application of post-modeling refinement. As such, this analysis incorporates uncertainty from the model validation (baseline conditions, without dewatering) and application of the model to the future dewatering scenarios.

A lower 95-percent confidence interval for predicted water levels was calculated by multiplying the scaled standard deviation by the sum of the range in future water levels and the drawdown and the z-value corresponding to a one-tailed 95-percent confidence interval for a normal distribution (i.e., z = 1.28). Expressed mathematically, this uncertainty is equal to:

1.28 * (scaled standard deviation) * (maximum drawdown + observed range).

As an example of this approach, consider monitoring well CHMW-2D. The observed range in water levels from 2004 to 2015 was 6.89 feet at CHMW-2D, and the standard deviation of the validated model is 0.66 feet (Table 7). Thus, the scaled standard deviation is 9.6 percent (0.66 feet/6.89 feet).

The maximum drawdown at CHMW-2D during Step 1 is predicted to be 8.8 feet (Table 8), based on refined model results. The model uncertainty is therefore approximately 1.9 feet (1.28 * 9.5% * (8.8 ft + 6.89 ft). Thus, the maximum predicted drawdown, including model uncertainty, is predicted to be approximately 10.7 feet (Table 8).

Similar calculations were made for each well in each month in each dewatering step, and are the basis for the minimum groundwater levels described in the following section.

6.6 Minimum Groundwater Levels in Each Dewatering Step

A primary use of the output from the predictive model runs is to establish minimum groundwater levels at the various monitoring wells for each dewatering step. These minimum water levels will be evaluated to determine environmental impacts, and if acceptable relative to the mitigation provided by the Restoration Plan, will be used as performance thresholds for the dewatering program. Measured groundwater levels below the performance threshold would trigger adaptive management, as described in the South Parcel Monitoring Plan (Aspect, 2017).

The minimum groundwater levels for each monitoring well, in each month, in each dewatering step are provided in Table 9. These minimum groundwater levels are the 95% lower confidence interval for the groundwater level predicted by the DuPont Model, and have been calculated for each existing monitoring well for each month of each

dewatering step. Minimum groundwater levels can be calculated with the DuPont Model for any new monitoring wells once the location has been determined.

Steps 1 and 2 will not last through all months of a year, but precise starting months and duration are not firmly established. Minimum groundwater levels were calculated for all months to allow flexibility in the future.

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Limitations

Work for this project was performed and this report prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. This report does not represent a legal opinion. No other warranty, expressed or implied, is made.

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Tables

Table 1: Summary of Hydrostratigraphic Units and Calibrated Parameter Values

Project #040001 -South Parcel Mine Expansion
Dupont, WA

Hydrostratigraphic Unit in DuPont Model	Correlated USGS Hydrogeologic Unit and Partial Description	Principal Layers in DuPont Model	Horizontal Hydraulic Conductivity (feet/day)					Vertical Anisotropy (-)	Specific Yield (-)	Specific Storage (1/foot)
			Max.	75 percentile	Average	25 percentile	Min.	horizontal: vertical		
Steilacoom Gravel	A1 – "recessional outwash…sand and gravel deposited by large meltwater streams…"	1,2	3,900	1,600	1,100	350	36	2.7	0.07	6.1E-05
Upper Confining Unit	A2 – "low-permeability unit composed of Vashon till and lesser amounts of ice-contact, moraine and fine-grained glaciolacustrine deposits…"	3	1.61	0.47	0.33	0.16	0.017	1.0	0.07	5.0E-05
Vashon Outwash	A3 – "aquifer composed of Vashon advance outwash…"	4,5	49	11	7.7	2.4	0.27	15.1	0.09	2.7E-05
Olympia Beds (Qob)	B – "low-permeability unit composed of fine-grained silts and clays deposited during the Olympia interglacial…"	6,7	0.018 (uniform)					10.0	0.09	1.1E-04
Sea Level Aquifer	C – "aquifer composed of pre-Olympia glacial drift deposits consisteing of sand and gravel…"	8,9	690 (uniform)					6.3	0.18	6.0E-05

Table 2: Summary of Wetland Properties used in Model

Project #040001 -South Parcel Mine Expansion
Dupont, WA

	Drain and River Cells			River Cells Only			
Wetland	Area In Model (acres)	Staff Gage(s) used to Establish Stage	Average Stage (feet)	Average Vertical K (feet/day)	Average Bottom Elevation (feet)	Wetland Water Depth (feet)	
						Average	Standard Deviation
Bell Marsh	11	SG-BM-1	218.4	0.55	215.6	2.8	1.0
McKay Marsh	35	SG-MKM-1	215.2	0.0086	213.6	1.6	1.1
Hamer Marsh	67	SG-HM-1	213.7	0.0090	211.7	2.0	0.9
East Edmond Marsh (JBLM)	25	SG-EM-3E, SG-SCM-1	212.1	0.020	210.0	2.1	0.5
East Edmond Marsh (JBLM) - Channel	10		212.1	11	210.0	2.1	0.5
East Edmond Marsh	27	SG-EM-2E, SG-EM-3W	211.9	0.0013	210.0	1.9	0.5
East Edmond Marsh - Channel	8		211.9	39	210.0	1.9	0.5
West Edmond Marsh - Eastern	29	SG-EM-2W, SG-EM-1/1A	210.4	0.0010	207.7	2.7	0.4
West Edmond Marsh - Middle	25		208.9	0.0026	206.6	2.2	1.1
West Edmond Marsh - Western	7		207.4	0.0015	205.8	1.6	1.4

Notes:

Wetlands were simulated with drains cells (for surface runoff) and river cells (for connection with aquifer) across the same areas, and with the same stage values.

The wetland area was assigned based on historical aerial photos.

Monthly-variable stages were assigned based on staff gage observations. Where two staff gages were used, stages were linearly interpolated.

Drain cells were uniformly assigned a vertical hydraulic conductivity (vertical K) of 10 feet per day.

Vertical K for river cells was calibrated.

The wetland bottom elevation was estimated.

The wetland peat was assigned a thickness of 1 foot.

The wetland water depth provides information on seasonal differences in water levels.

Table 3: Parameters Adjusted during Calibration

Project #040001 -South Parcel Mine Expansion
Dupont, WA

Hydraulic Conductivity		
Hydrostratigraphic Unit	***Horizontal Hydraulic Conductivity***	***Vertical Hydraulic Conductivity***
Steilacoom Gravel	Regularization with Pilot Points	Anisotropy Maintained
Upper Confining Unit	Regularization with Pilot Points	Anisotropy Maintained
Vashon Outwash	Regularization with Pilot Points	Anisotropy Maintained
Olympia Beds	Piecewise Constancy	Anisotropy Maintained
Sea Level Aquifer	Piecewise Constancy	Anisotropy Maintained
Storage Coefficients		
Hydrostratigraphic Unit	***Specific Yield***	***Specific Storage***
Steilacoom Gravel	Piecewise Constancy	Piecewise Constancy
Upper Confining Unit	Piecewise Constancy	Piecewise Constancy
Vashon Outwash	Piecewise Constancy	Piecewise Constancy
Olympia Beds	Piecewise Constancy	Piecewise Constancy
Sea Level Aquifer	Piecewise Constancy	Piecewise Constancy

River Cells	
Wetland	***Conductance***
Bell Marsh	Piecewise Constancy
McKay Marsh	Piecewise Constancy
Hamer Marsh	Piecewise Constancy
East Edmond Marsh (JBLM)	Piecewise Constancy
East Edmond Marsh (JBLM) - Channel	Piecewise Constancy
East Edmond Marsh	Piecewise Constancy
East Edmond - Channel	Piecewise Constancy
West Edmond Marsh - Eastern	Piecewise Constancy
West Edmond Marsh - Middle	Piecewise Constancy
West Edmond Marsh - Western	Piecewise Constancy

Table 4: Model Calibration - Residual Statistics - Overall and Over Time

Project #040001 -South Parcel Mine Expansion
Dupont, WA

		Residual Statistics					Range in Observed Values [Max. - Min.] (feet)	Scaled Statistics	
		Number of Observations	Mean (feet)	Standard Deviation (feet)	Sum of Squares	Root Mean Squared Error (feet)		Standard Deviation	Root Mean Square Error
Overall Model Fit									
Head Targets		1,467	1.77	2.71	15,382	3.24	30.81	9%	11%
Drawdown Targets		1,467	1.17	1.40	4,874	1.82	11.51	12%	16%
Head Difference Targets		414	0.11	1.80	1,343	1.80	13.14	14%	14%
Model Fit By Calendar Year									
Head Targets	2004	192	1.63	3.40	2,709	3.76	27.52	12%	14%
	2005	208	1.90	2.69	2,251	3.29	29.98	9%	11%
	2006	205	1.99	2.55	2,135	3.23	30.81	8%	10%
	2007	212	1.88	2.47	2,040	3.10	29.51	8%	11%
	2008	228	1.75	2.65	2,294	3.17	30.16	9%	11%
	2009	209	1.61	2.61	1,961	3.06	29.58	9%	10%
	2010	213	1.60	2.61	1,992	3.06	28.8	9%	11%
Model Fit By Month									
Head Targets	January	103	2.41	2.73	1,358	3.63	25.82	11%	14%
	February	102	2.14	2.73	1,222	3.46	26.43	10%	13%
	March	133	2.10	3.06	1,823	3.70	27.09	11%	14%
	April	134	2.37	3.01	1,959	3.82	27.86	11%	14%
	May	121	1.91	2.84	1,409	3.41	27.81	10%	12%
	June	122	1.74	2.66	1,223	3.17	28.12	9%	11%
	July	130	1.61	2.51	1,146	2.97	28.38	9%	10%
	August	124	1.41	2.43	976	2.81	28.26	9%	10%
	September	103	1.21	2.40	736	2.67	28.87	8%	9%
	October	148	0.90	2.52	1,055	2.67	29.92	8%	9%
	November	124	1.67	2.52	1,126	3.01	28.53	9%	11%
	December	123	1.92	2.71	1,348	3.31	27.54	10%	12%

Table 5: Model Calibration - Residual Statistics By Well

Project #040001 -South Parcel Mine Expansion
Dupont, WA

Well ID	Calibration Results							
	Residual Statistics (residual = observed - calculated)					Range in Observed Water Levels [Max. - Min.] (feet)	Range in Calculated Water Levels [Max. - Min.] (feet)
	Number of Observations	Mean (feet)	Standard Deviation (feet)	Sum of Squares	Root Mean Squared Error (feet)		
MW-EM-1s	79	5.26	1.50	2,362	5.47	7.02	7.50
MW-EM-1d	85	4.95	0.99	2,168	5.05	6.91	7.92
MW-EM-2s	82	0.23	0.35	14	0.42	2.28	2.39
MW-EM-2d	85	0.39	0.30	20	0.49	2.39	2.39
MW-EM-3	85	0.10	0.14	2	0.17	2.49	2.01
CHMW-1	85	-0.69	0.91	110	1.14	9.48	6.75
CHMW-2S	85	3.30	0.62	955	3.35	6.84	5.77
CHMW-2D	85	3.65	0.62	1,168	3.71	6.81	5.74
CHMW-3S	85	5.25	1.60	2,562	5.49	10.8	5.90
CHMW-3D	83	6.05	1.55	3,232	6.24	10.43	5.94
CHMW-4S	85	1.41	0.99	251	1.72	9.54	7.70
CHMW-4D	85	-0.18	0.90	72	0.92	9.40	7.57
MW-SRC-2	79	0.17	0.61	31	0.63	6.61	4.25
MW-D-3	81	2.11	1.05	450	2.36	7.77	5.49
MW-93-MFS-C5-3	83	-2.92	0.97	787	3.08	7.26	4.55
88-2-VD	10	-7.49	0.74	565	7.52	2.85	0.75
MW-BM-1	80	2.39	0.51	477	2.44	5.45	6.47
MW-HM-1	80	0.49	0.43	34	0.65	4.79	4.52
MW-PL-1	45	0.27	1.65	123	1.66	6.04	10.27

Notes:
1. Model results and statistics are presented at the typical field-measurement precision (0.01 ft).

Table 6: Model Validation - Residual Statistics Overall and Over Time

Project #040001 -South Parcel Mine Expansion
Dupont, WA

		Residual Statistics					Range in Observed Values [Max. - Min.] (feet)	Scaled Statistics	
		Number of Observations	Mean (feet)	Standard Deviation (feet)	Sum of Squares	Root Mean Squared Error (feet)		Standard Deviation	Root Mean Square Error
Overall Model Fit									
Head Targets		2,503	1.86	2.65	26,217	3.24	31.08	9%	10%
Model Fit By Calendar Year									
Head Targets	2004	193	1.66	3.38	2,732	3.76	27.52	12%	14%
	2005	208	2.04	2.72	2,394	3.39	29.98	9%	11%
	2006	205	2.17	2.58	2,317	3.36	30.81	8%	11%
	2007	212	2.06	2.52	2,242	3.25	29.51	9%	11%
	2008	228	1.87	2.67	2,417	3.26	30.16	9%	11%
	2009	209	1.69	2.62	2,023	3.11	29.58	9%	11%
	2010	213	1.88	2.64	2,239	3.24	28.8	9%	11%
	2011	203	1.58	2.48	1,751	2.94	29.26	8%	10%
	2012	206	1.89	2.47	1,991	3.11	29.44	8%	11%
	2013	208	1.68	2.54	1,918	3.04	28.76	9%	11%
	2014	209	1.85	2.55	2,066	3.14	28.65	9%	11%
	2015	209	1.92	2.55	2,128	3.19	29.8	9%	11%

Table 6: Model Validation - Residual Statistics Overall and Over Time

Project #040001 -South Parcel Mine Expansion
Dupont, WA

		Residual Statistics					Range in Observed Values [Max. - Min.] (feet)	Scaled Statistics	
		Number of Observations	Mean (feet)	Standard Deviation (feet)	Sum of Squares	Root Mean Squared Error (feet)		Standard Deviation	Root Mean Square Error
Overall Model Fit									
Head Targets		2,503	1.86	2.65	26,217	3.24	31.08	9%	10%
Model Fit By Month									
Head Targets	January	187	2.31	2.74	2,399	3.58	26.7	10%	13%
	February	154	2.21	2.73	1,893	3.51	26.51	10%	13%
	March	217	2.28	2.89	2,925	3.67	27.21	11%	13%
	April	252	2.39	2.84	3,464	3.71	28.3	10%	13%
	May	208	1.99	2.73	2,363	3.37	28.51	10%	12%
	June	193	1.84	2.60	1,953	3.18	28.99	9%	11%
	July	197	1.69	2.47	1,760	2.99	29.18	8%	10%
	August	231	1.51	2.35	1,802	2.79	29.29	8%	10%
	September	171	1.48	2.33	1,295	2.75	29.23	8%	9%
	October	253	1.33	2.57	2,116	2.89	30.78	8%	9%
	November	230	1.56	2.52	2,013	2.96	28.83	9%	10%
	December	209	1.86	2.69	2,230	3.27	27.69	10%	12%

Table 7: Model Calibration - Residual Statistics By Well

Project #040001 -South Parcel Mine Expansion
Dupont, WA

Well ID	Validation Results							Post-Model Refinement Results				
	Residual Statistics (residual = observed - calculated)					Range in Observed Water Levels [Max. - Min.] (feet)	Range in Calculated Water Levels [Max. - Min.] (feet)	Residual Statistics (residual = observed - calculated)				Range in Calculated Water Levels [Max. - Min.] (feet)
	Number of Observations	Mean (feet)	Standard Deviation (feet)	Sum of Squares	Root Mean Squared Error (feet)			Mean (feet)	Standard Deviation (feet)	Sum of Squares	Root Mean Squared Error (feet)	
MW-EM-1s	136	4.99	1.75	3,799	5.29	7.56	10.44	0.00	1.74	411	1.74	9.65
MW-EM-1d	131	4.97	0.98	3,355	5.06	7.9	10.92	0.00	0.94	115	0.94	9.43
MW-EM-2s	140	0.24	0.35	25	0.42	2.39	2.90	0.00	0.23	7	0.23	1.75
MW-EM-2d	144	0.38	0.30	34	0.48	2.54	2.91	0.00	0.20	6	0.20	1.94
MW-EM-3	144	0.11	0.14	5	0.18	3	2.59	0.00	0.13	3	0.13	2.88
CHMW-1	143	-0.55	0.92	163	1.07	9.48	9.08	0.00	0.88	109	0.87	10.63
CHMW-2S	145	3.46	0.71	1,804	3.53	7.55	7.16	0.00	0.70	71	0.70	7.63
CHMW-2D	145	3.79	0.66	2,141	3.84	6.89	7.14	0.00	0.65	61	0.65	7.56
CHMW-3S	145	5.41	1.55	4,596	5.63	10.8	8.15	0.00	1.33	253	1.32	12.54
CHMW-3D	143	6.17	1.51	5,771	6.35	10.43	8.17	0.00	1.23	216	1.23	13.00
CHMW-4S	145	1.37	1.03	425	1.71	9.54	10.49	0.00	1.02	150	1.02	11.25
CHMW-4D	145	-0.11	0.92	124	0.92	9.40	10.30	0.00	0.90	117	0.90	11.26
MW-SRC-2	138	0.28	0.61	62	0.67	6.7	5.17	0.01	0.49	32	0.49	5.84
MW-D-3	141	2.36	0.97	920	2.55	7.77	6.54	0.00	0.96	128	0.95	7.42
MW-93-MFS-C5-3	142	-2.76	1.01	1,229	2.94	7.26	5.34	0.00	0.91	118	0.91	7.68
88-2-VD	10	-7.45	0.69	559	7.47	2.85	0.86	0.00	0.48	2	0.46	2.42
MW-BM-1	140	2.39	0.46	831	2.44	5.72	7.53	0.00	0.45	29	0.45	6.95
MW-HM-1	139	0.83	0.59	142	1.01	5.95	4.51	0.00	0.54	40	0.54	5.66
MW-PL-1	86	0.56	1.55	231	1.64	6.04	10.70	0.00	0.84	59	0.83	5.05

Notes:
1. Model results and statistics are presented at the typical field-measurement precision (0.01 ft).

Table 8: Well-Specific Maximum Water Level Changes

Project #040001 -South Parcel Mine Expansion
Dupont, WA

Well ID	Predictive Model Results							
	Maximum Decrease in Water Level based on Refined Model Results				Maximum Decrease in Water Level based on Refined Model Results, and includes Model Uncertainty			
	Step 1	Step 2	Step 3	Step 4	Step 1	Step 2	Step 3	Step 4
MW-EM-1s	0.50	1.61	5.44	5.00	2.90	4.33	9.29	8.73
MW-EM-1d	0.47	1.51	5.12	4.71	1.81	3.01	7.20	6.72
MW-EM-2s	0.06	0.15	0.35	0.33	0.52	0.63	0.87	0.84
MW-EM-2d	0.07	0.17	0.39	0.36	0.46	0.58	0.83	0.80
MW-EM-3	0.01	0.02	0.02	0.02	0.20	0.21	0.21	0.21
CHMW-1	1.30	5.23	59.79	30.47	2.64	7.06	68.41	35.44
CHMW-2S	7.37	45.45	50.98	29.92	9.17	51.82	58.01	34.43
CHMW-2D	8.80	45.20	50.79	31.76	10.71	51.55	57.83	36.47
CHMW-3S	0.83	3.24	53.86	52.76	2.97	5.82	65.73	64.43
CHMW-3D	0.10	2.70	57.02	50.29	2.05	5.14	69.56	61.57
CHMW-4S	0.95	3.14	14.33	13.79	2.40	4.90	17.64	17.02
CHMW-4D	0.76	2.96	15.03	14.01	2.03	4.51	18.10	16.95
MW-SRC-2	0.29	0.33	0.30	0.34	1.11	1.15	1.12	1.16
MW-D-3	1.79	4.27	7.68	6.55	3.33	6.20	10.16	8.85
MW-93-MFS-C5-3	1.40	2.73	4.21	3.63	2.96	4.52	6.27	5.58
88-2-VD	0.40	0.57	1.41	1.35	1.41	1.63	2.72	2.64
MW-BM-1	0.21	0.35	0.39	0.74	0.83	0.98	1.03	1.41
MW-HM-1	0.25	0.41	0.27	0.41	1.03	1.21	1.05	1.22
MW-PL-1	0.10	0.35	1.10	1.01	2.11	2.45	3.44	3.33

Notes:

1. Model predictions are presented at the typical field-measurement precision (0.01 ft).
2. Maximum Change in Water Level based on refined model results.
3. Maximum Change in Water Level calculated for 95% lower confidence interval for 1-tailed test.
4. Shaded values indicate forecasted change in water level exceeds half the range in observed values.

Table 9 - Minimum Predicted Groundwater Levels for Each Dewatering Step

South Parcel Mine Expansion, Proj. No. 040001

Step 1 - Initial Pumping Test

Well	Groundwater Elevation in Feet (NGVD 29)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MW-EM-1S	203.6	202.4	202.9	202.2	202.3	201.4	200.4	200.4	199.5	199.5	202.1	202.9
MW-EM-1D	204.6	203.4	203.9	203.2	203.3	202.5	201.5	201.5	200.7	200.7	203.1	203.9
MW-EM-2S	210.6	210.3	210.4	210.3	210.2	210.0	209.7	209.6	209.3	209.5	210.2	210.4
MW-EM-2D	210.8	210.4	210.6	210.5	210.4	210.2	209.8	209.7	209.4	209.6	210.4	210.5
MW-EM-3	212.1	211.9	211.8	211.9	212.0	211.6	211.4	210.8	210.2	210.3	211.5	211.9
MW-SRC-2	213.2	212.4	212.7	212.6	212.8	212.0	211.4	210.2	209.6	210.5	212.3	212.7
MW-BM-1	218.0	217.0	216.6	217.4	217.3	216.6	216.1	213.1	213.3	214.2	216.8	217.4
MW-HM-1	214.2	213.5	213.3	213.8	213.6	212.7	211.8	211.2	210.6	211.1	213.1	213.6
MW-PL-1	200.8	200.1	200.4	200.1	200.0	199.4	198.6	198.7	198.0	197.7	199.6	200.2
CHMW-1	191.3	189.9	190.4	189.6	189.7	189.0	188.1	188.0	187.4	187.5	190.0	190.7
CHMW-2S	184.6	183.3	183.7	183.0	183.0	182.5	181.7	181.6	181.2	181.4	183.5	184.0
CHMW-2D	183.4	181.8	182.4	181.4	181.5	180.8	179.8	179.7	179.3	179.4	182.1	182.7
CHMW-3S	193.3	191.7	192.4	191.3	191.5	190.6	189.6	189.5	188.7	188.8	191.7	192.6
CHMW-3D	193.2	191.5	192.2	191.1	191.3	190.4	189.2	189.1	188.3	188.4	191.5	192.5
CHMW-4S	196.1	194.7	195.3	194.4	194.6	193.7	192.7	192.6	191.9	191.9	194.6	195.5
CHMW-4D	194.3	192.9	193.5	192.6	192.7	191.9	190.9	190.8	190.1	190.1	192.8	193.6
MW-D-3	196.5	195.3	195.7	195.0	195.1	194.6	193.9	193.7	193.3	193.5	195.6	195.9
MW-93-MFS-C5-3	192.3	191.2	191.7	191.0	191.0	190.5	190.0	189.9	189.5	189.8	191.6	191.7

Table 9 - Minimum Predicted Groundwater Levels for Each Dewatering Step

South Parcel Mine Expansion, Proj. No. 040001

Step 2 - Preparation for Mining/Expanded Dewatering Test

Well	Groundwater Elevation in Feet (NGVD 29)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MW-EM-1S	202.3	201.1	201.6	200.9	201.1	200.1	199.1	199.2	198.4	198.3	200.8	201.5
MW-EM-1D	203.4	202.3	202.8	202.2	202.3	201.4	200.5	200.5	199.7	199.7	202.0	202.7
MW-EM-2S	210.6	210.2	210.3	210.2	210.1	210.0	209.6	209.5	209.2	209.4	210.1	210.3
MW-EM-2D	210.8	210.4	210.5	210.4	210.3	210.1	209.7	209.6	209.3	209.5	210.3	210.5
MW-EM-3	212.1	211.9	211.8	211.9	212.0	211.6	211.4	210.8	210.2	210.3	211.5	211.9
MW-SRC-2	213.2	212.4	212.6	212.6	212.8	212.0	211.4	210.2	209.5	210.5	212.0	212.7
MW-BM-1	218.0	217.0	216.5	217.3	217.2	216.6	216.1	213.0	213.3	214.1	216.8	217.3
MW-HM-1	214.2	213.4	213.3	213.8	213.6	212.7	211.8	211.2	210.5	211.1	213.0	213.6
MW-PL-1	200.4	199.7	200.1	199.8	199.8	199.1	198.2	198.4	197.7	197.4	199.2	199.8
CHMW-1	187.0	185.7	186.3	185.5	185.6	184.9	184.0	184.0	183.3	183.4	185.8	186.4
CHMW-2S	143.8	141.4	142.2	141.0	141.0	140.1	139.1	138.9	138.3	138.6	141.8	142.9
CHMW-2D	142.5	141.0	141.6	140.7	140.7	140.0	139.1	138.9	138.3	138.5	141.2	141.9
CHMW-3S	190.6	189.0	189.8	188.8	189.0	188.1	187.0	187.0	186.2	186.2	189.0	189.8
CHMW-3D	190.2	188.6	189.4	188.3	188.5	187.5	186.3	186.3	185.4	185.3	188.4	189.3
CHMW-4S	193.7	192.3	193.0	192.1	192.3	191.4	190.4	190.4	189.6	189.6	192.2	193.0
CHMW-4D	191.8	190.5	191.2	190.3	190.5	189.6	188.6	188.6	187.8	187.8	190.4	191.1
MW-D-3	193.7	192.5	193.0	192.3	192.3	191.9	191.2	191.1	190.7	190.9	192.9	193.4
MW-93-MFS-C5-3	190.8	189.8	190.3	189.6	189.6	189.1	188.7	188.5	188.2	188.5	190.2	190.5

Table 9 - Minimum Predicted Groundwater Levels for Each Dewatering Step

South Parcel Mine Expansion, Proj. No. 040001

Step 3 - Active Dewatering during Mining

Well	Groundwater Elevation in Feet (NGVD 29)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MW-EM-1S	197.5	196.4	196.9	196.4	196.5	195.6	194.7	194.8	194.1	194.1	196.1	196.8
MW-EM-1D	199.4	198.4	198.9	198.3	198.4	197.6	196.8	196.9	196.2	196.2	198.1	198.7
MW-EM-2S	210.3	210.0	210.1	209.9	209.9	209.7	209.4	209.3	209.0	209.2	209.9	210.0
MW-EM-2D	210.5	210.1	210.3	210.1	210.0	209.8	209.5	209.4	209.1	209.3	210.0	210.2
MW-EM-3	212.1	211.9	211.8	211.9	212.0	211.6	211.4	210.8	210.2	210.3	211.5	211.8
MW-SRC-2	213.2	212.4	212.7	212.6	212.8	212.0	211.4	210.2	209.5	210.5	212.0	212.7
MW-BM-1	217.8	216.8	216.4	217.2	217.1	216.4	215.9	212.8	213.1	213.9	216.7	217.2
MW-HM-1	214.2	213.4	213.3	213.8	213.6	212.7	211.8	211.2	210.4	211.1	213.0	213.6
MW-PL-1	199.4	198.7	199.0	198.8	198.7	198.0	197.1	197.3	196.6	196.2	198.1	198.8
CHMW-1	129.8	129.1	129.4	128.9	128.9	128.5	127.8	127.8	127.3	127.4	129.2	129.5
CHMW-2S	136.0	134.5	135.0	134.1	134.1	133.5	132.9	132.8	132.3	132.5	134.9	135.5
CHMW-2D	135.9	134.7	135.1	134.3	134.2	133.7	133.1	132.9	132.4	132.6	134.9	135.5
CHMW-3S	131.1	128.4	130.3	128.9	129.2	127.9	126.6	127.0	126.2	126.3	129.0	130.2
CHMW-3D	128.3	127.4	127.9	127.6	127.6	126.8	125.8	126.1	125.4	125.1	127.0	127.6
CHMW-4S	181.0	179.7	180.4	179.6	179.7	178.8	177.7	177.8	176.9	176.9	179.5	180.3
CHMW-4D	178.5	177.3	178.0	177.1	177.3	176.4	175.3	175.4	174.5	174.4	177.1	177.8
MW-D-3	189.9	188.6	189.1	188.4	188.4	187.9	187.4	187.3	186.9	187.3	189.1	189.6
MW-93-MFS-C5-3	189.5	188.5	189.0	188.4	188.3	187.9	187.5	187.4	187.2	187.5	189.0	189.3

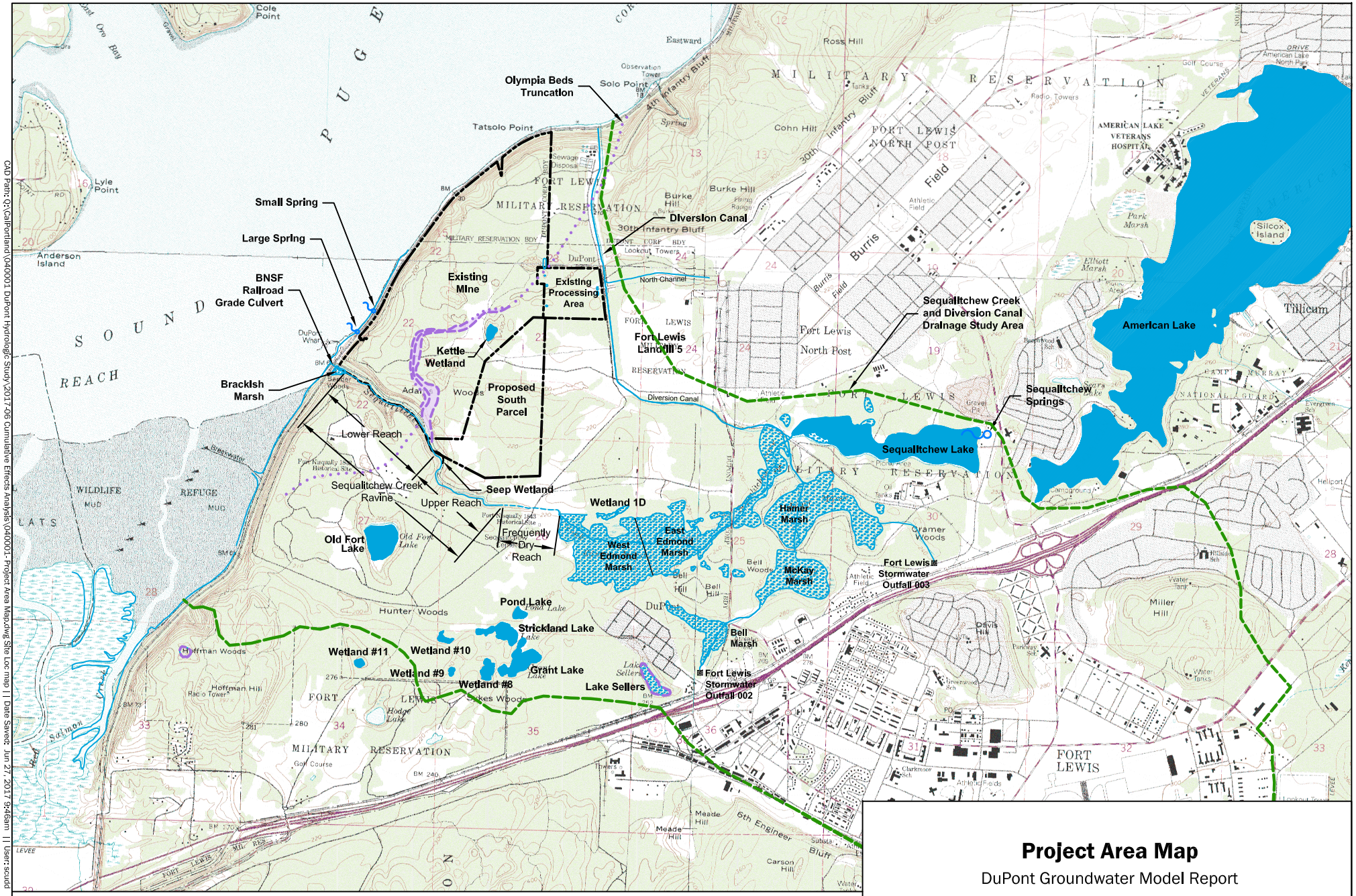
Table 9 - Minimum Predicted Groundwater Levels for Each Dewatering Step

South Parcel Mine Expansion, Proj. No. 040001

Step 4 - Cessation of Active Dewatering

Well	Groundwater Elevation in Feet (NGVD 29)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MW-EM-1S	198.1	197.0	197.6	197.0	197.1	196.2	195.4	195.3	194.8	194.7	196.8	197.4
MW-EM-1D	199.9	198.9	199.4	198.8	199.0	198.2	197.3	197.3	196.7	196.7	198.7	199.3
MW-EM-2S	210.3	210.0	210.1	210.0	209.9	209.7	209.4	209.3	209.0	209.2	209.9	210.1
MW-EM-2D	210.5	210.2	210.3	210.1	210.1	209.9	209.5	209.4	209.1	209.3	210.1	210.2
MW-EM-3	212.1	211.9	211.8	211.9	212.0	211.6	211.4	210.8	210.2	210.3	211.5	211.8
MW-SRC-2	213.2	212.4	212.7	212.6	212.8	212.0	211.4	209.9	209.4	210.4	212.0	212.7
MW-BM-1	217.9	216.9	216.4	217.2	217.1	216.5	216.0	212.3	213.0	213.8	216.7	217.2
MW-HM-1	214.2	213.4	213.3	213.8	213.6	212.7	211.8	211.0	210.3	211.1	213.0	213.6
MW-PL-1	199.5	198.8	199.2	198.9	198.9	198.2	197.3	197.5	196.8	196.4	198.2	198.9
CHMW-1	163.2	162.7	162.9	162.7	162.6	162.4	162.1	162.1	161.8	162.0	162.9	163.1
CHMW-2S	169.3	165.0	168.1	163.2	162.8	158.9	157.1	157.2	156.2	156.9	167.9	168.8
CHMW-2D	160.3	158.5	159.2	158.1	157.9	156.9	155.4	155.5	154.6	155.2	159.1	159.8
CHMW-3S	140.4	140.2	140.3	140.2	140.2	140.0	139.7	139.7	139.5	139.7	140.3	140.3
CHMW-3D	141.9	141.6	141.8	141.6	141.6	141.4	141.1	141.1	140.9	141.0	141.6	141.8
CHMW-4S	183.0	181.9	182.5	181.8	181.9	181.3	180.5	180.5	179.9	180.0	181.9	182.4
CHMW-4D	181.0	180.0	180.6	179.9	180.0	179.4	178.7	178.7	178.2	178.2	180.0	180.5
MW-D-3	191.4	190.2	190.7	190.0	189.9	189.5	188.9	188.8	188.5	188.9	190.7	191.1
MW-93-MFS-C5-3	190.1	189.1	189.5	188.9	188.8	188.4	187.9	187.9	187.6	188.0	189.6	189.9

Figures



Project Area Map

DuPont Groundwater Model Report

DuPont, Washington

Aspect Consulting	Jun-2017	BY: OGR/SCC	FIGURE NO. 1
	PROJECT NO. 040001-014	REVISED BY: SCC	

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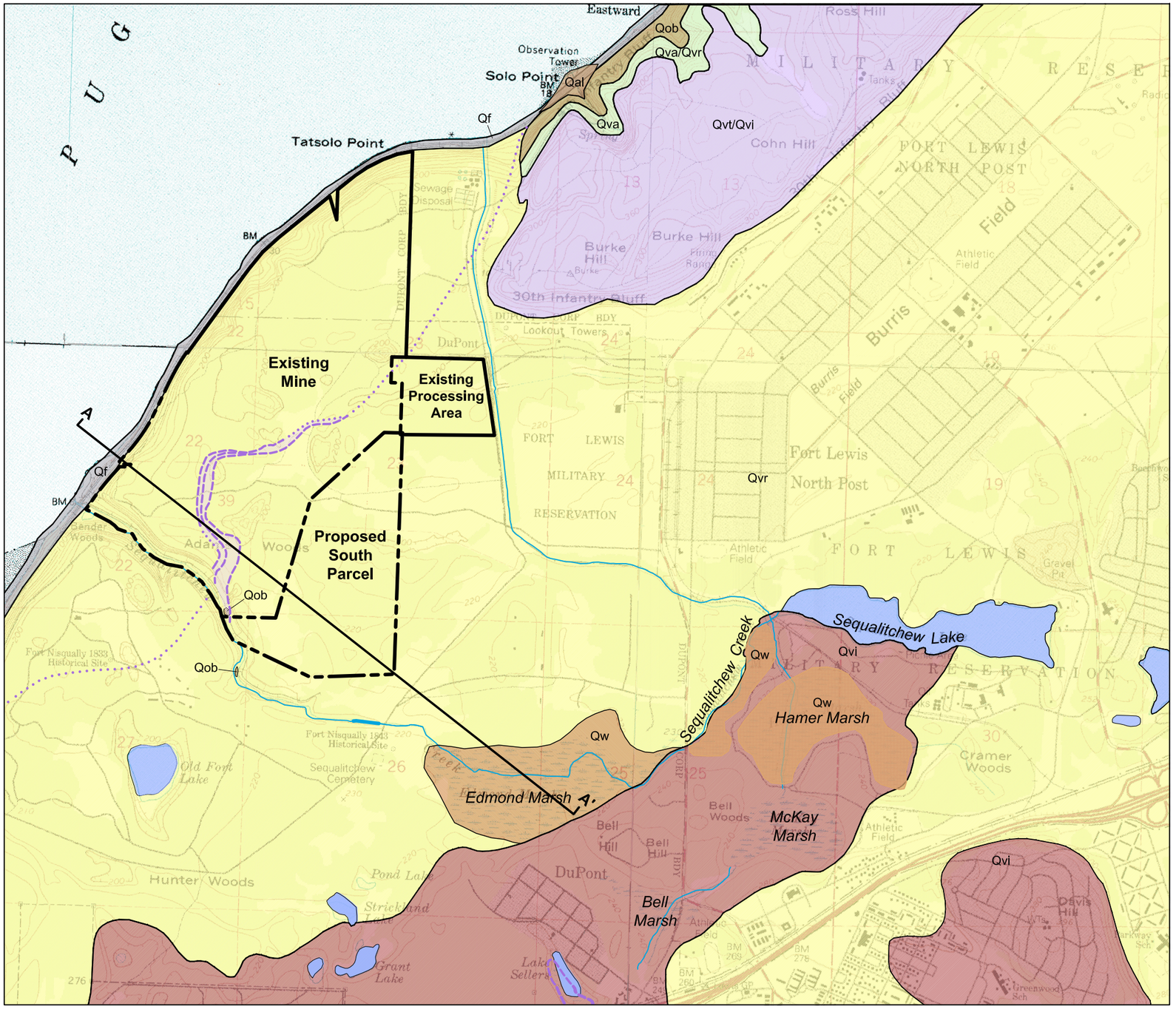

Legend

- **Qf (Fill)**
  Artificial fill. Likely consists primarily of crushed rock and rip-rap placed for railroad embankment.
- **Qw (Wetland Deposits)**
  Peat, organic-rich muck, silt and clay.
- **Qal (Recent Alluvium)**
  Silt, sand, gravel, and peat deposited in stream beds and estuaries, includes some lacustrine and beach deposits.
- **Qvr (Vashon Recessional Glacial Outwash)**
  Medium dense to dense, slightly silty to clean sand and gravel. Includes some silty beds. The majority of near-surface Vashon recessional outwash on the Project Site is made up of the Steilacoom Gravel member, which is composed of sandy gravel and gravelly sand, with minor amounts of silt.
- **Qvi (Ice-Contact Deposits)**
  Water-worked sands and gravels with interbeds and lenses of silty, till-like deposits.
- **Qvt/Qvi (Till and Ice Contact Deposits)**
  Dense to very dense discontinuous layers of silty, sandy, and gravelly basal till. Ice contact deposits contain water-worked sands and gravels with interbeds and lenses of silty, till-like deposits.
- **Qva (Vashon Advance Glacial Outwash)**
  Sand and gravel, and lacustrine clay, silt, and sand of northern source, deposited during Vashon glacial advance.
- **Qob (Olympia Beds)**
  The Olympia Beds Qob unit is generally composed of interbedded lacustrine silt and clay and fluvial deposits.
- **Olympia Beds Truncation (Surface Projection)**
  Approximate surface projection line showing the northwestward lateral subcrop extent of the Olympia Beds unit. Dashed where approximate, dotted where inferred.

Note: Map modified based on subsurface data and geologic interpretation from Walsh, Logan and Polenz 2003; Walsh et al. 2003, Walters and Kimmel, 1968, and Troost, Booth, and Borden, in review.

N

0 2000 4000
Feet

Geologic Map

DuPont Groundwater Model Report
DuPont, Washington

Aspect Consulting	Jun-2017	BY: DFR/SCC	FIGURE NO. 2
	PROJECT NO. 040001-014	REV BY: SCC	

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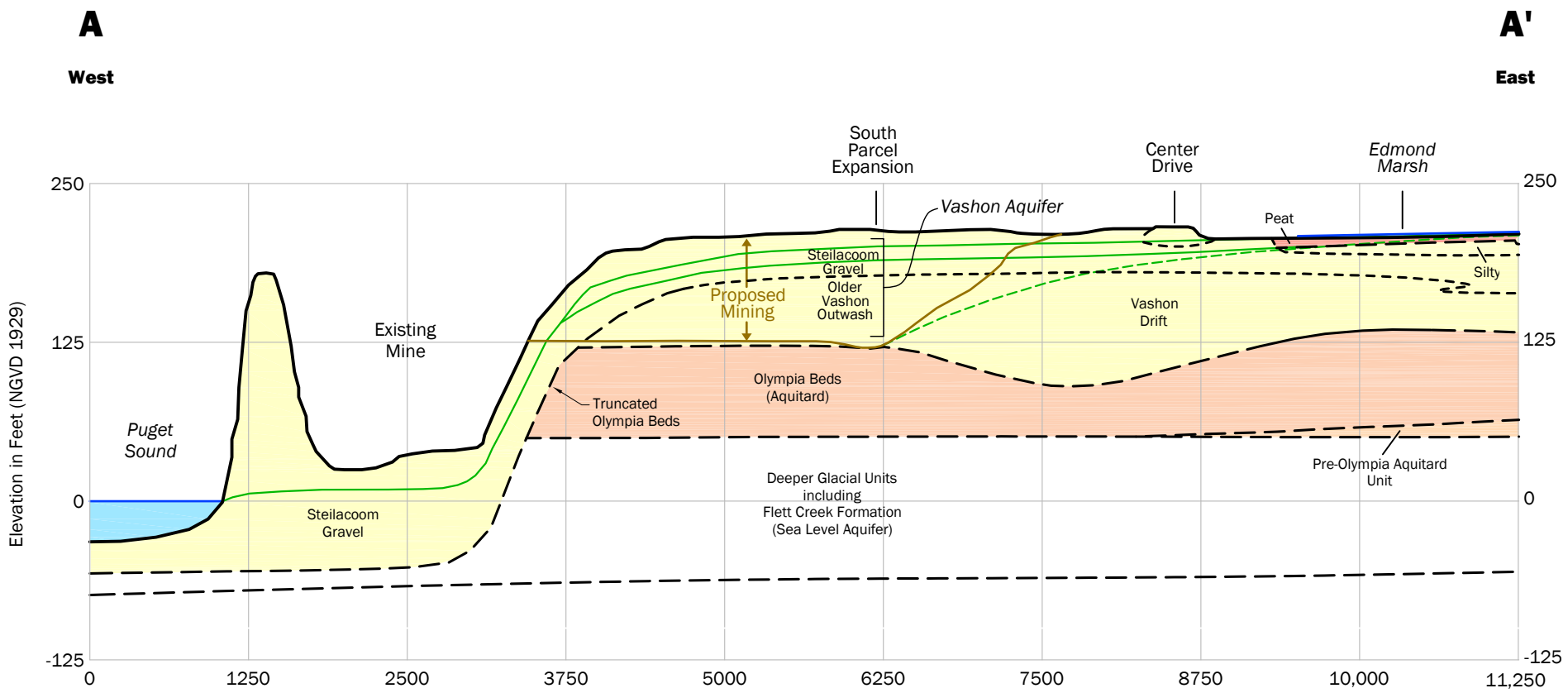


Predicted Water Table Change

Water Table Elevation February 2008
(Range at TW-4 shown for 2003-2008)

Note: 10x Vertical vs. Horizontal Exaggeration for Illustration

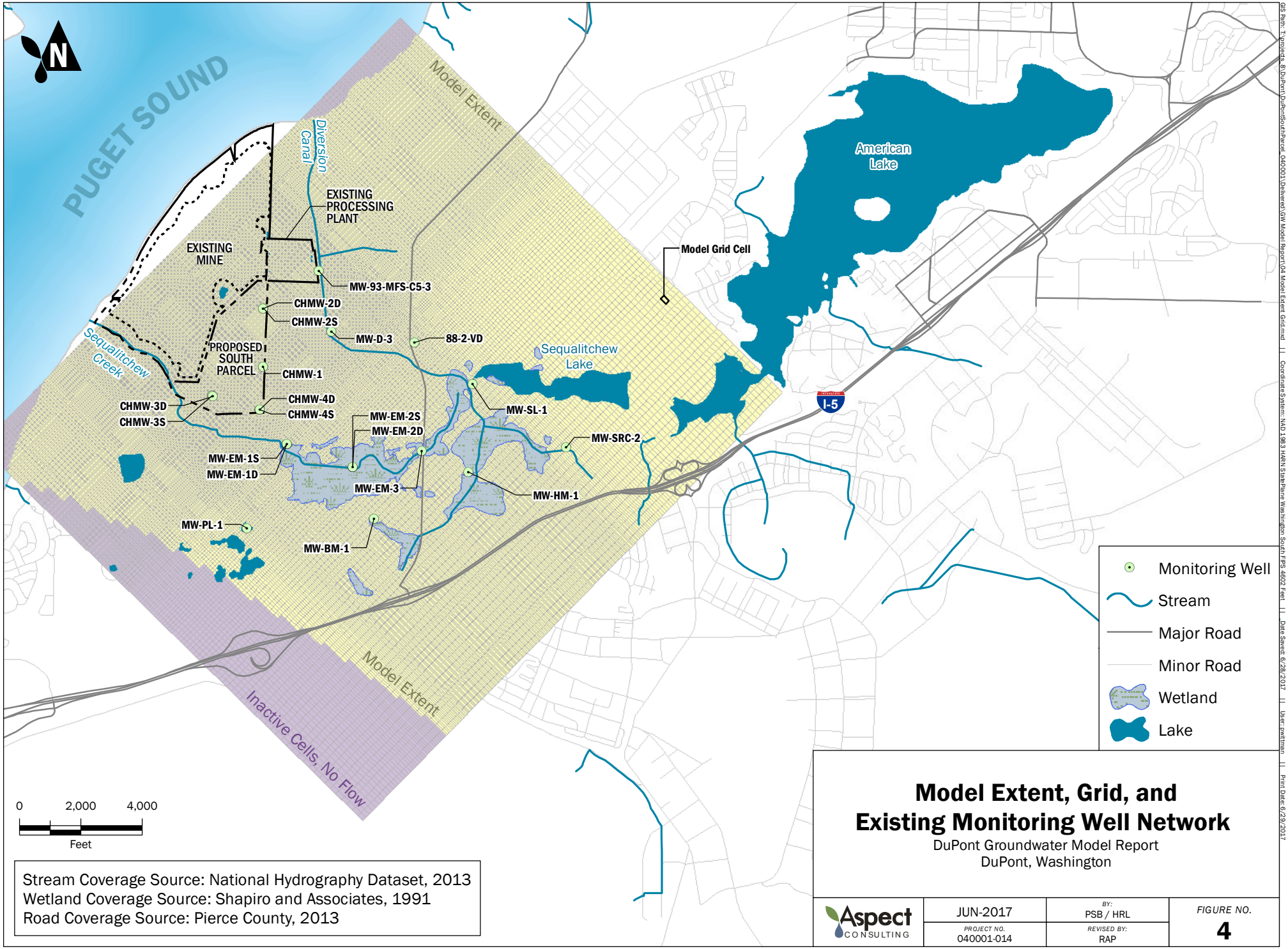
Horizontal Scale: 0 — 1250 Feet

Vertical Scale: 0 — 125 Feet

Hydrogeologic Cross Section

CalPortland DuPont South Parcel
Groundwater Modeling
DuPont, Washington

Aspect Consulting	DEC-2014	BY: OGR/SCC	FIGURE NO. 3
	PROJECT NO. 040001-014	REVISED BY: -	



Stream Coverage Source: National Hydrography Dataset, 2013
Wetland Coverage Source: Shapiro and Associates, 1991
Road Coverage Source: Pierce County, 2013

Model Extent, Grid, and Existing Monitoring Well Network

DuPont Groundwater Model Report
DuPont, Washington

Aspect CONSULTING	JUN-2017	BY: PSB / HRL	FIGURE NO. 4
	PROJECT NO. 040001-014	REVISED BY: RAP	

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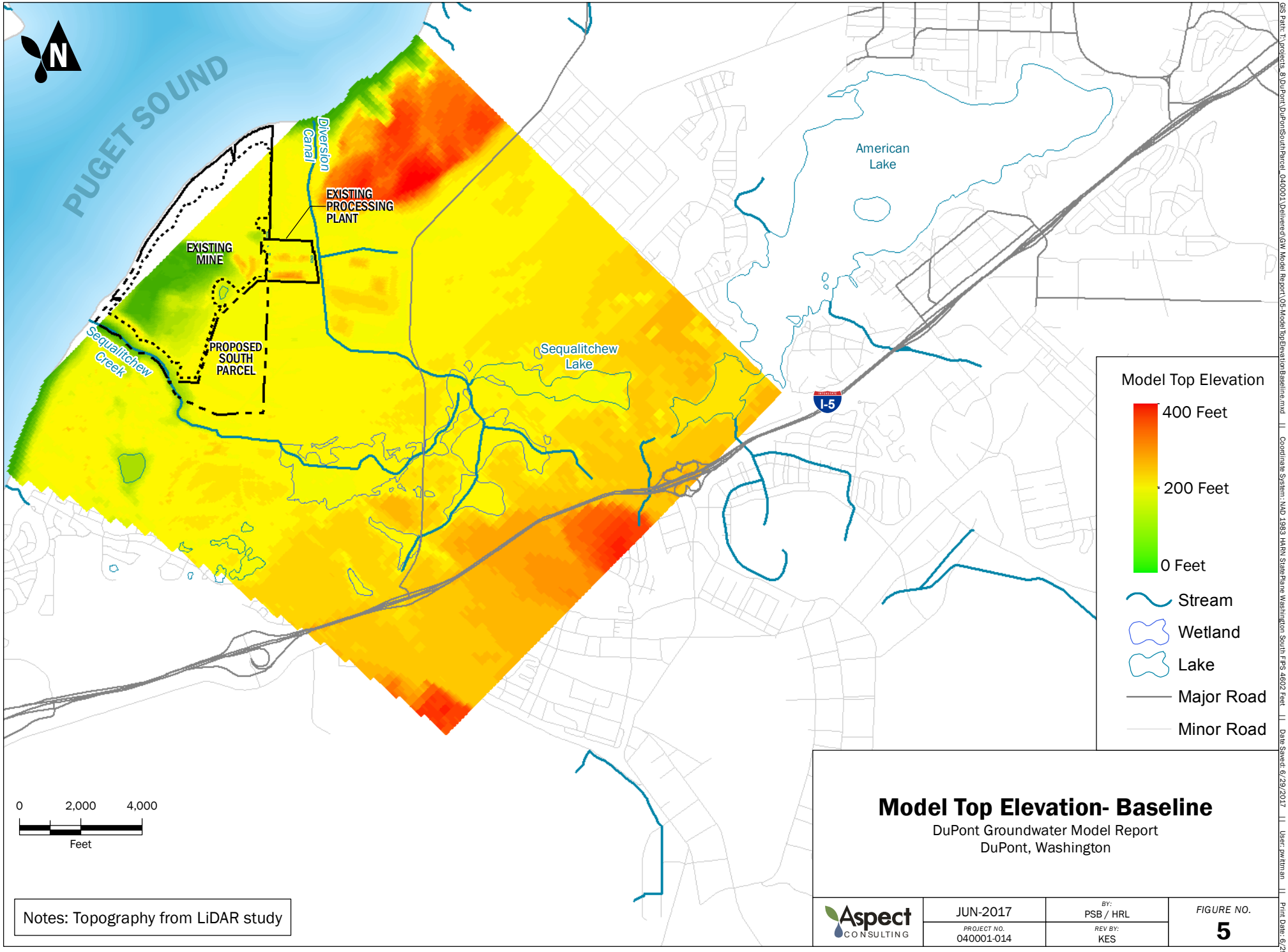

Model Top Elevation- Baseline

DuPont Groundwater Model Report
DuPont, Washington

Notes: Topography from LiDAR study

Aspect CONSULTING	JUN-2017	BY: PSB / HRL	FIGURE NO. 5
	PROJECT NO. 040001-014	REV BY: KES	

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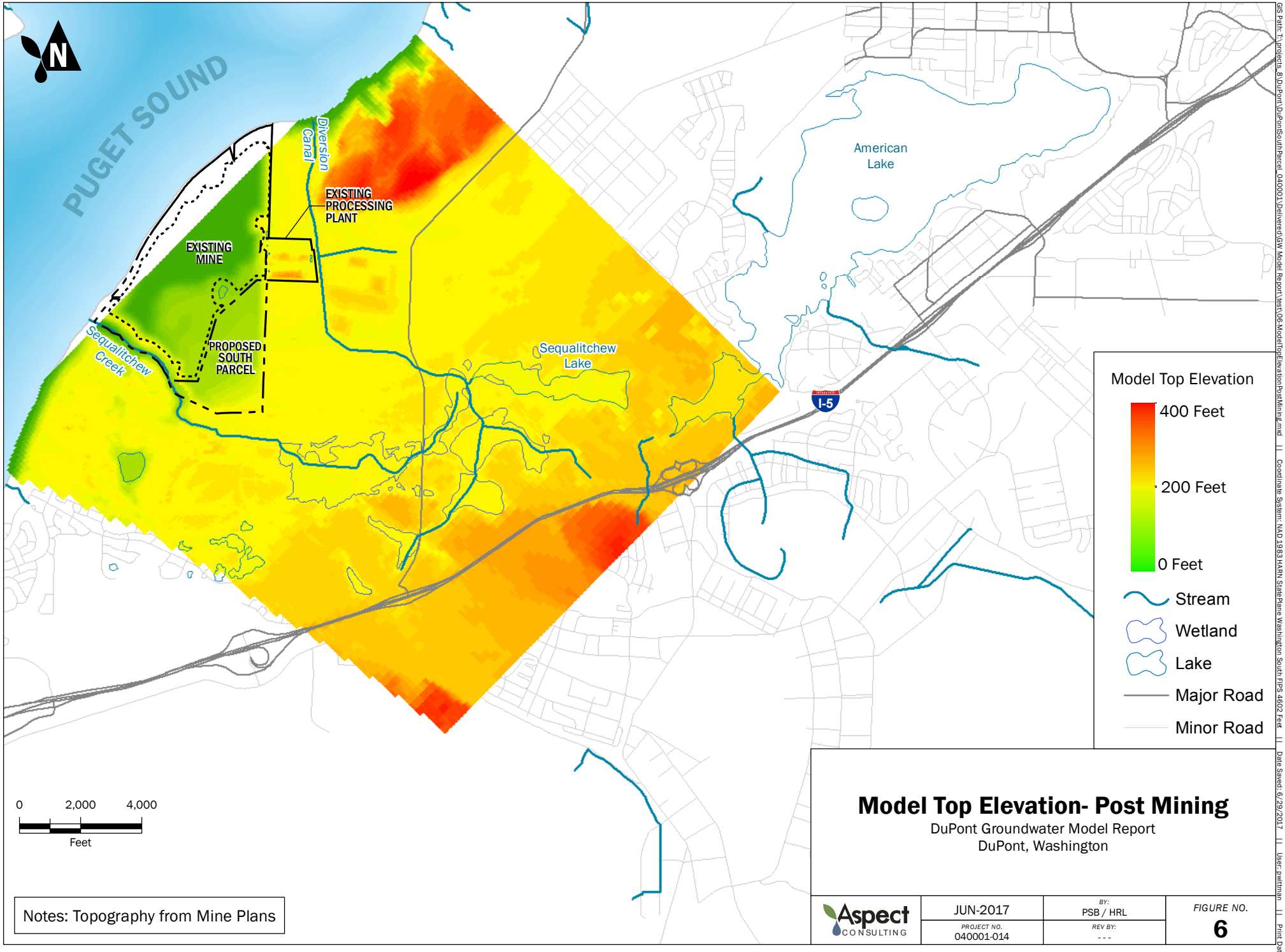


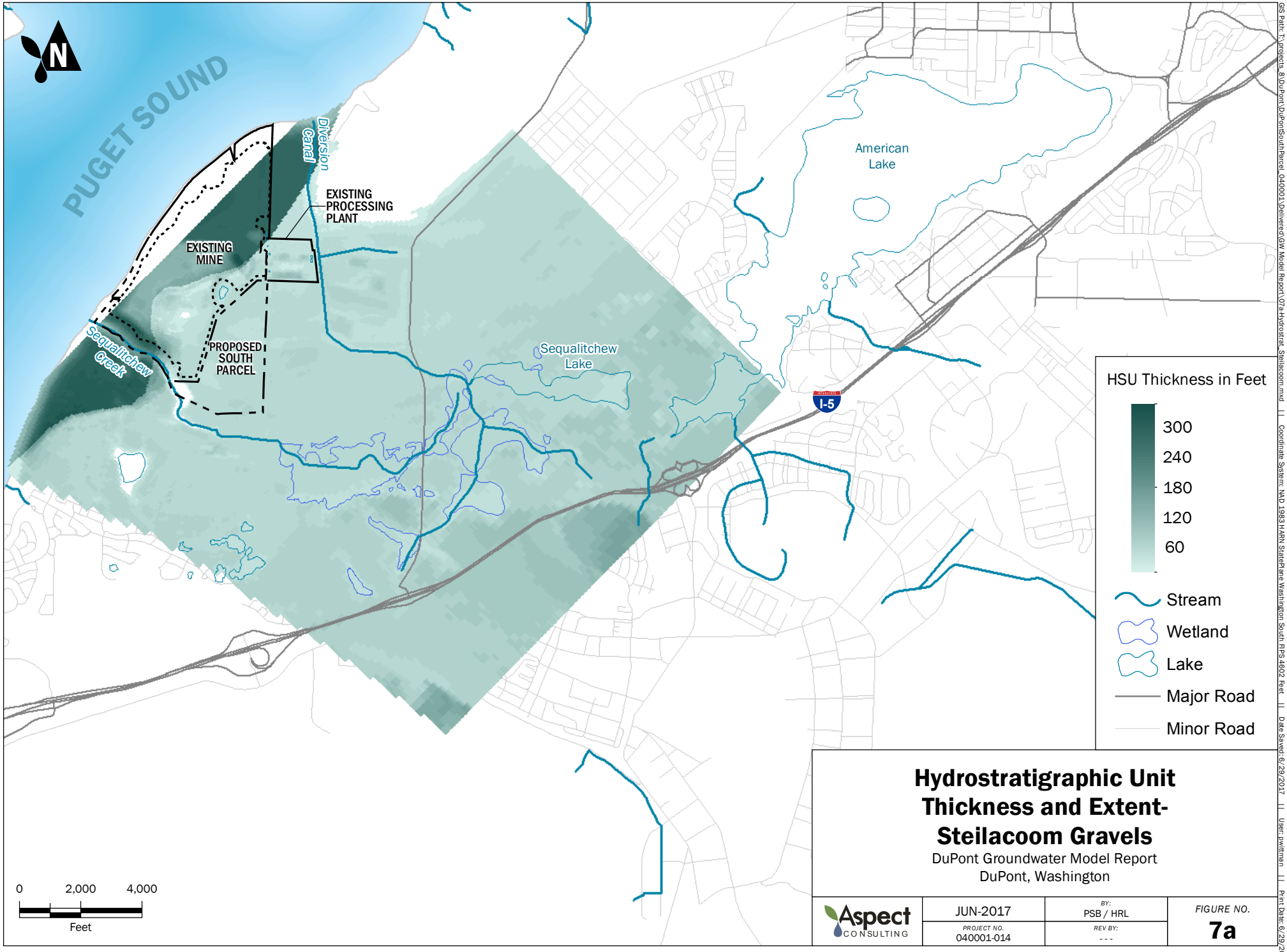
Model Top Elevation- Post Mining

DuPont Groundwater Model Report
DuPont, Washington

Notes: Topography from Mine Plans

Aspect CONSULTING	JUN-2017	BY: PSB / HRL	FIGURE NO. 6
	PROJECT NO. 040001-014	REV BY: ---	

GIS Path: T:\projects_8\DuPont\DuPontSouthParcel_040001\Delivered\GW Model Report\text\06-ModelTopElevationPostMining.mxd || Coordinate System: NAD 1983 HARN StatePlane Washington South FIPS 4602 Feet || Date Saved: 6/29/2017 || User: pwittman || Print Date: 6/29/201



Hydrostratigraphic Unit Thickness and Extent- Steilacoom Gravels

DuPont Groundwater Model Report
DuPont, Washington

Aspect CONSULTING	JUN-2017	BY: PSB / HRL	FIGURE NO. 7a
	PROJECT NO. 040001-014	REV BY: ---	

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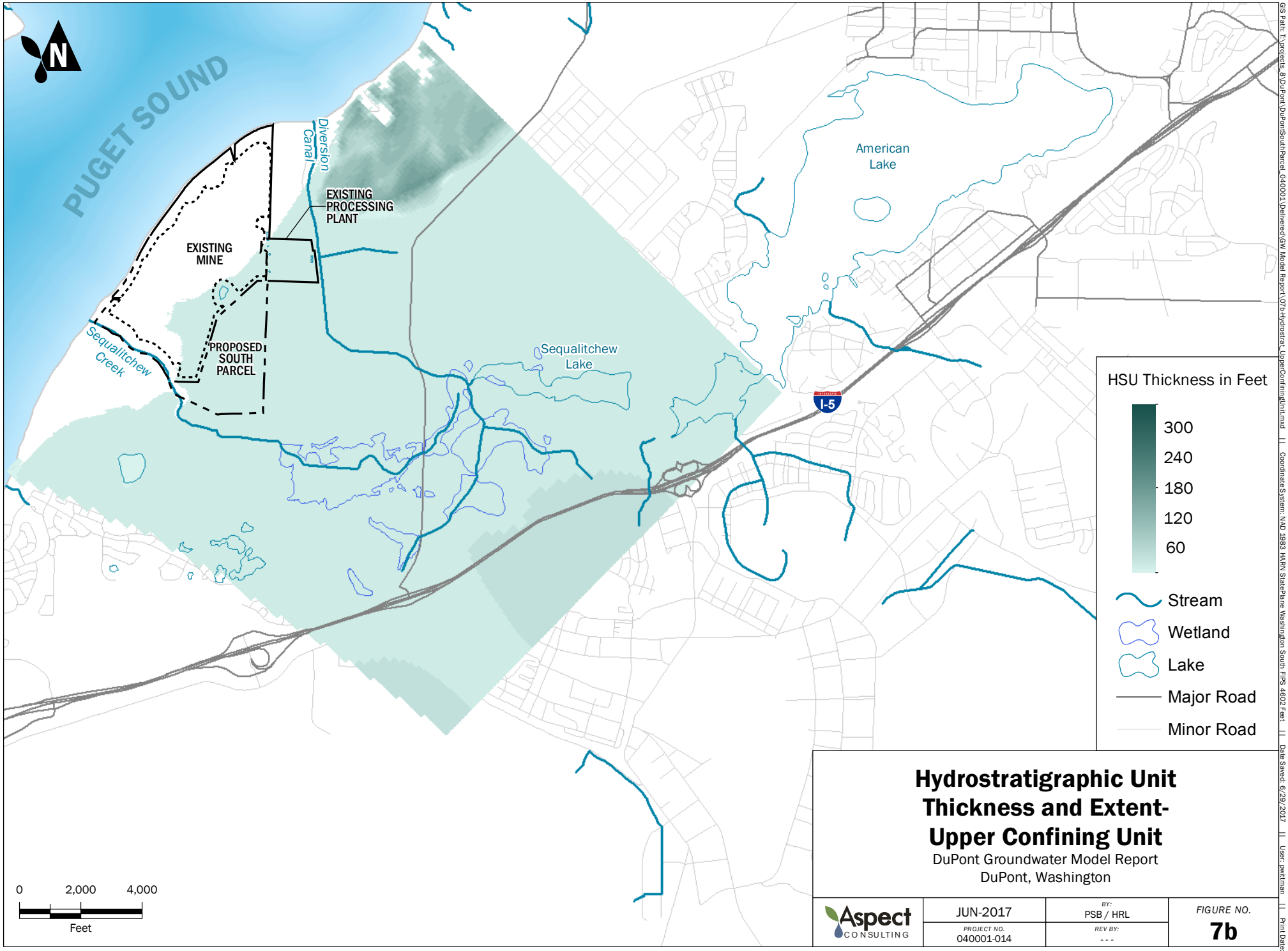

Hydrostratigraphic Unit Thickness and Extent- Upper Confining Unit

DuPont Groundwater Model Report
DuPont, Washington

Aspect CONSULTING	JUN-2017	BY: PSB / HRL	FIGURE NO. 7b
	PROJECT NO. 040001-014	REV BY: ---	

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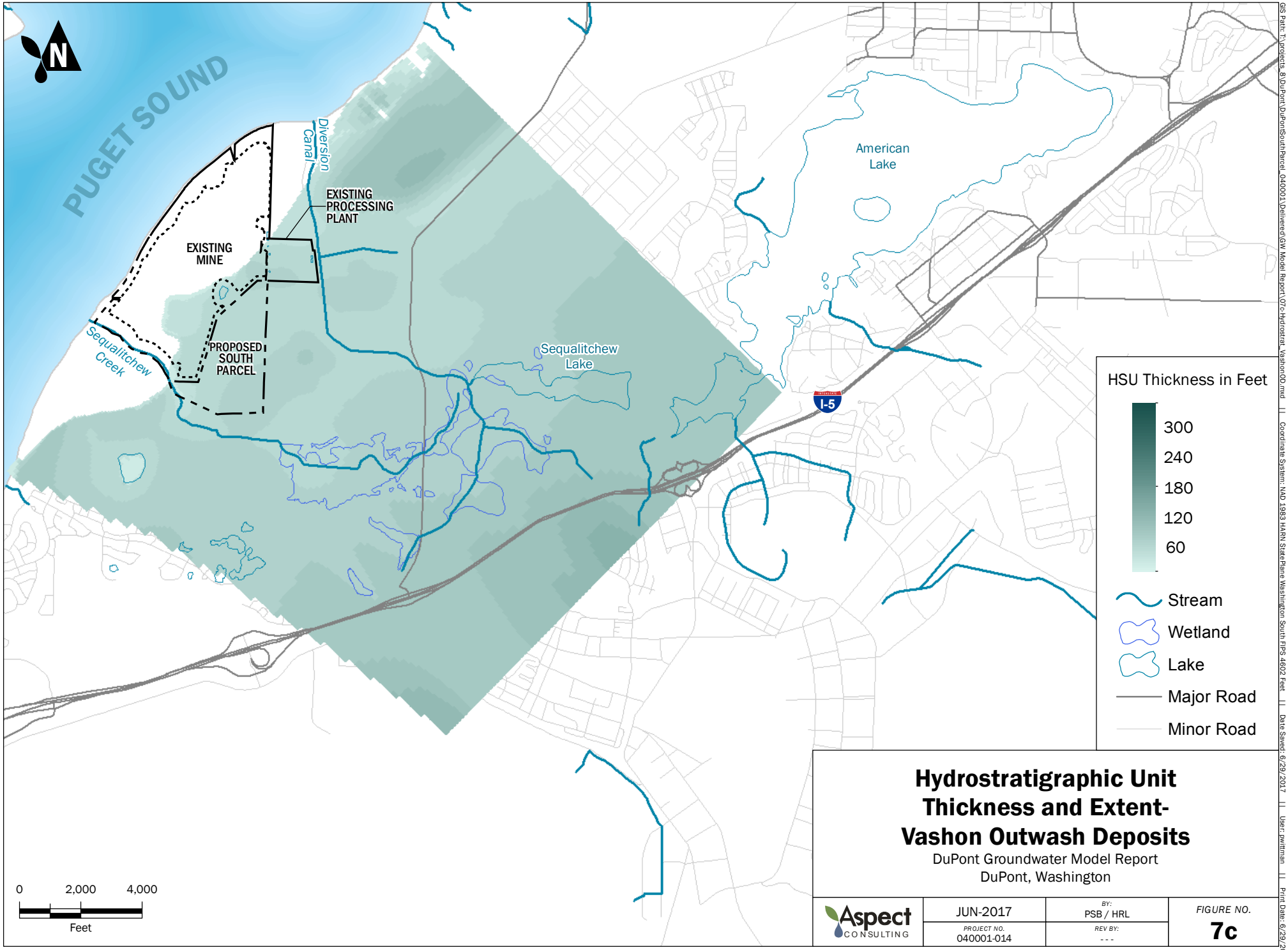

Hydrostratigraphic Unit Thickness and Extent- Vashon Outwash Deposits

DuPont Groundwater Model Report
DuPont, Washington

Aspect CONSULTING	JUN-2017	BY: PSB / HRL	FIGURE NO. 7c
	PROJECT NO. 040001-014	REV BY: ---	

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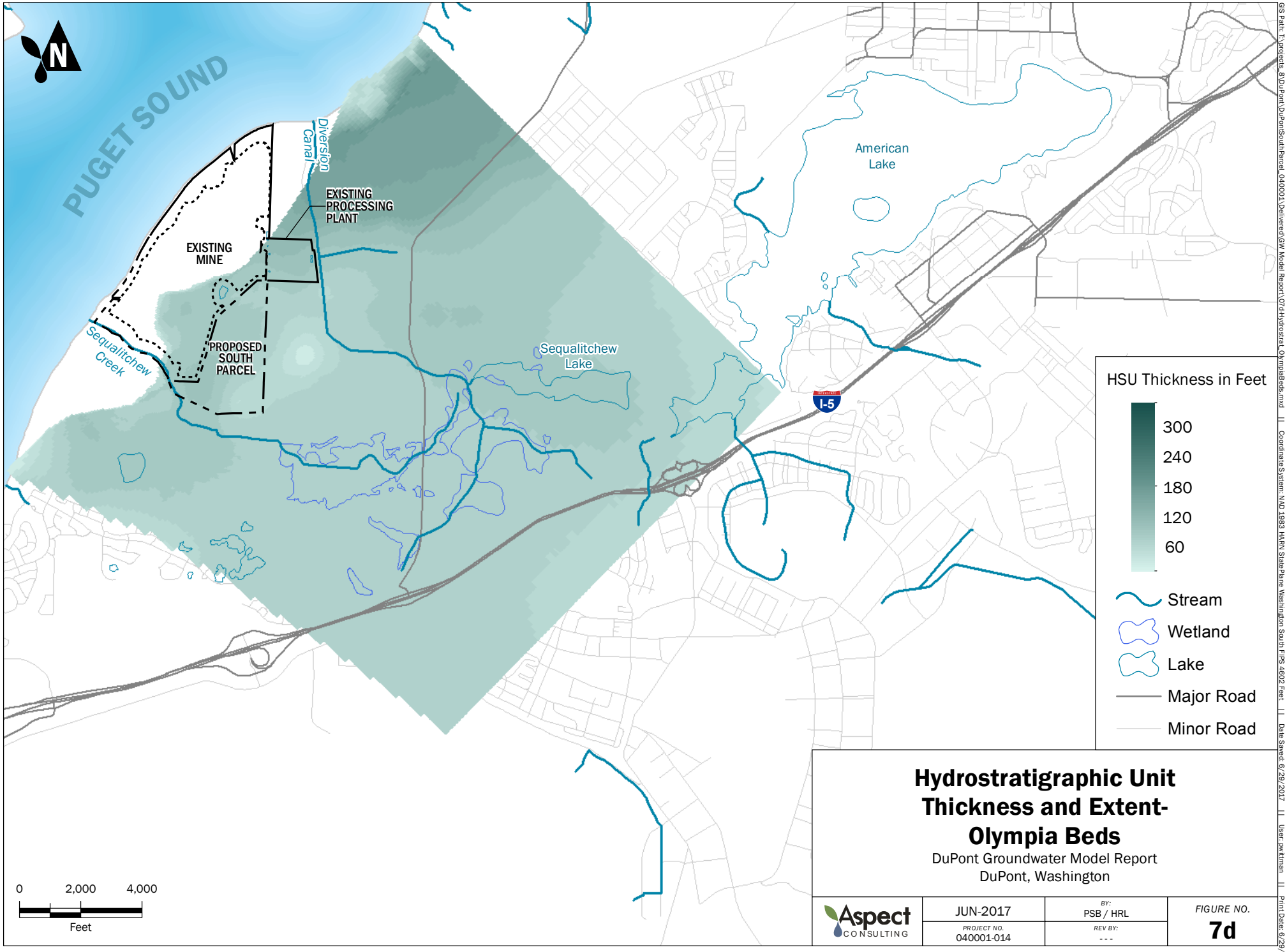

Hydrostratigraphic Unit Thickness and Extent- Olympia Beds

DuPont Groundwater Model Report
DuPont, Washington

Aspect CONSULTING	JUN-2017	BY: PSB / HRL	FIGURE NO. 7d
	PROJECT NO. 040001-014	REV BY: ---	

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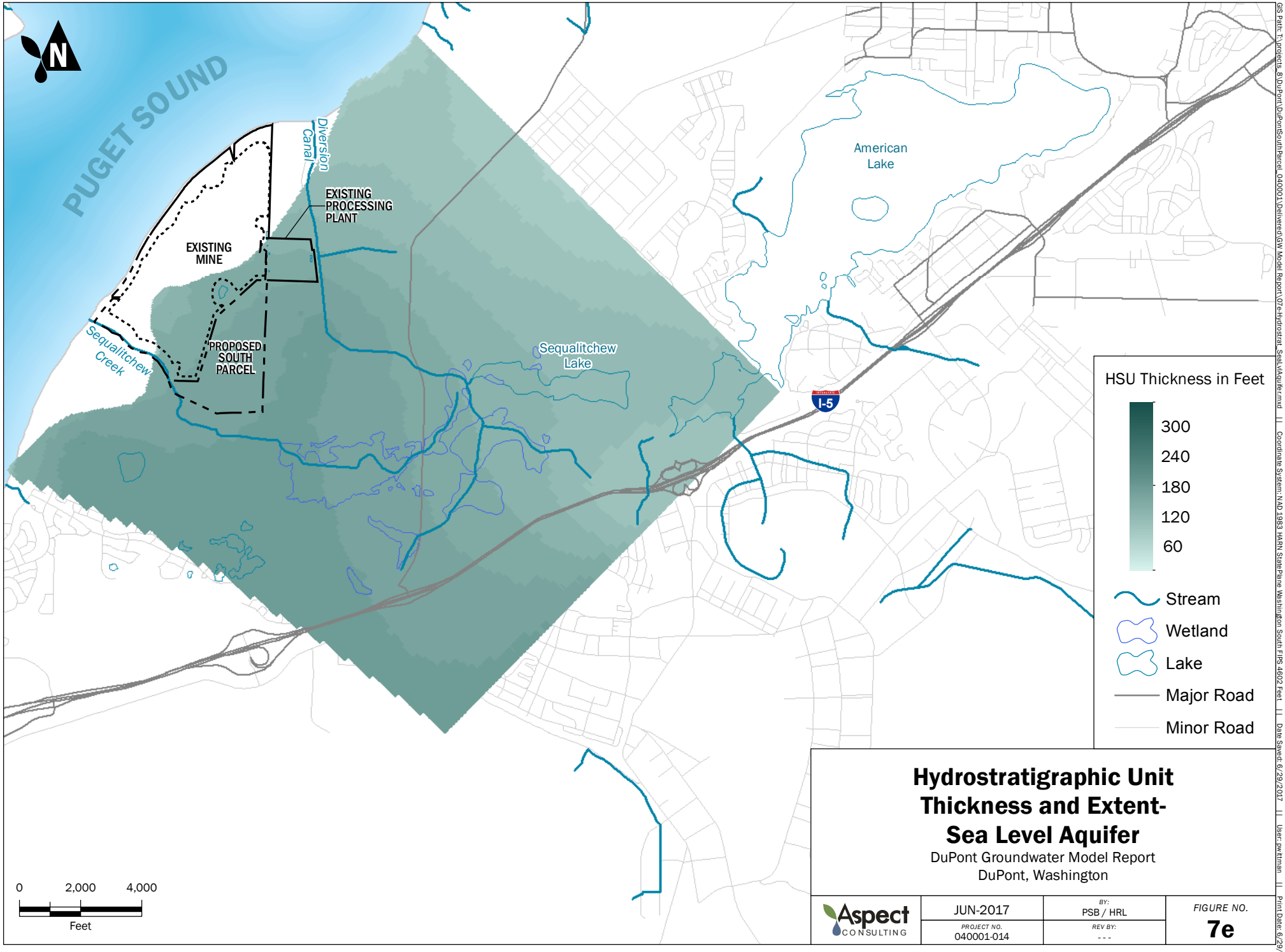

Hydrostratigraphic Unit Thickness and Extent- Sea Level Aquifer

DuPont Groundwater Model Report
DuPont, Washington

Aspect CONSULTING	JUN-2017	BY: PSB / HRL	FIGURE NO. 7e
	PROJECT NO. 040001-014	REV BY: ---	

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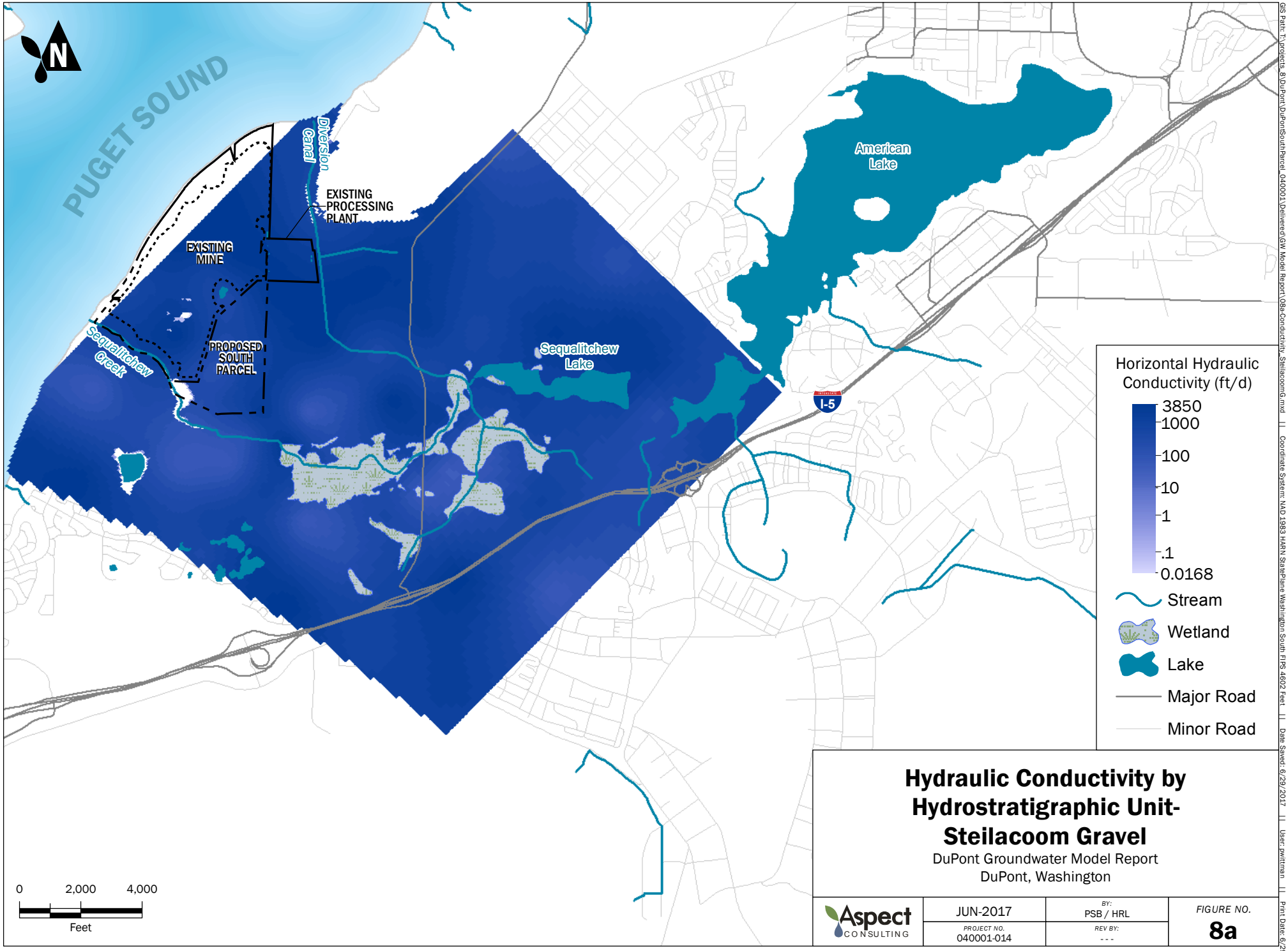

Hydraulic Conductivity by Hydrostratigraphic Unit- Steilacoom Gravel

DuPont Groundwater Model Report
DuPont, Washington

Aspect CONSULTING	JUN-2017	BY: PSB / HRL	FIGURE NO. 8a
	PROJECT NO. 040001-014	REV BY: ---	

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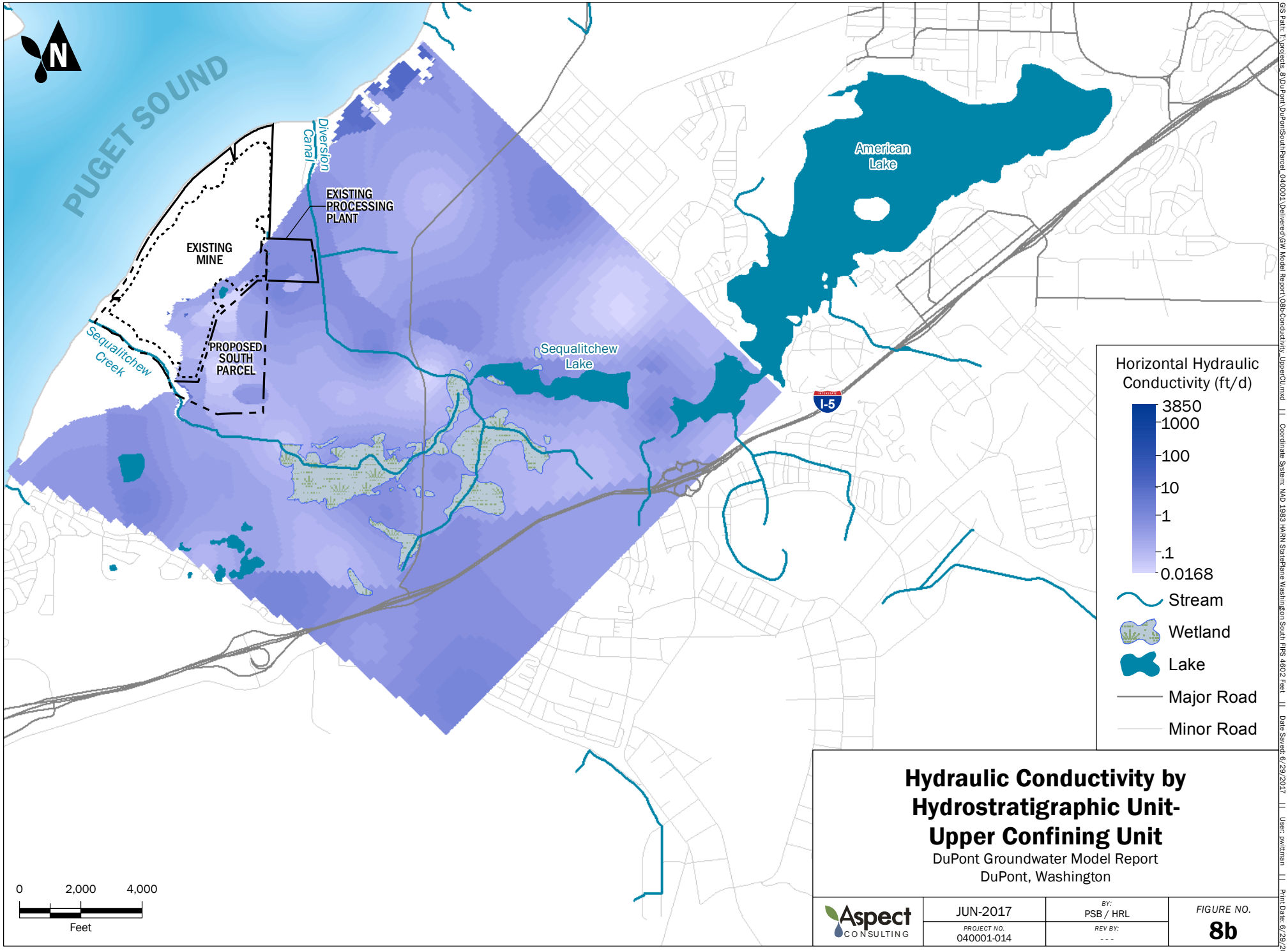

Hydraulic Conductivity by Hydrostratigraphic Unit- Upper Confining Unit

DuPont Groundwater Model Report
DuPont, Washington

Aspect CONSULTING	JUN-2017	BY: PSB / HRL	FIGURE NO. 8b
	PROJECT NO. 040001-014	REV BY: ---	

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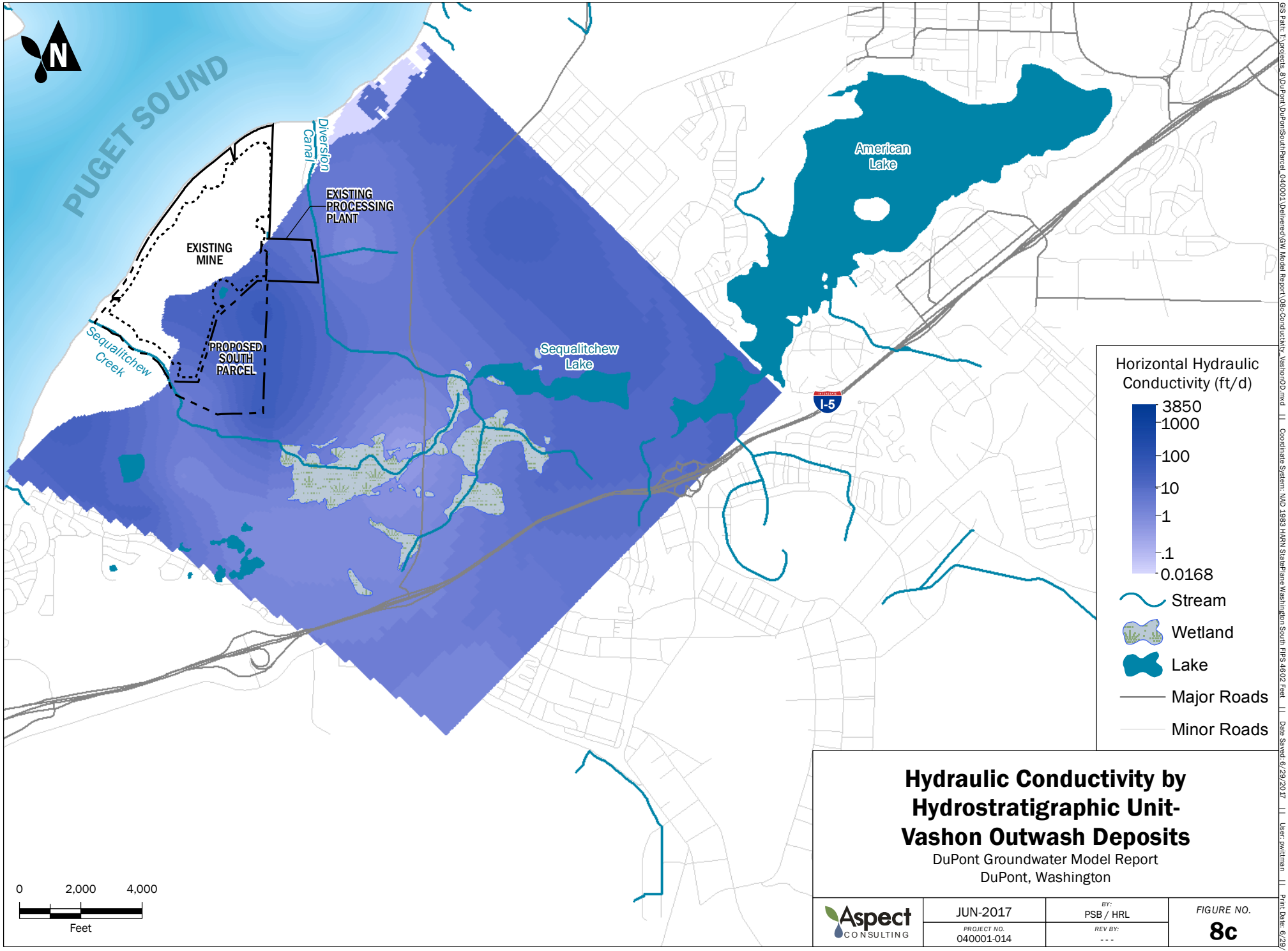

Hydraulic Conductivity by Hydrostratigraphic Unit- Vashon Outwash Deposits

DuPont Groundwater Model Report
DuPont, Washington

Aspect CONSULTING	JUN-2017	BY: PSB / HRL	FIGURE NO. 8c
	PROJECT NO. 040001-014	REV BY: ---	

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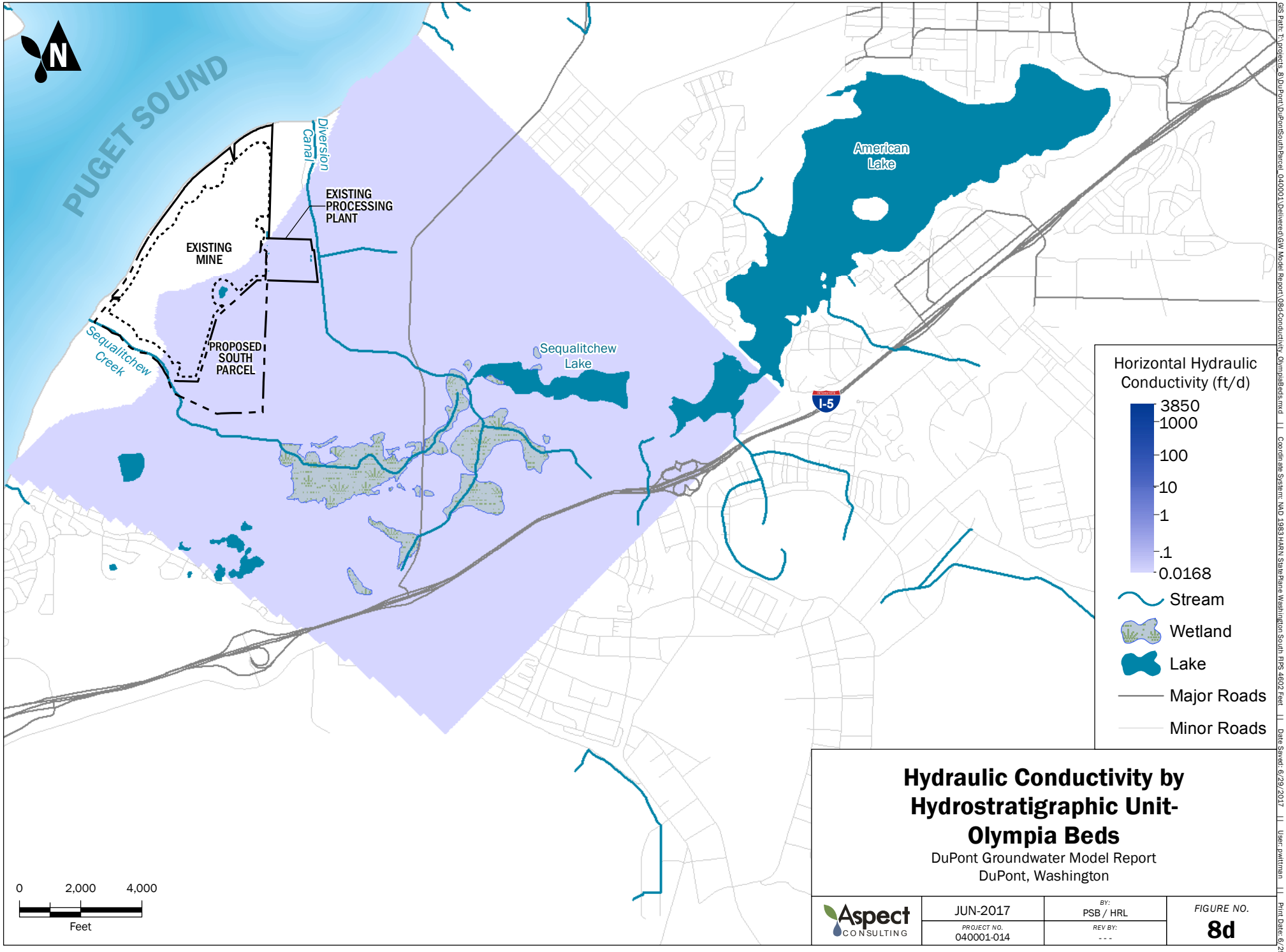

Hydraulic Conductivity by Hydrostratigraphic Unit- Olympia Beds

DuPont Groundwater Model Report
DuPont, Washington

Aspect CONSULTING	JUN-2017	BY: PSB / HRL	FIGURE NO. 8d
	PROJECT NO. 040001-014	REV BY: ---	

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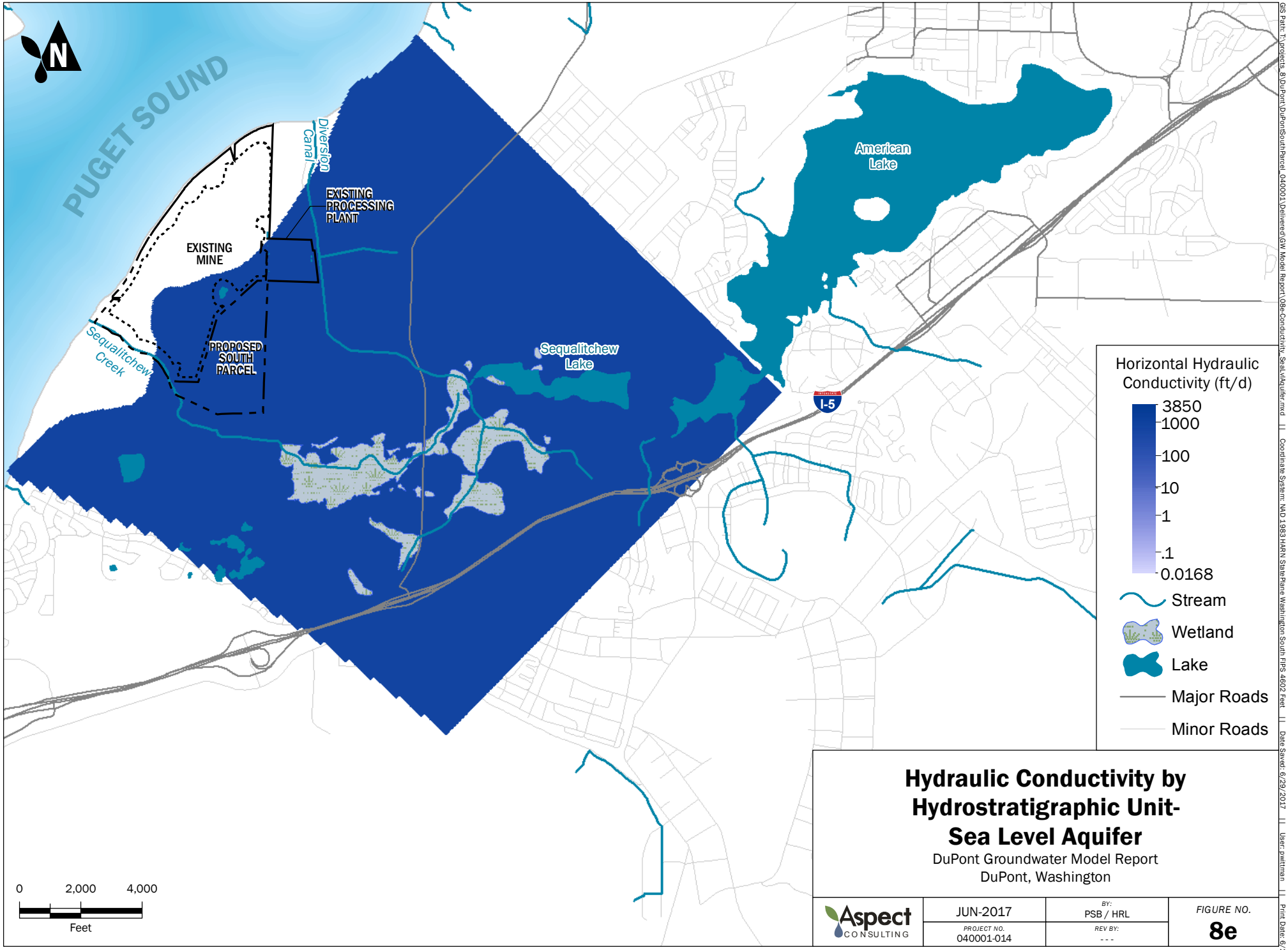

Hydraulic Conductivity by Hydrostratigraphic Unit- Sea Level Aquifer

DuPont Groundwater Model Report
DuPont, Washington

Aspect CONSULTING	JUN-2017	BY: PSB / HRL	FIGURE NO. 8e
	PROJECT NO. 040001-014	REV BY: ---	

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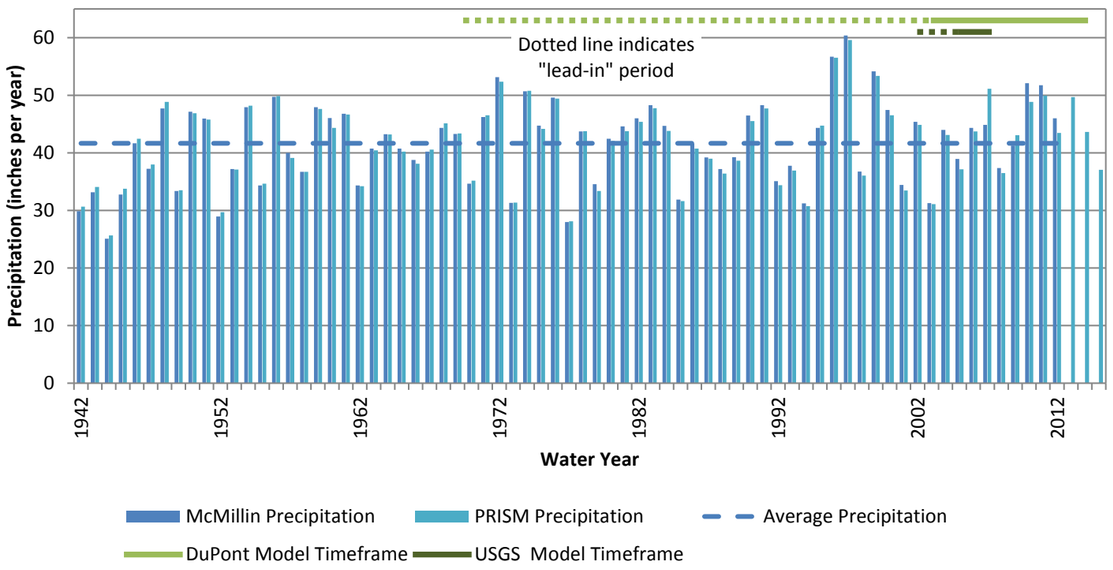

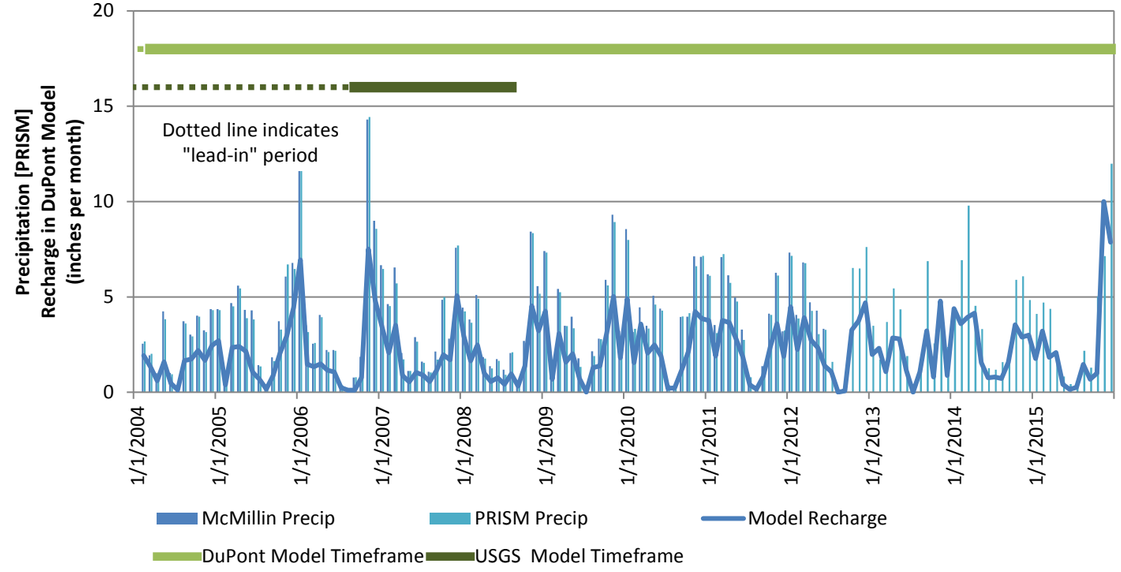

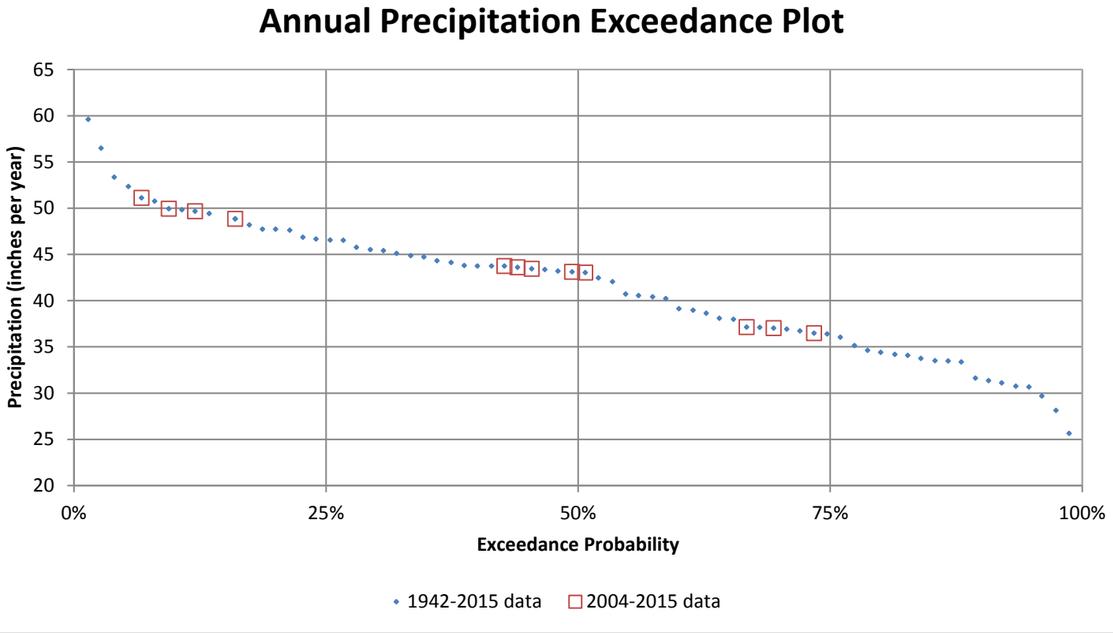

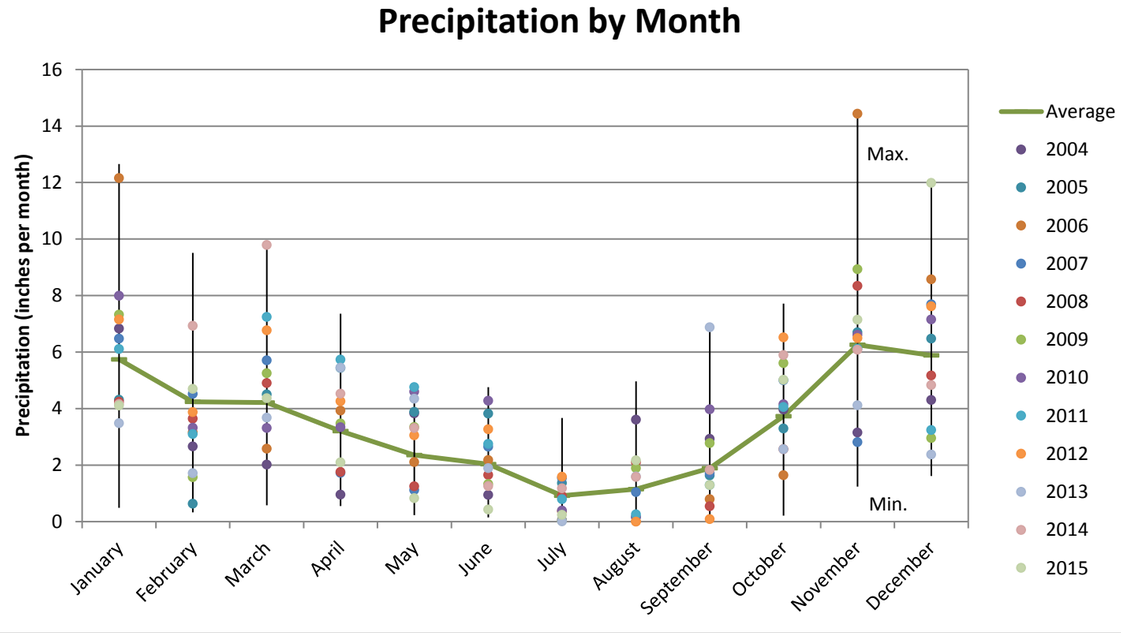

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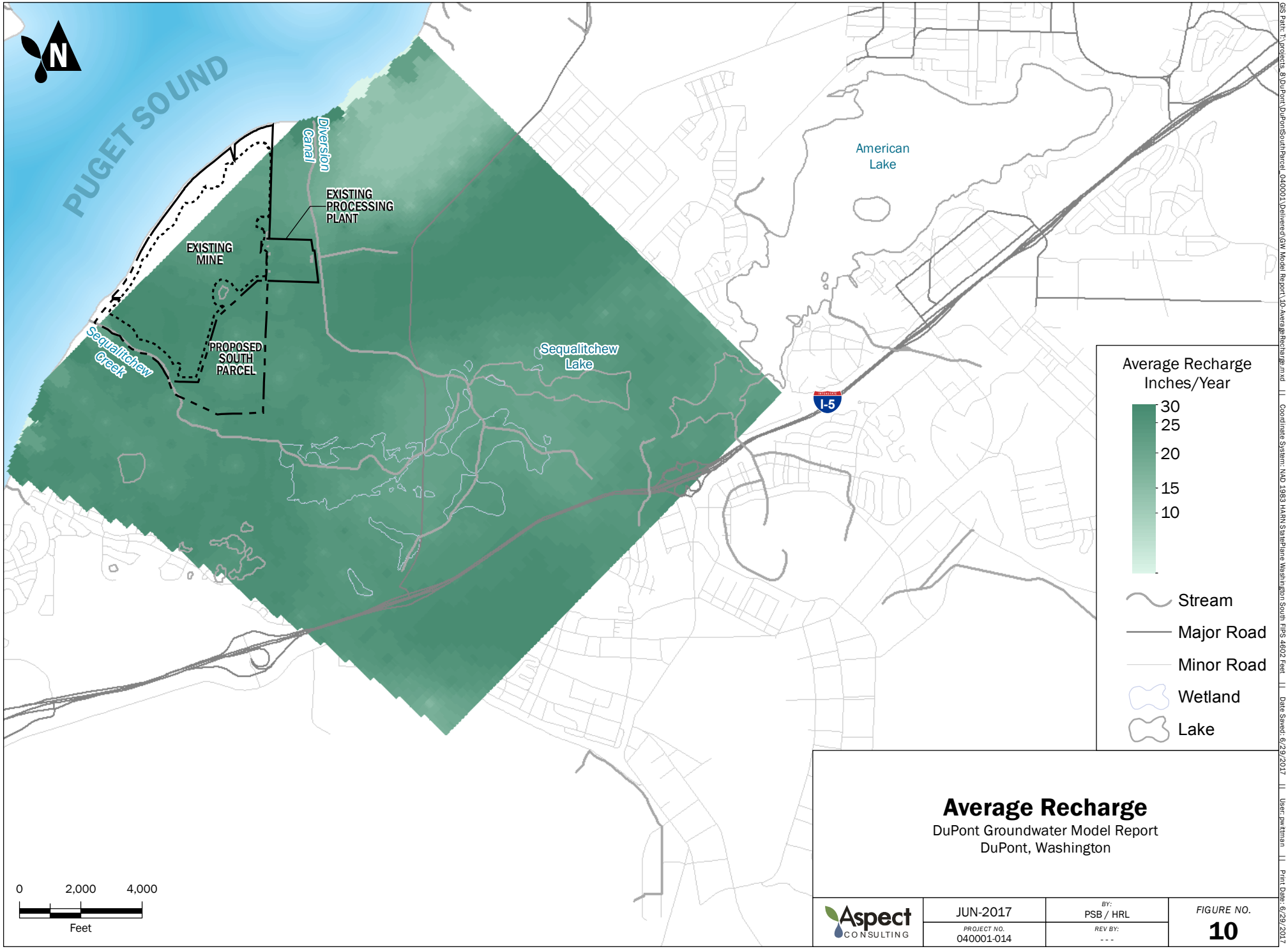
S:\CalPortland\DuPont\South Parcel\Groundwater Modeling\DRAFT_20170327\StatusUpdate_20170320

Figure 9
Model Timeframe and Historical Precipitation
Dupont Groundwater Model Report



Average Recharge

DuPont Groundwater Model Report
DuPont, Washington

Aspect CONSULTING	JUN-2017	BY: PSB / HRL	FIGURE NO. 10
	PROJECT NO. 040001-014	REV BY: ---	

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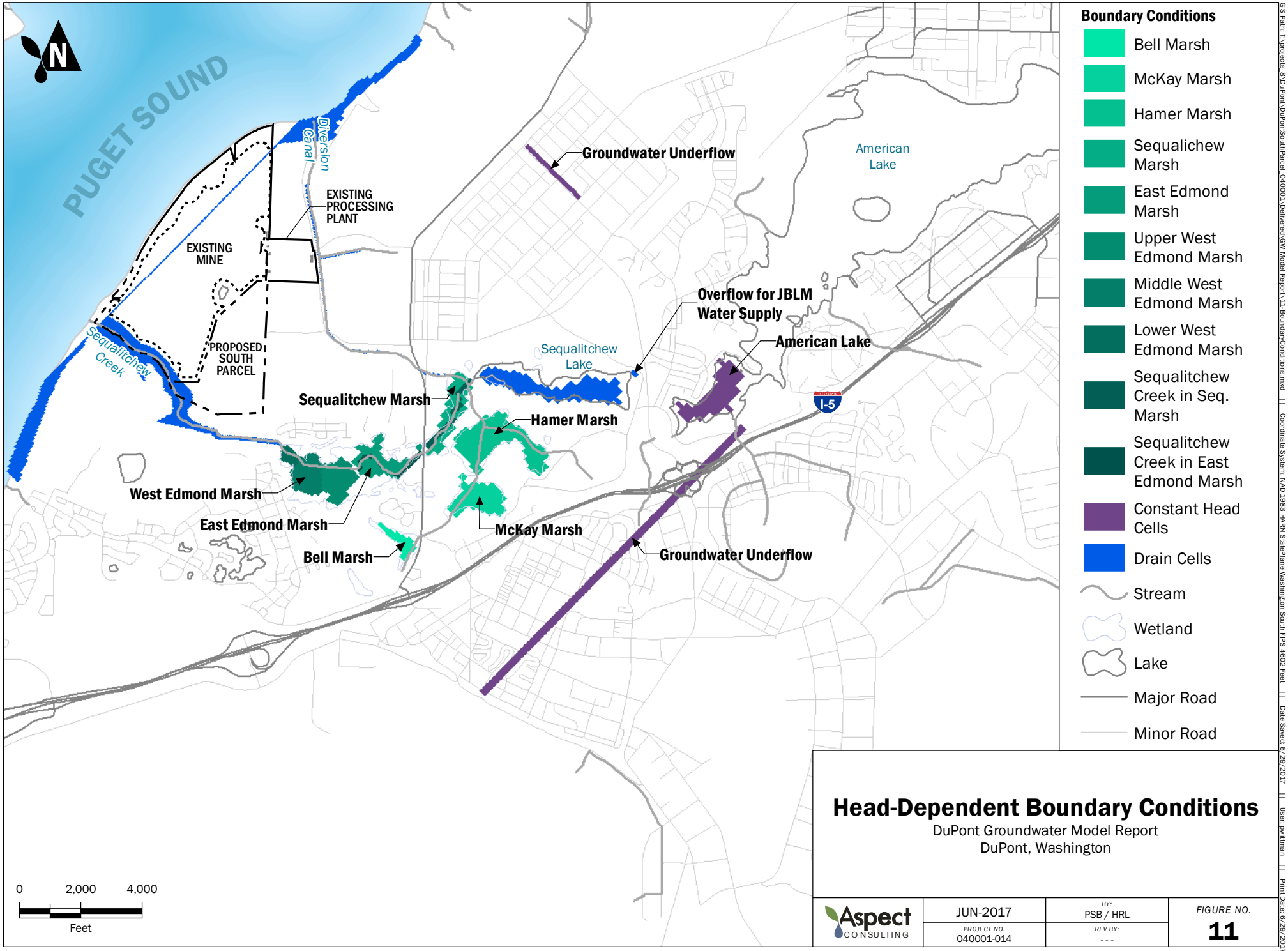
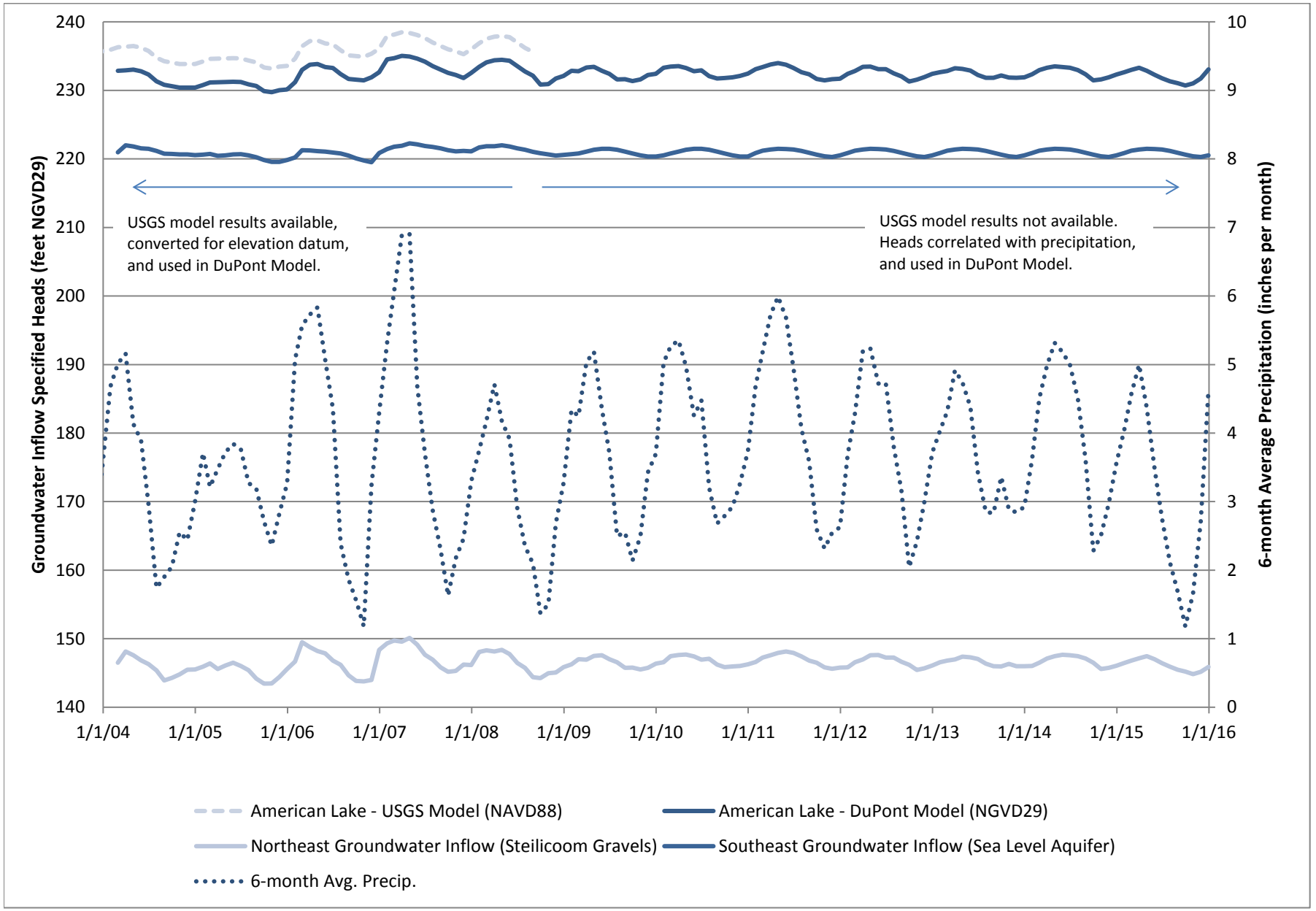


Head-Dependent Boundary Conditions

DuPont Groundwater Model Report
DuPont, Washington

Aspect CONSULTING	JUN-2017	BY: PSB / HRL	FIGURE NO. 11
	PROJECT NO. 040001-014	REV BY: ---	

GIS Path: T:\projects_8\DuPont\DuPontSouthParcel_040001\Delivered\GW Model Report\11-BoundaryConditions.mxd || Coordinate System: NAD 1983 HARN StatePlane Washington South FIPS 4602 Feet || Date Saved: 6/29/2017 || User: pwittman || Print Date: 6/29/2017



Aspect Consulting, LLC
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Figure 12
Groundwater Inflow Heads over Time
DuPont Groundwater Model Report

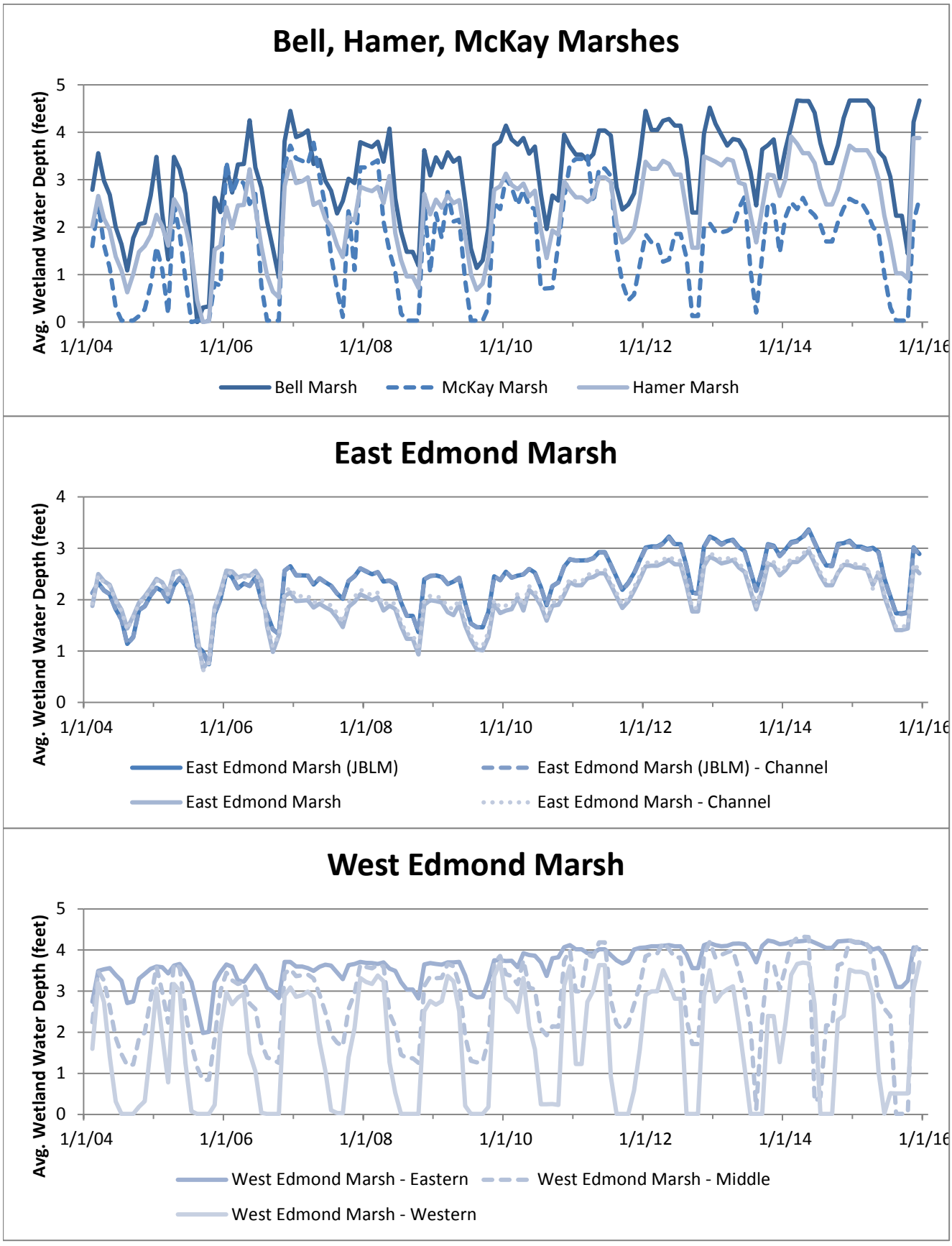
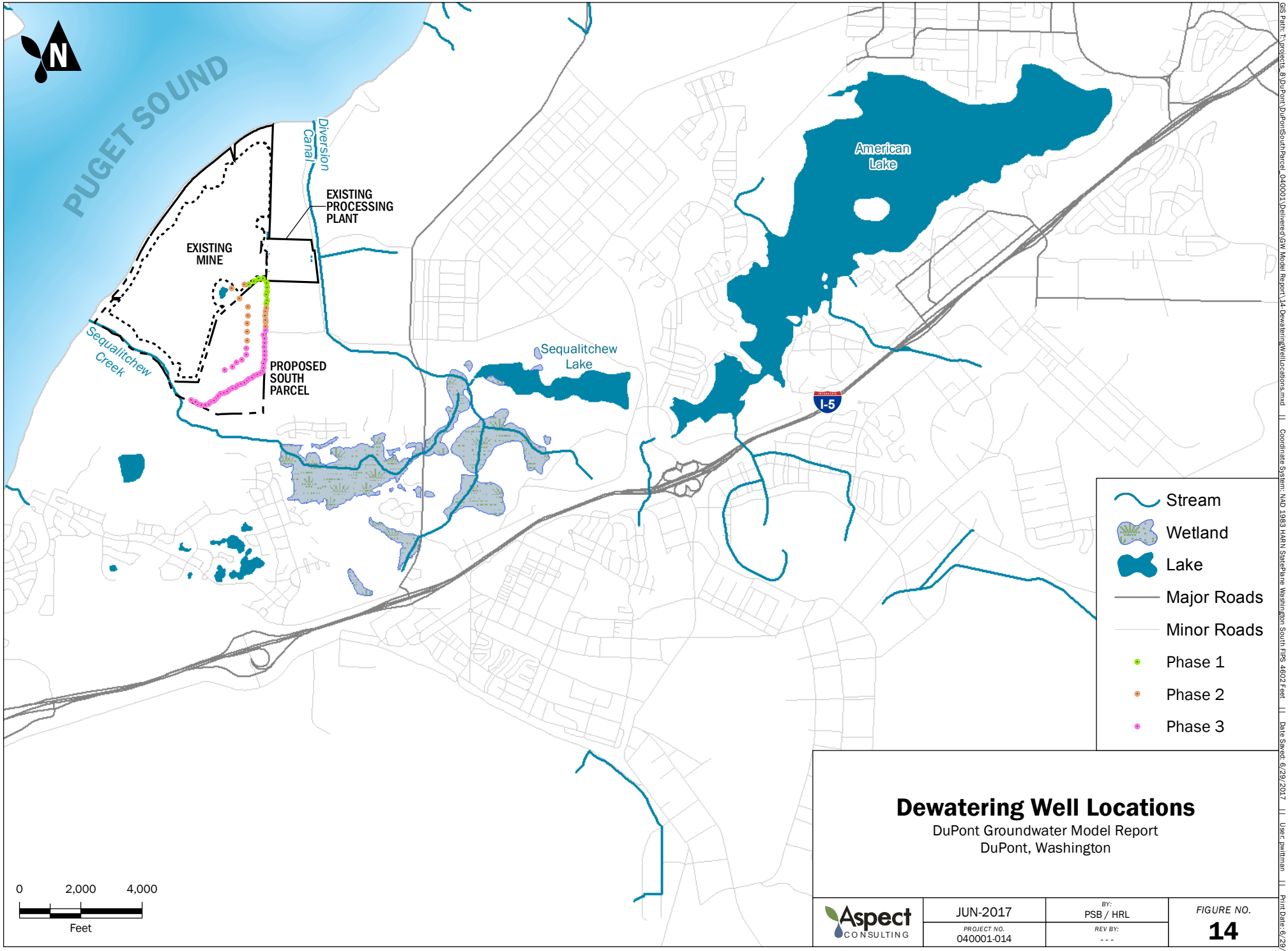


Figure 13
Wetland Water Depths Over Time



Dewatering Well Locations

DuPont Groundwater Model Report
DuPont, Washington

Aspect CONSULTING	JUN-2017	BY: PSB / HRL	FIGURE NO. 14
	PROJECT NO. 040001-014	REV BY: ---	

GIS Path: T:\projects_8\DuPont\DuPontSouthParcel_040001\Delivered\GW Model Report\14-DewateringWellLocations.mxd || Coordinate System: NAD 1983 HARN StatePlane Washington South FIPS 4602 Feet || Date Saved: 6/29/2017 || User: pwittman || Print Date: 6/29/2017

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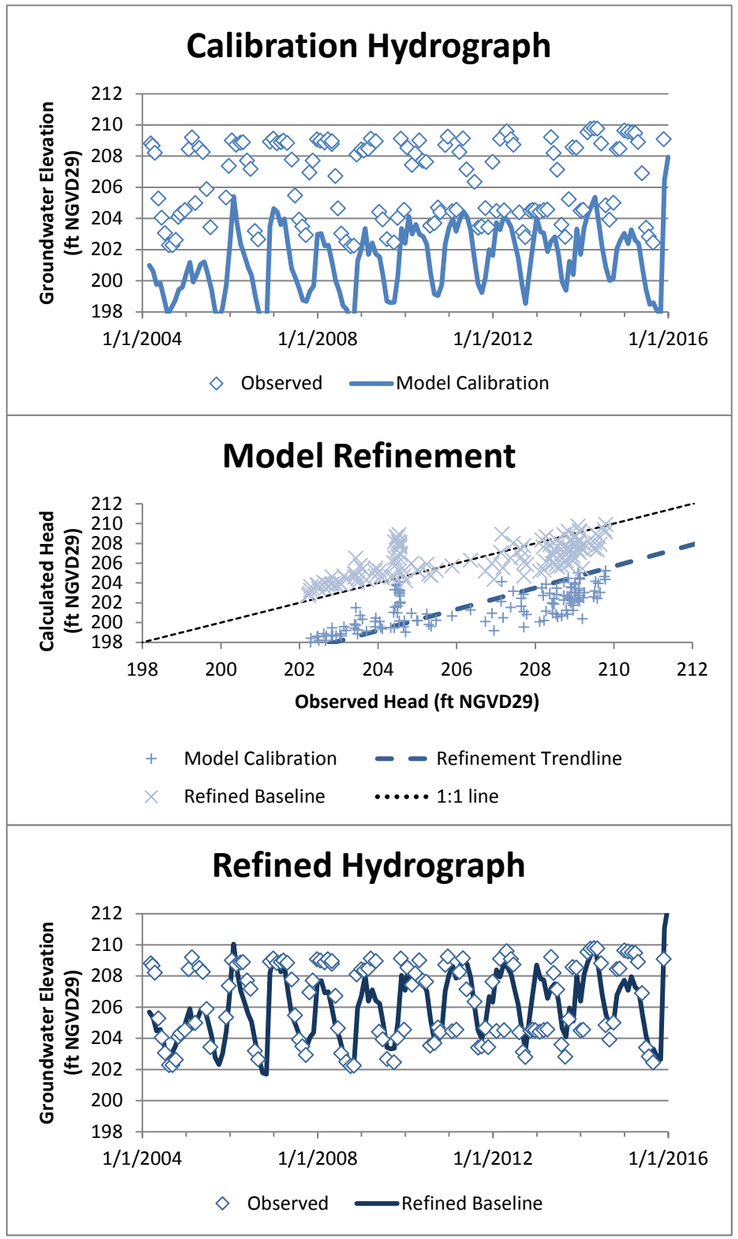

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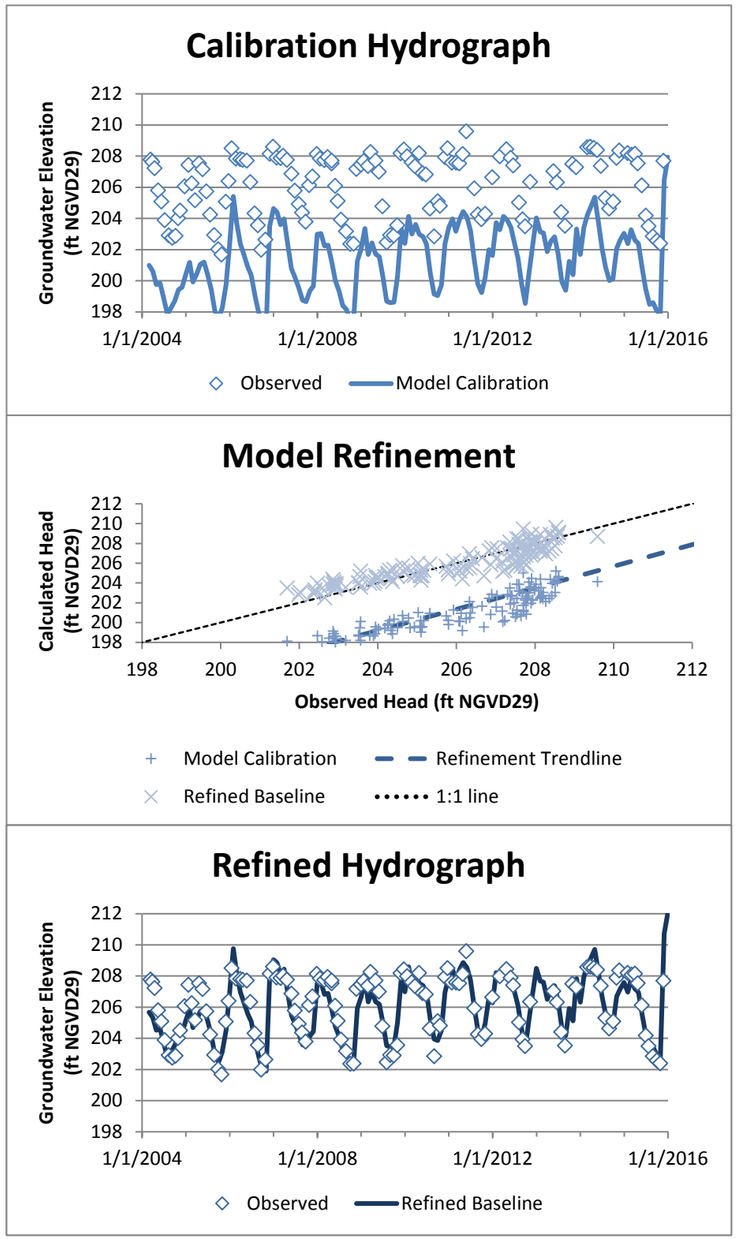

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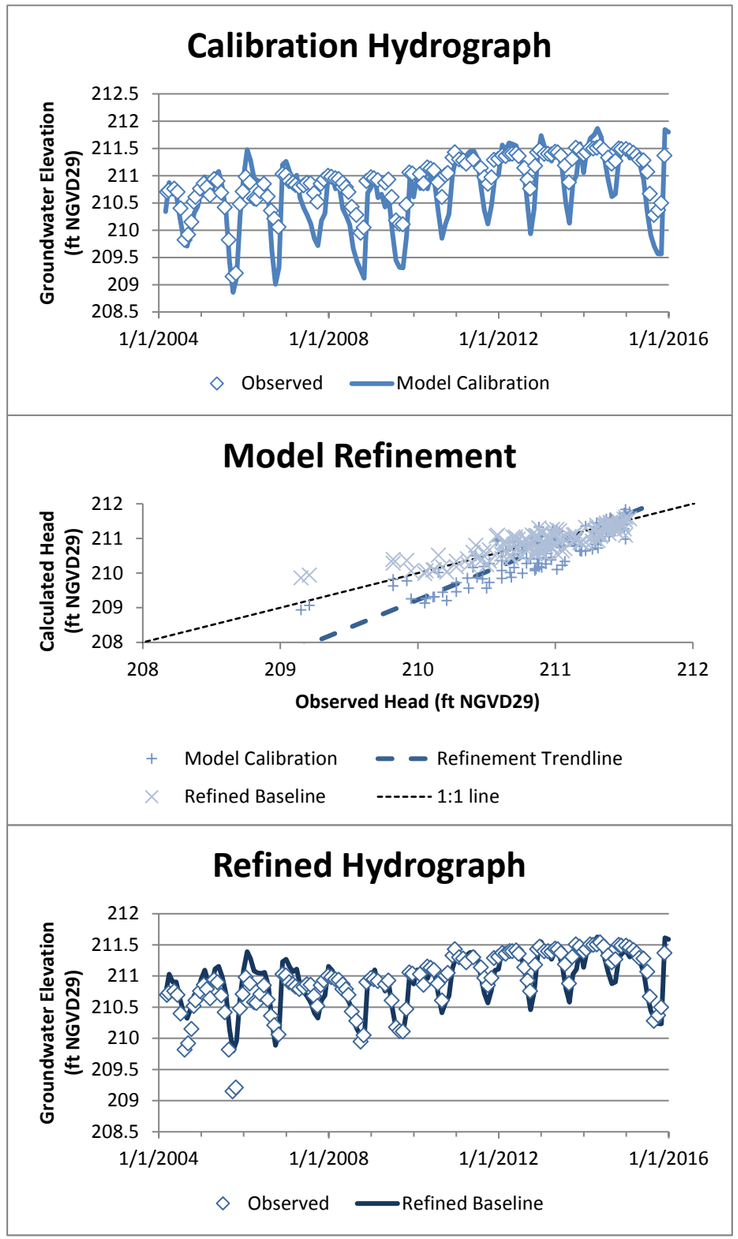
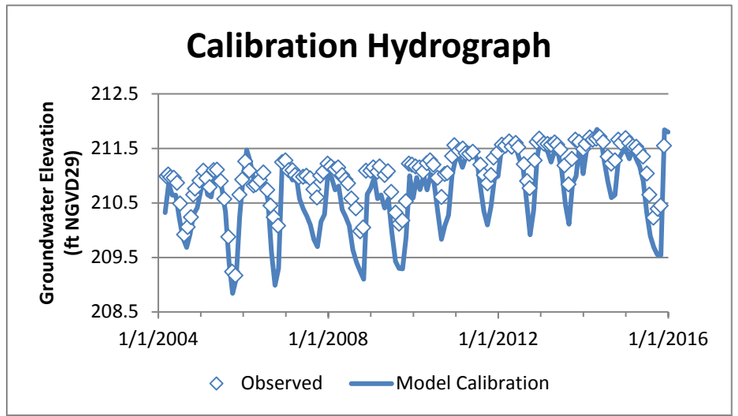
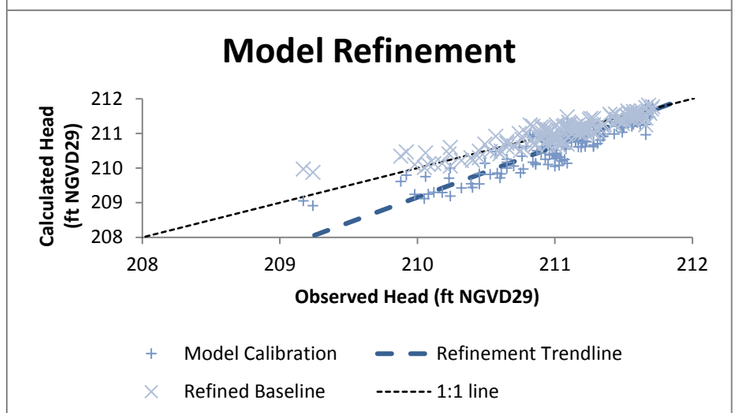
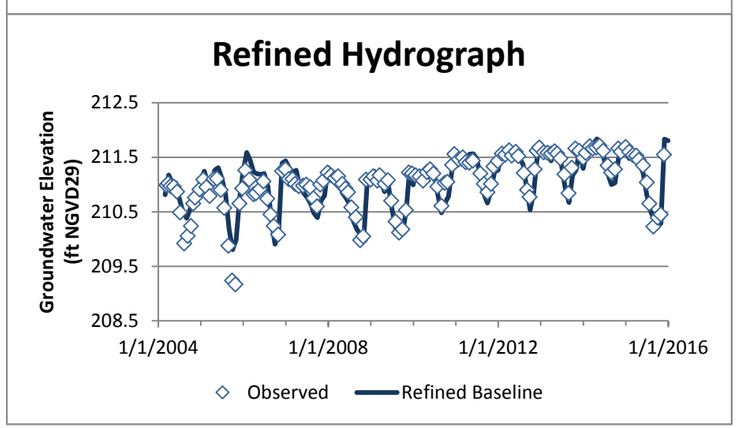


Figure 15
Calibration and Refined Hydrographs
Dupont Groundwater Model Report

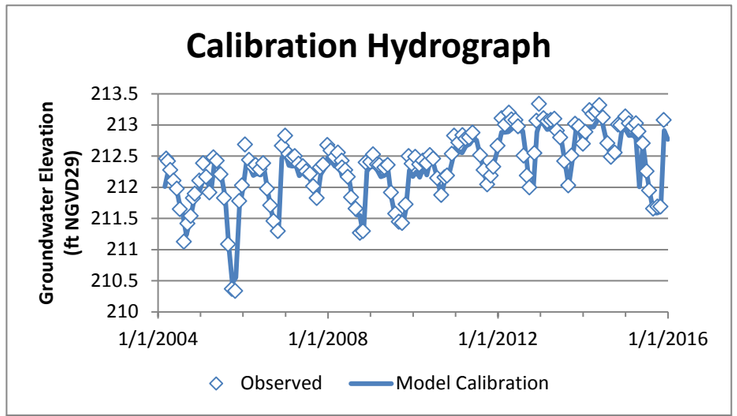
MW-EM-2D

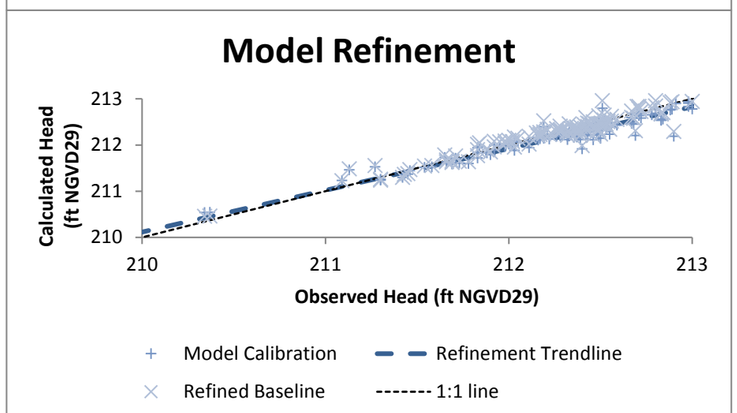


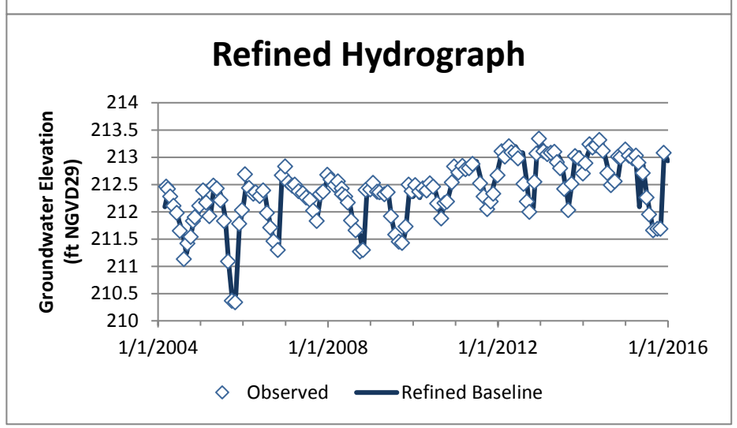




MW-EM-3







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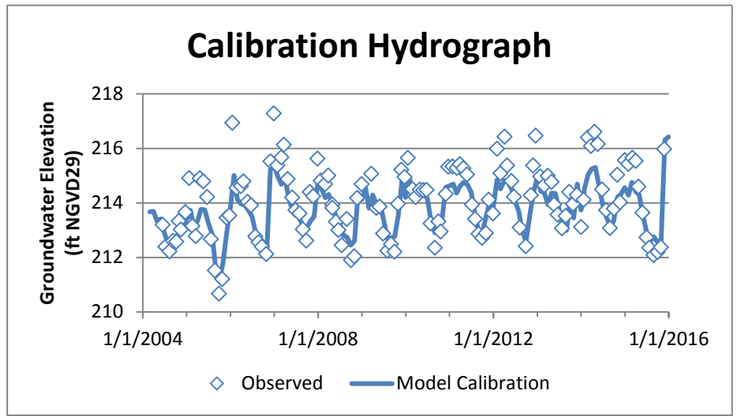
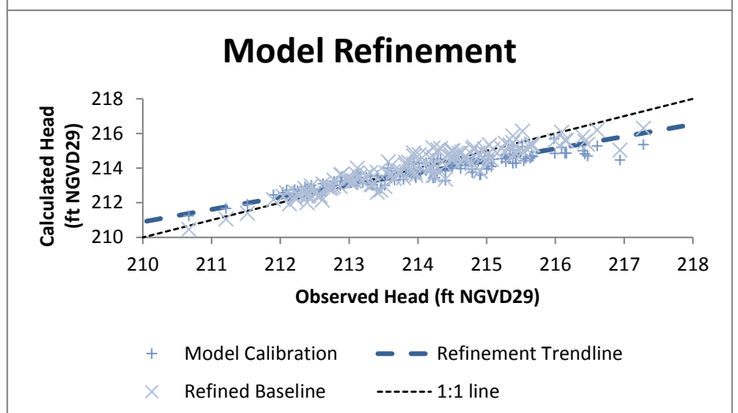




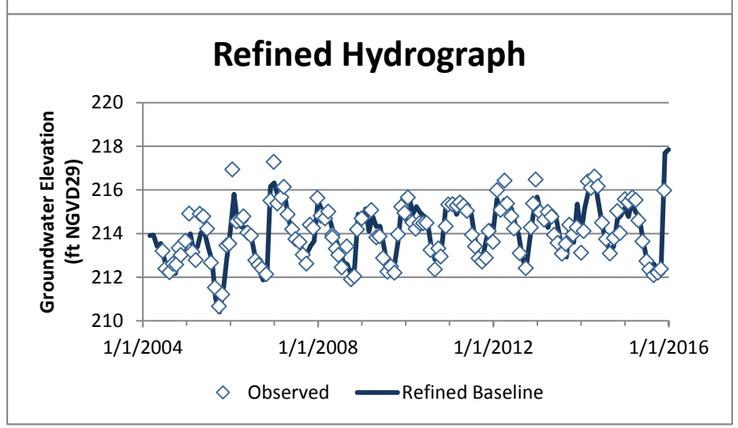
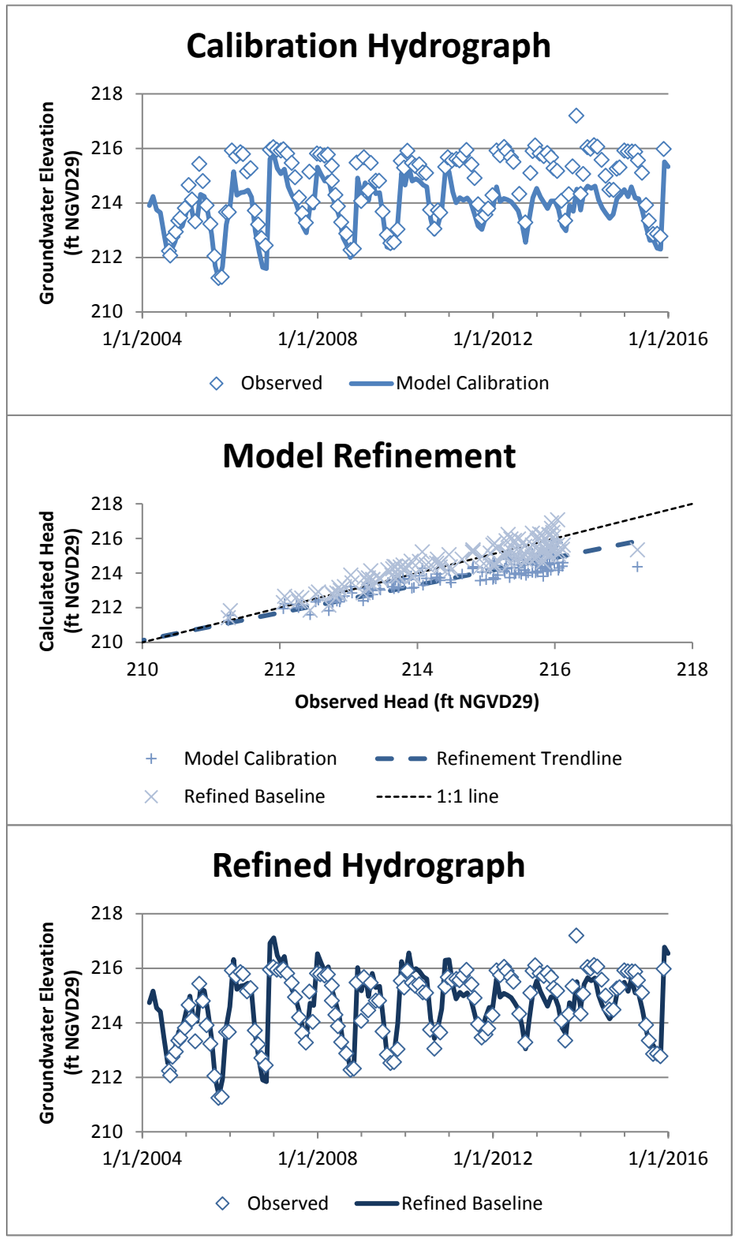


Figure 15
Calibration and Refined Hydrographs
Dupont Groundwater Model Report

MW-HM-1



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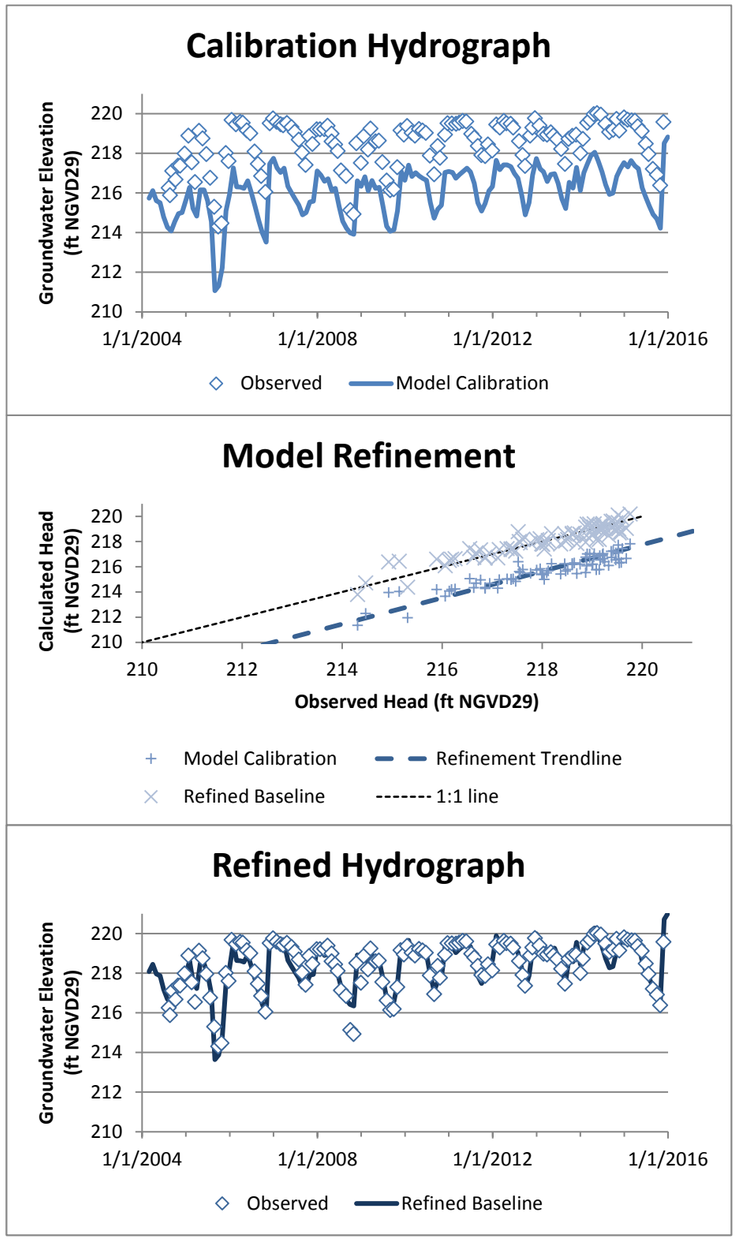

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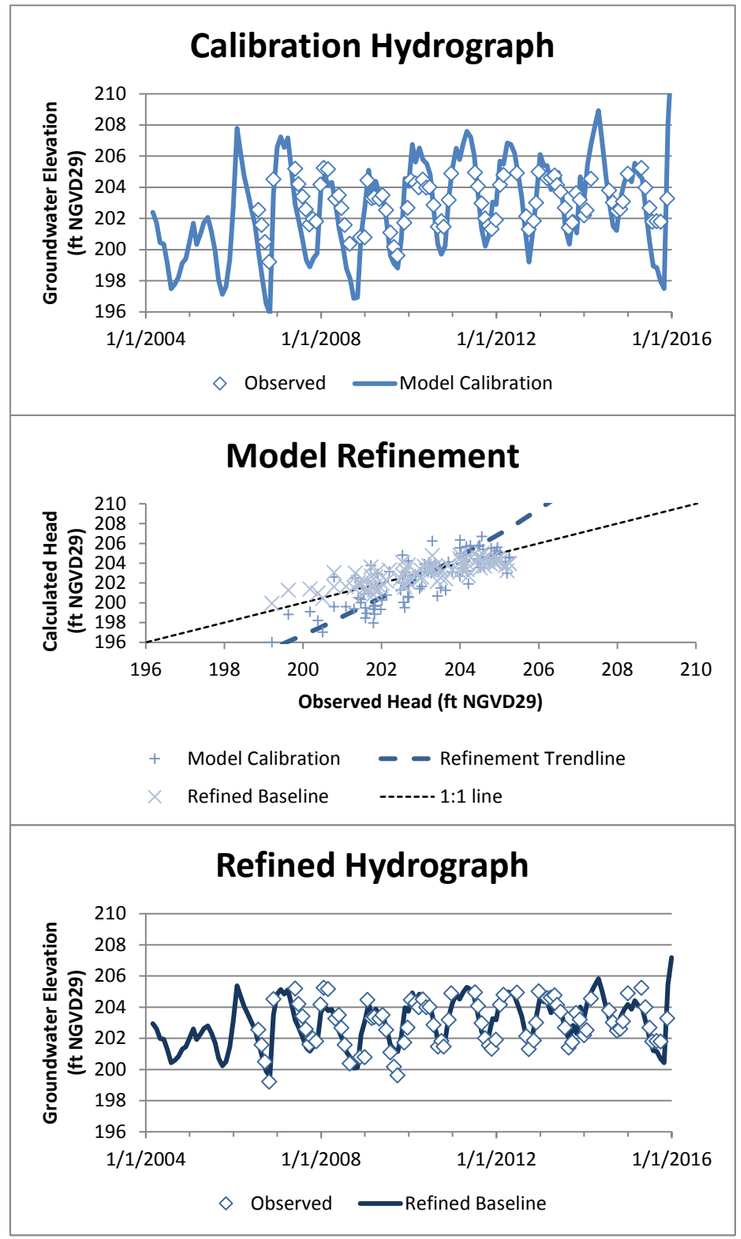
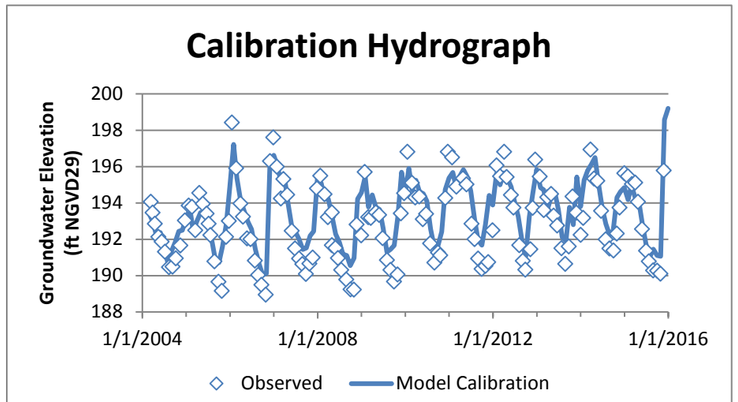
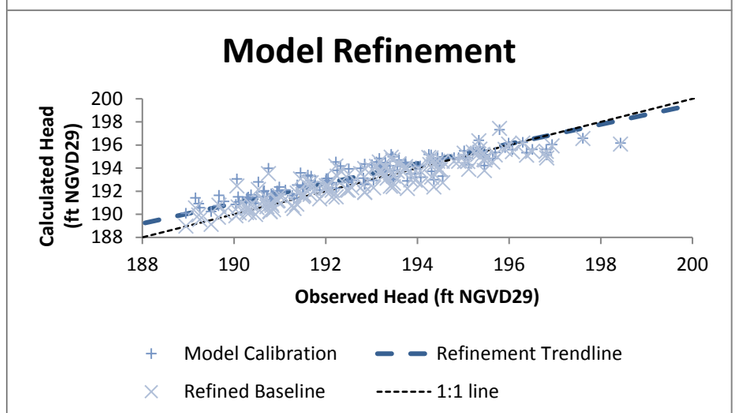
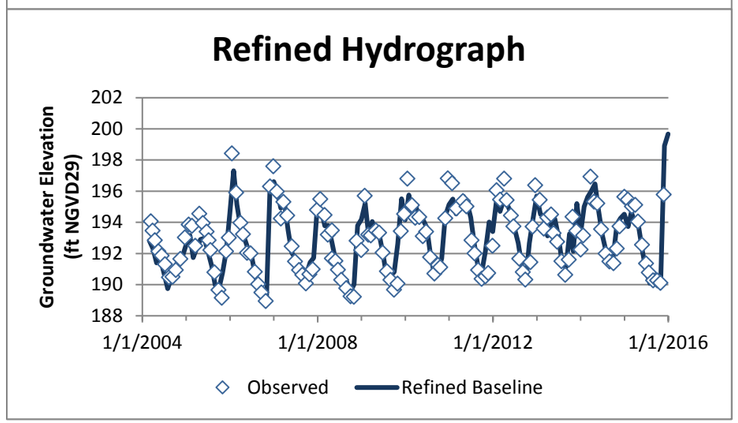


Figure 15
Calibration and Refined Hydrographs
Dupont Groundwater Model Report

CHMW-1







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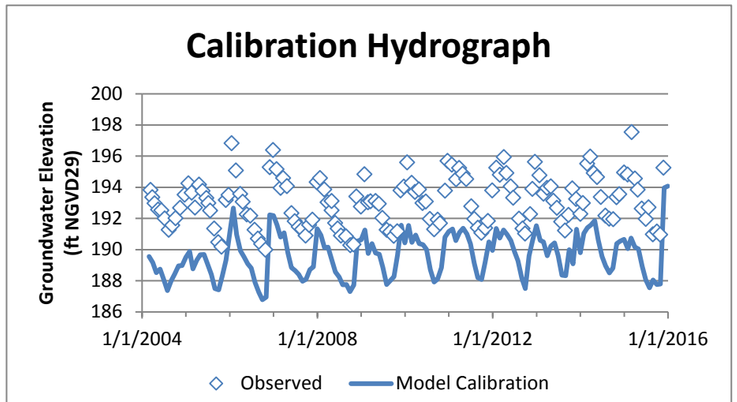

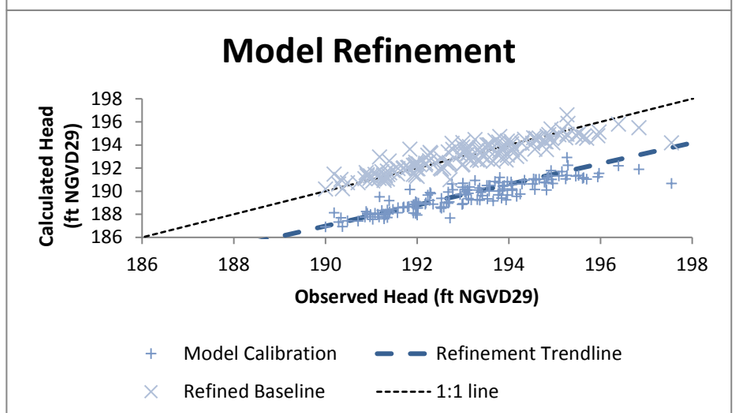

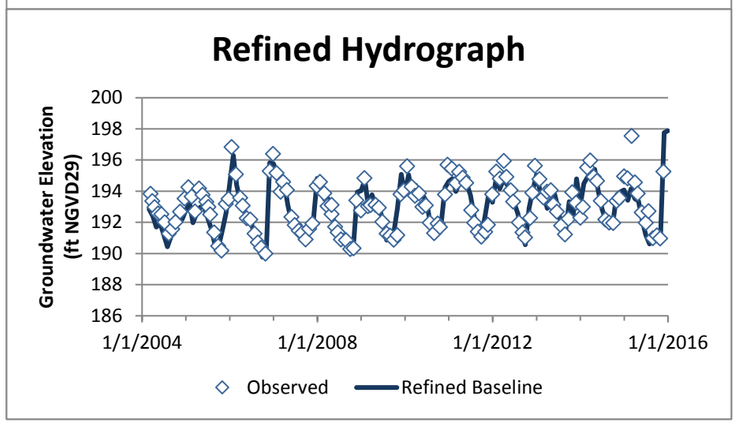

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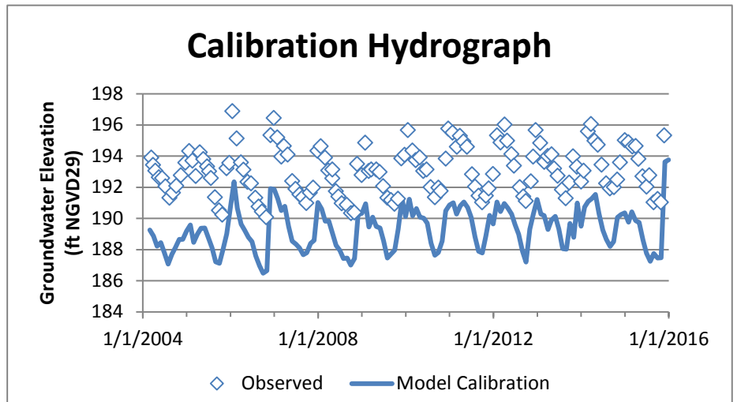
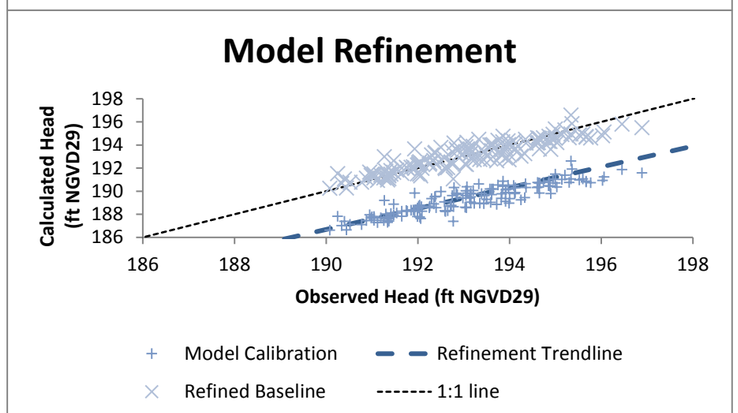




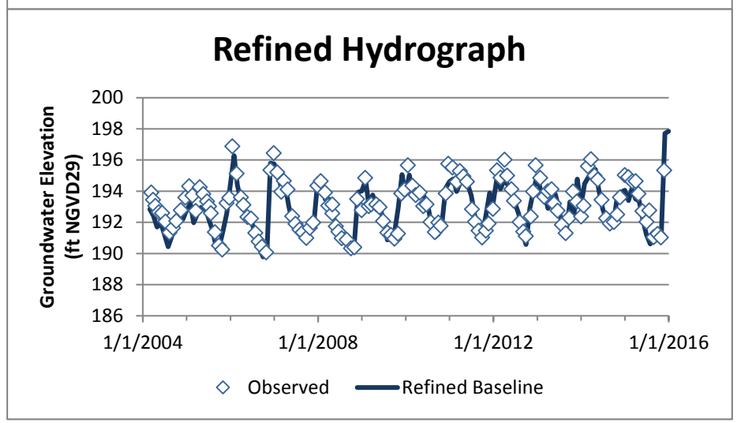
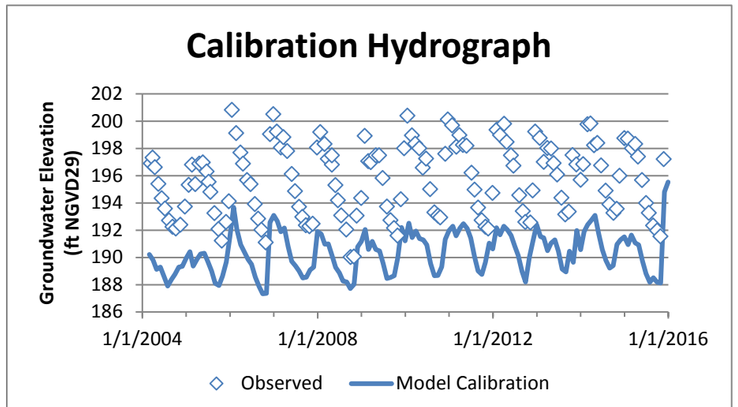
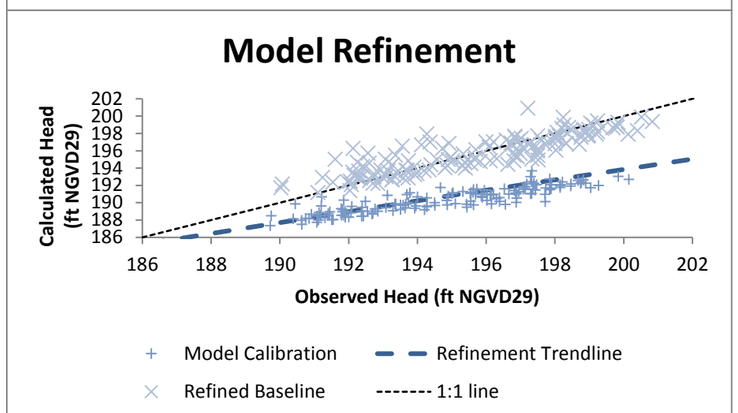
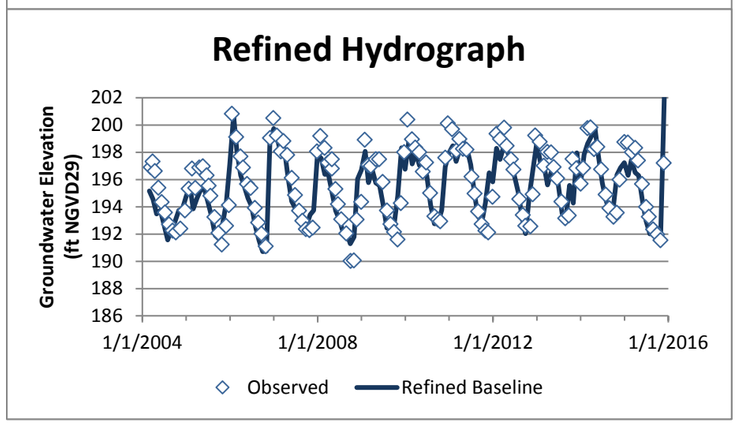


Figure 15
Calibration and Refined Hydrographs
Dupont Groundwater Model Report

CHMW-3S







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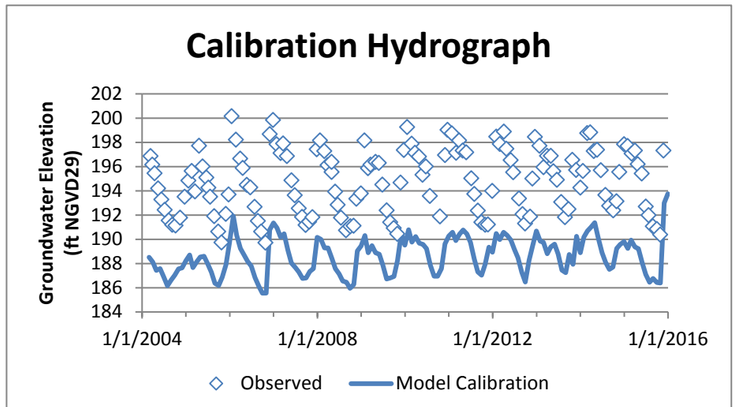

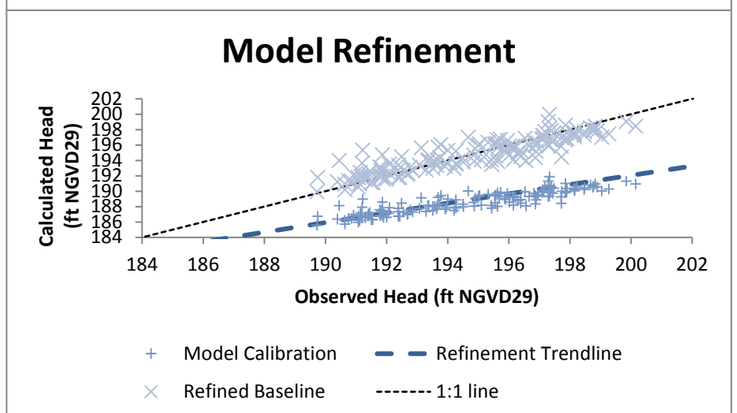

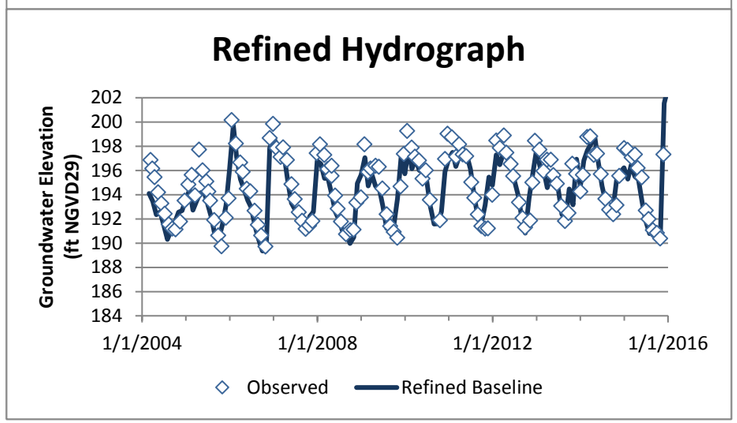

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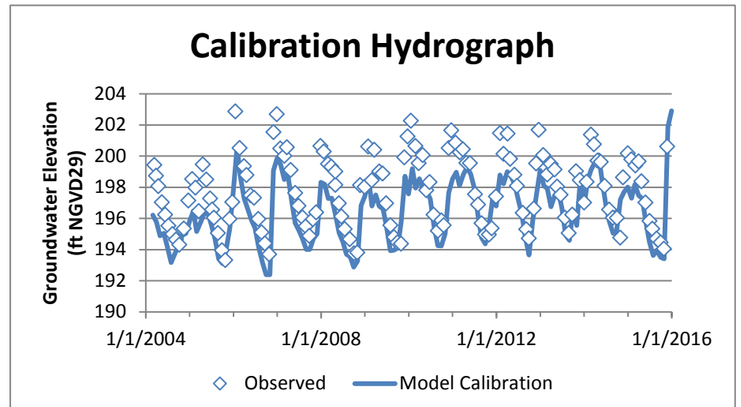

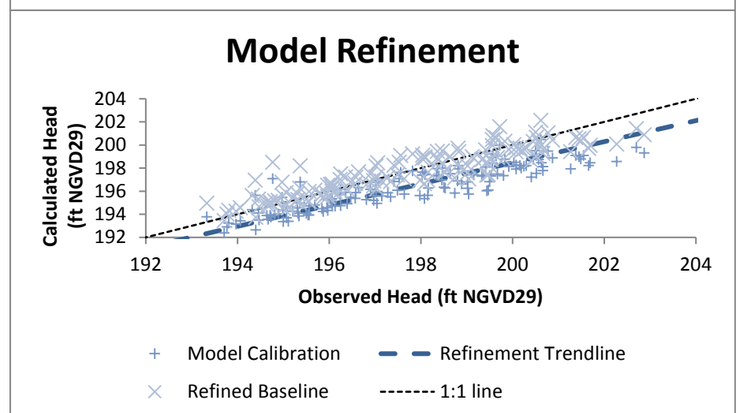

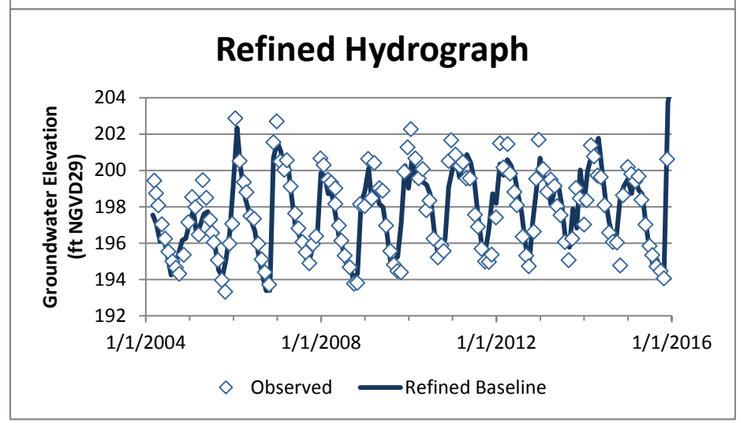

Figure 15
Calibration and Refined Hydrographs
Dupont Groundwater Model Report

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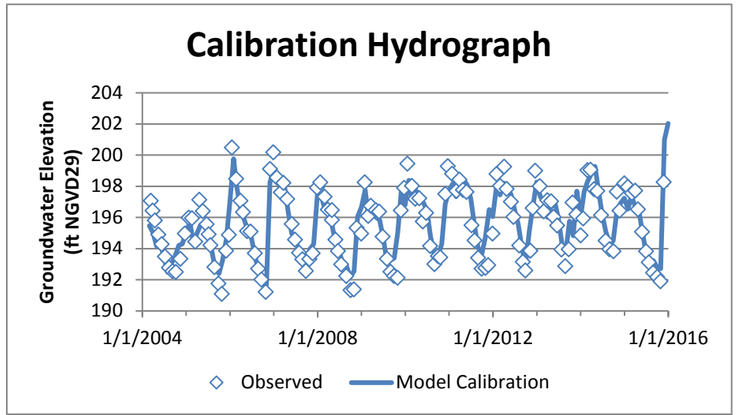

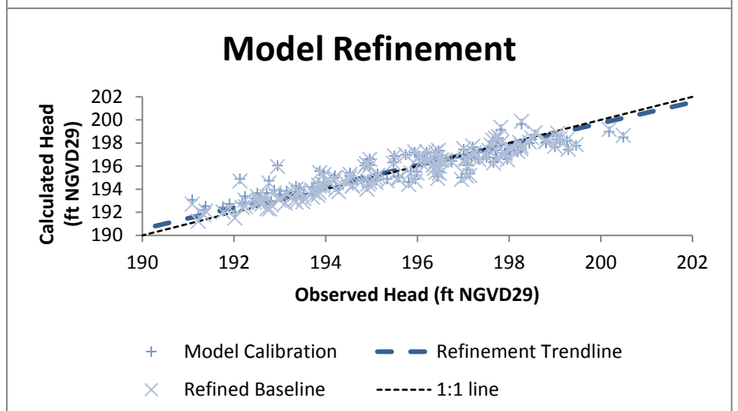

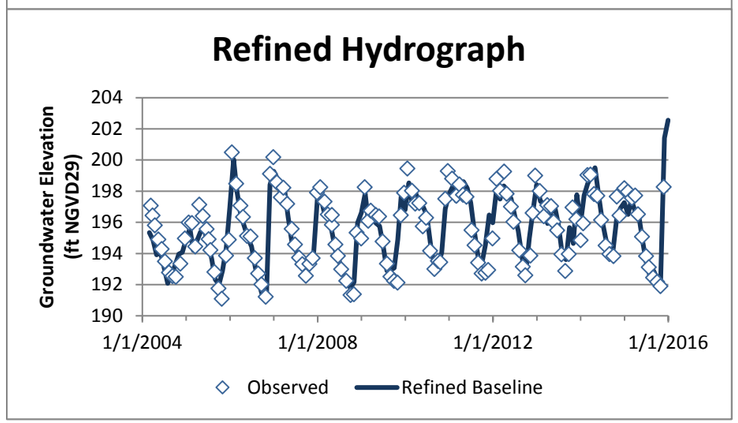

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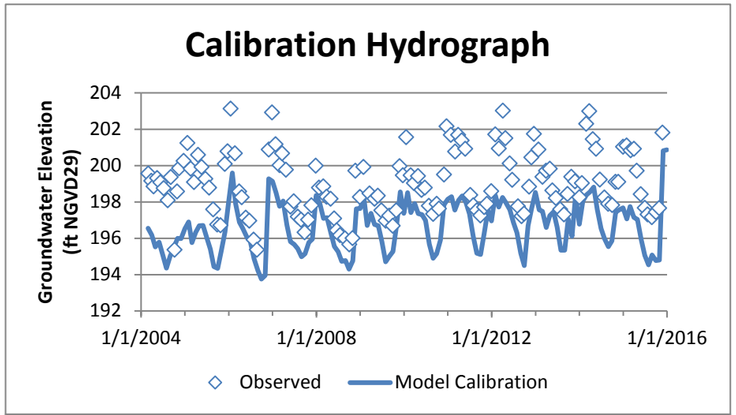

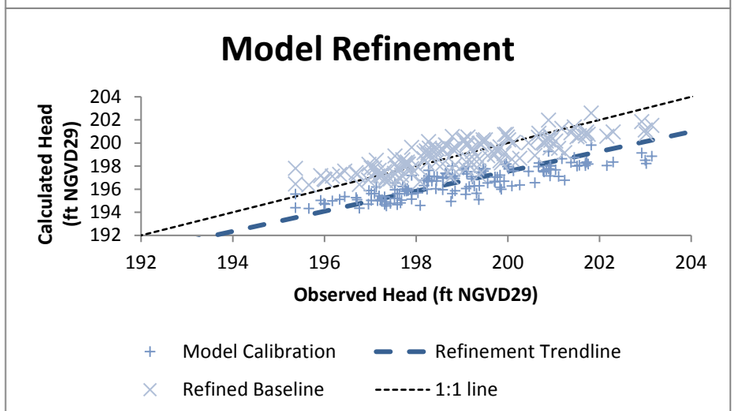

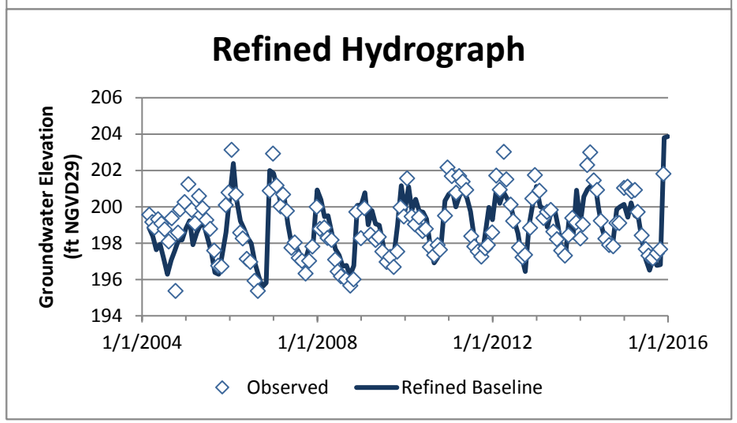

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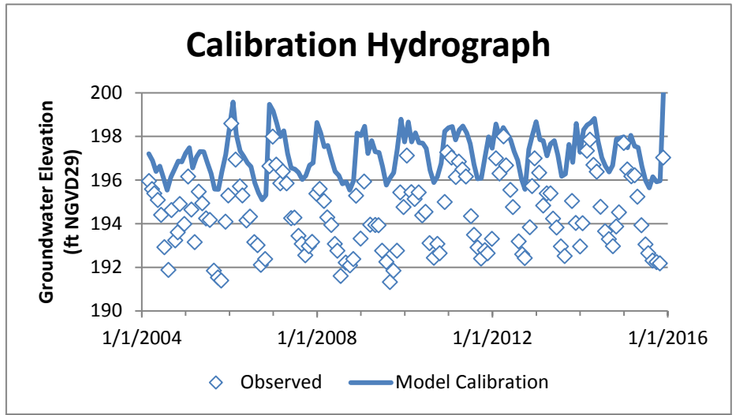
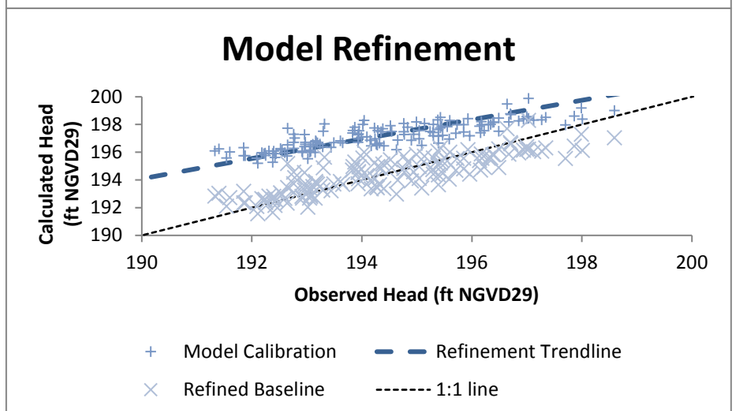




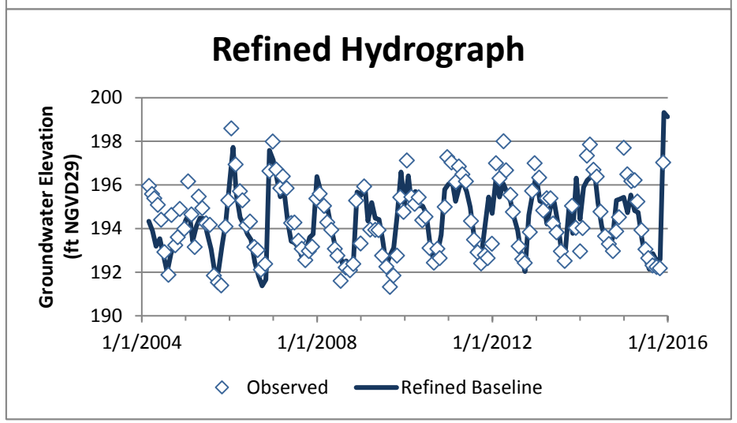
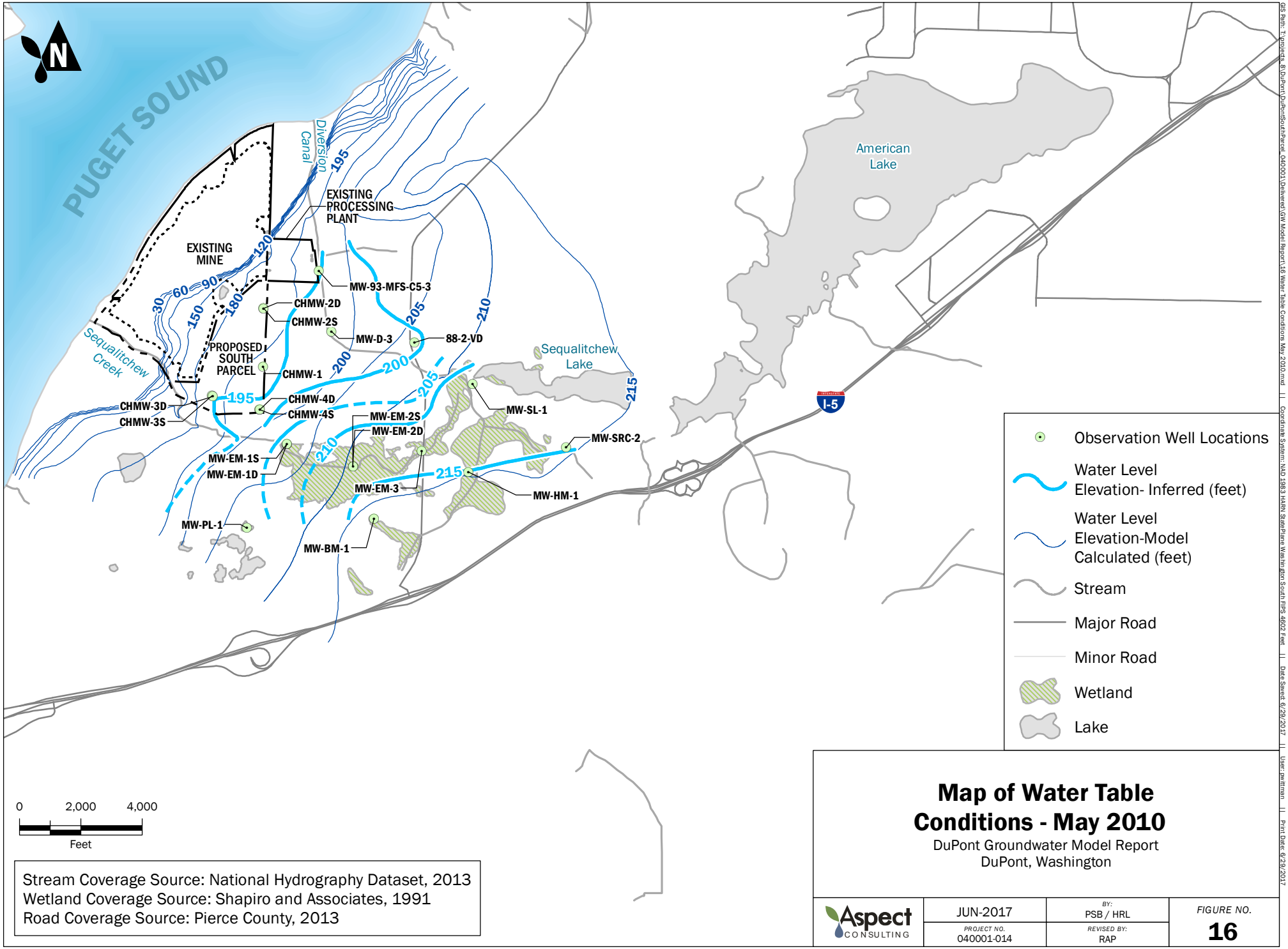


Figure 15
Calibration and Refined Hydrographs
Dupont Groundwater Model Report



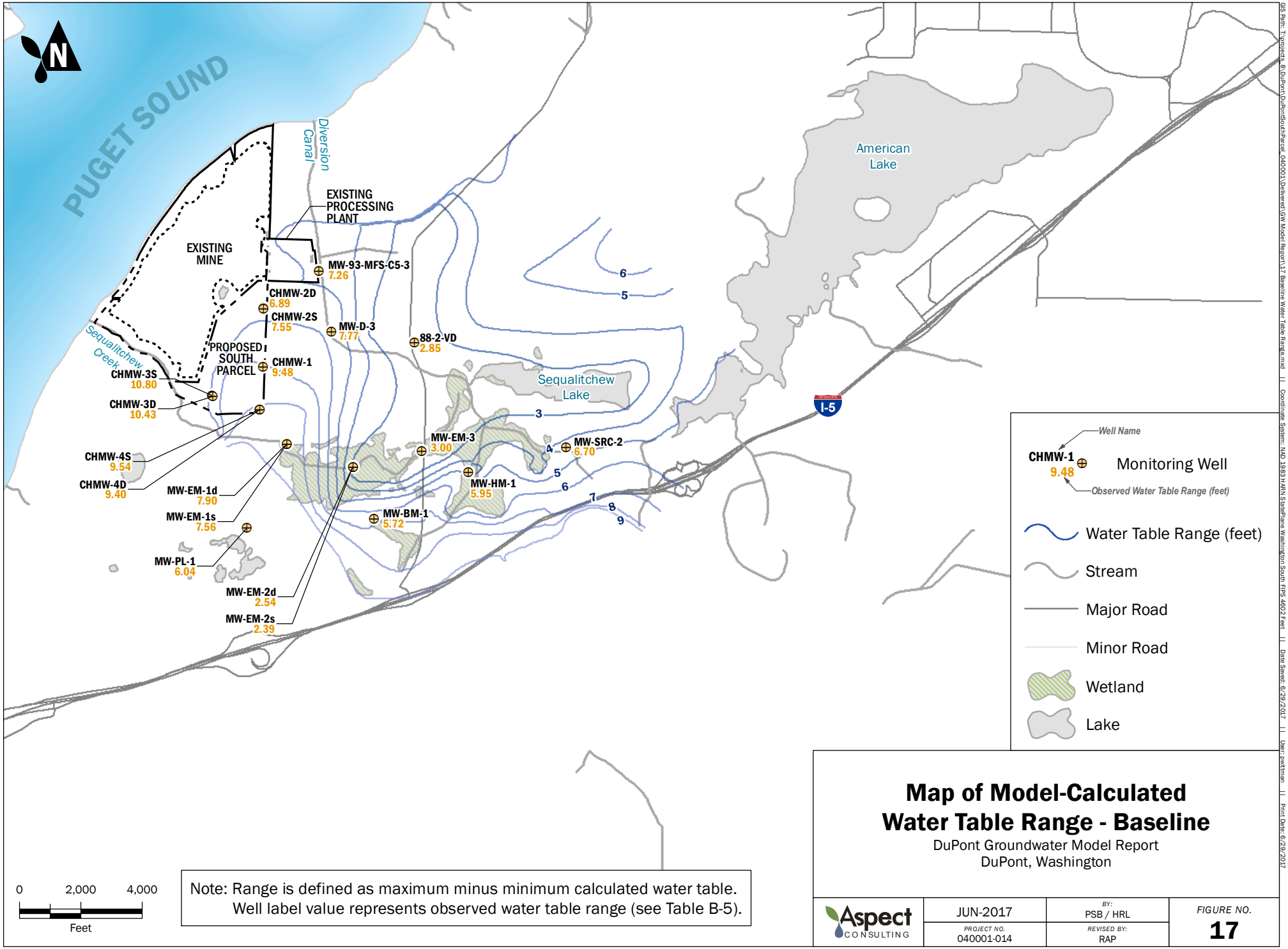
Stream Coverage Source: National Hydrography Dataset, 2013
Wetland Coverage Source: Shapiro and Associates, 1991
Road Coverage Source: Pierce County, 2013

Map of Water Table Conditions - May 2010

DuPont Groundwater Model Report
DuPont, Washington

Aspect CONSULTING	JUN-2017	BY: PSB / HRL	FIGURE NO. 16
	PROJECT NO. 040001-014	REVISED BY: RAP	

GIS Path: T:\projects_8\DuPont\DuPontSouthParcel_040001\Deliverest\GW Model Report\16 Water Table Conditions May 2010.mxd || Coordinate System: NAD 1983 HARN StatePlane Washington South FIPS 4602 Feet || Date Saved: 6/29/2017 || User: jwittman || Print Date: 6/29/2017



Note: Range is defined as maximum minus minimum calculated water table.
Well label value represents observed water table range (see Table B-5).

Map of Model-Calculated Water Table Range - Baseline

DuPont Groundwater Model Report
DuPont, Washington

Aspect CONSULTING	JUN-2017	BY: PSB / HRL	FIGURE NO. 17
	PROJECT NO. 040001-014	REVISED BY: RAP	

GIS Path: T:\projects_8\DuPont\DuPontSouthParcel_040001\Deliverest\GW Model Report\17 Baseline Water Table Range.mxd || Coordinate System: NAD 1983 HARN StatePlane Washington South FIPS 4602 Feet || Date Saved: 6/29/2017 || User: jwittman || Print Date: 6/29/2017

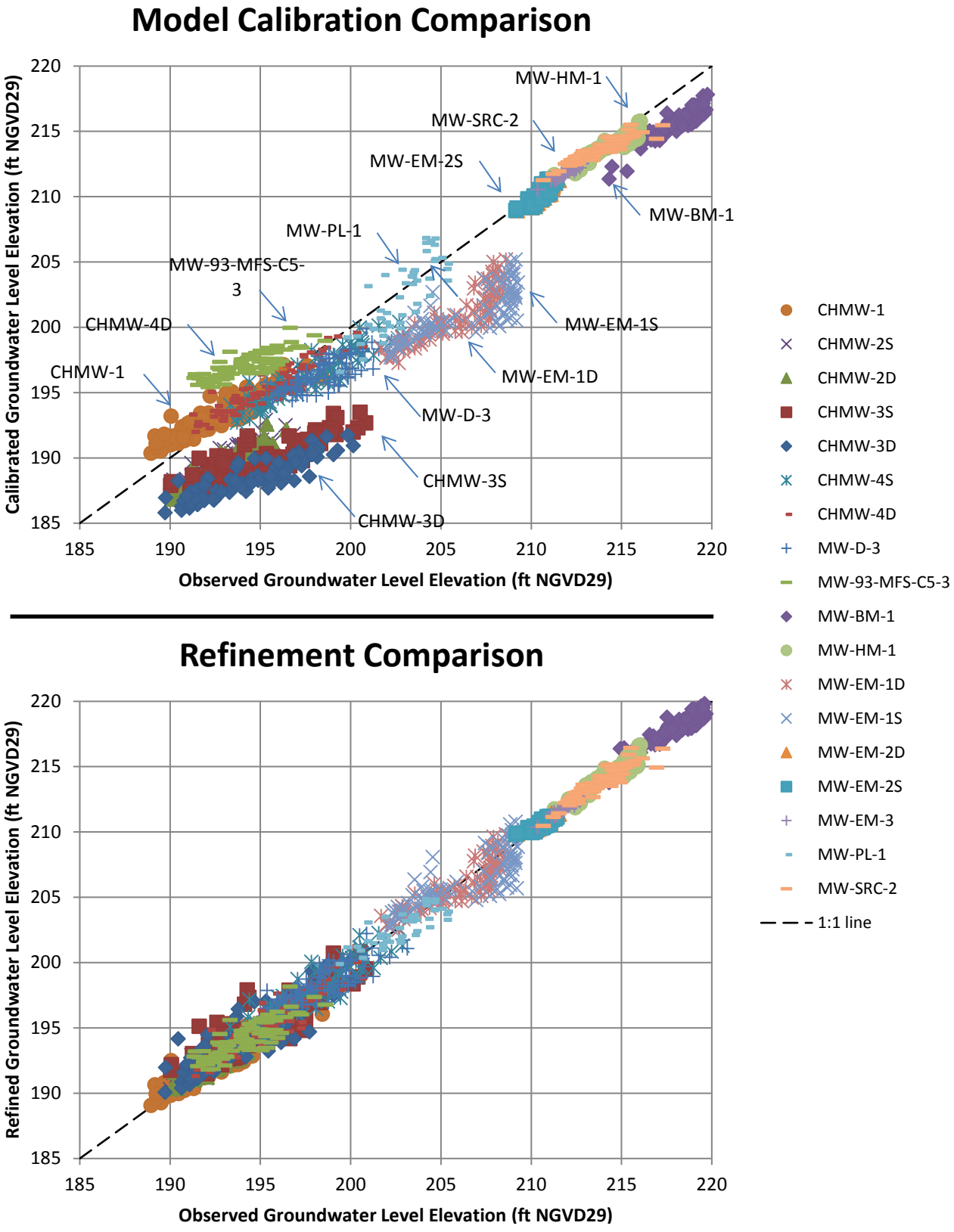
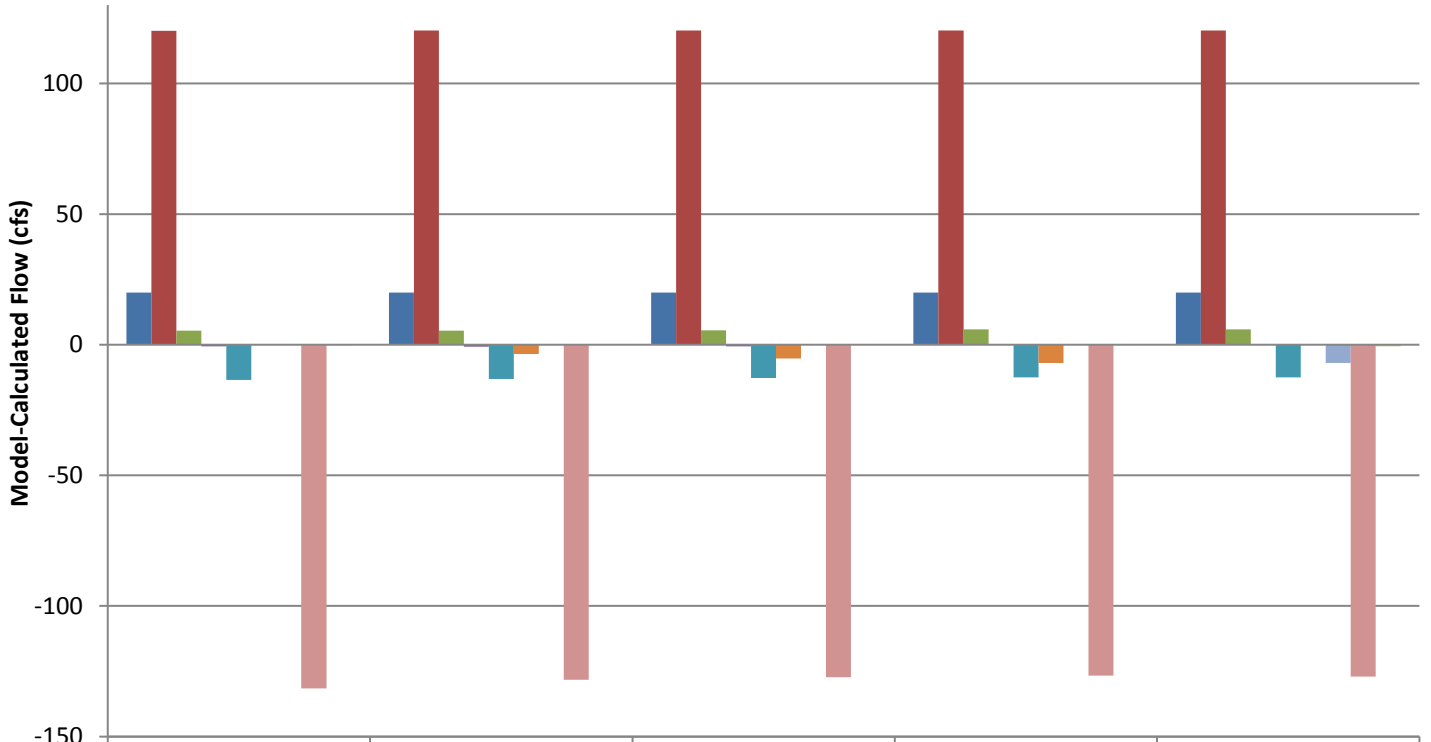


Figure 18
Observed vs. Calculated Groundwater Levels
Dupont Groundwater Model Report



	Baseline	Step 1	Step 2	Step 3	Step 4
Recharge	20.0	20.0	20.0	20.0	20.0
Groundwater Inflow	120.1	120.2	120.3	120.3	120.3
Wetland Infiltration	5.3	5.4	5.5	5.9	5.8
Discharge - Seq Ck	-0.6	-0.7	-0.6	-0.1	-0.1
Discharge - Other Surface Water	-13.5	-13.1	-12.8	-12.5	-12.6
Discharge - Well	0.0	-3.6	-5.2	-6.9	0.0
Discharge - Mine	0.0	0.0	0.0	0.0	-6.9
Groundwater Outflow	-131.5	-128.2	-127.2	-126.7	-127.1
Change in Storage	-0.2	-0.1	0.0	-0.1	-0.6

Figure 19
Average Groundwater Balance Comparison - Overall
DuPont Groundwater Model Report

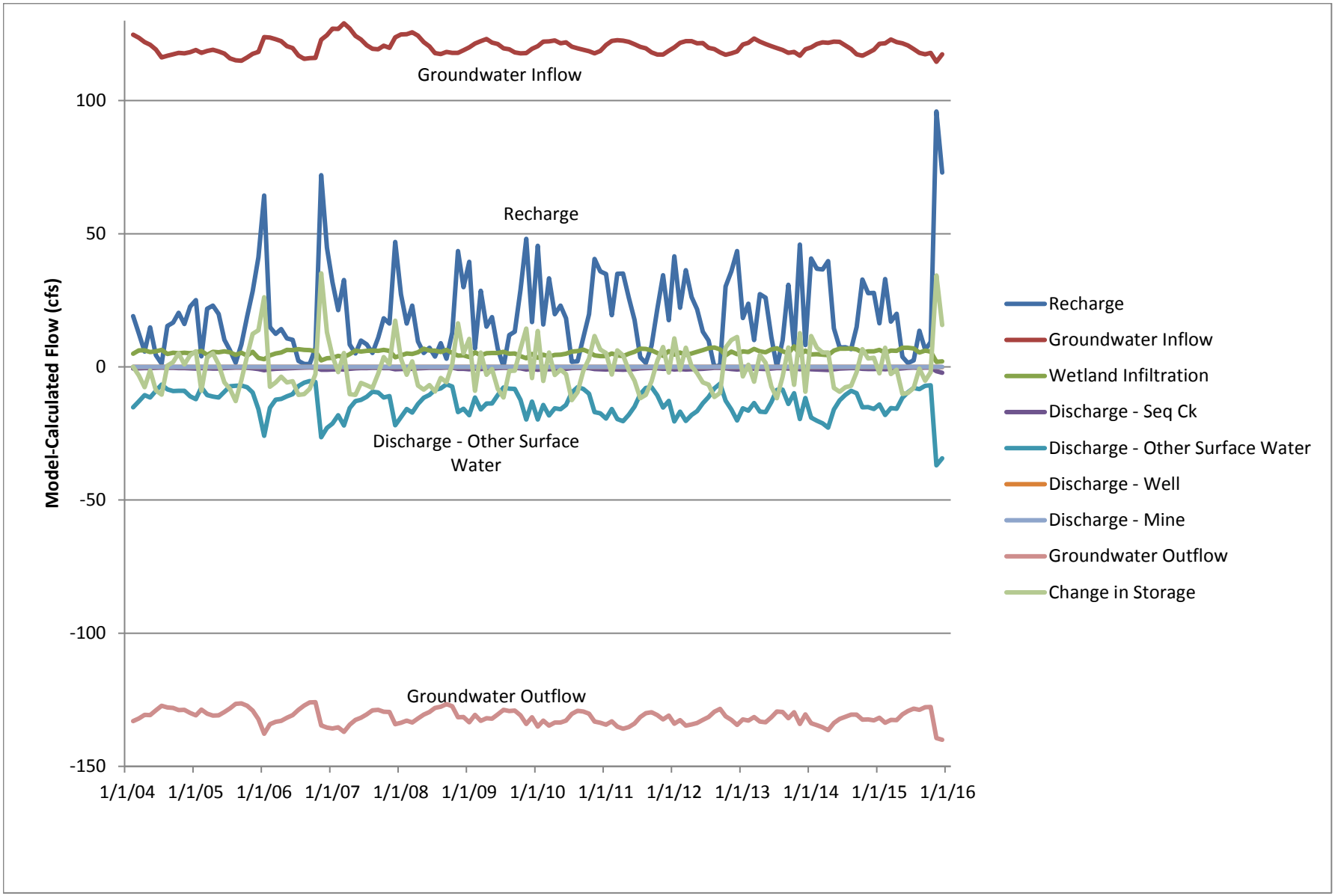
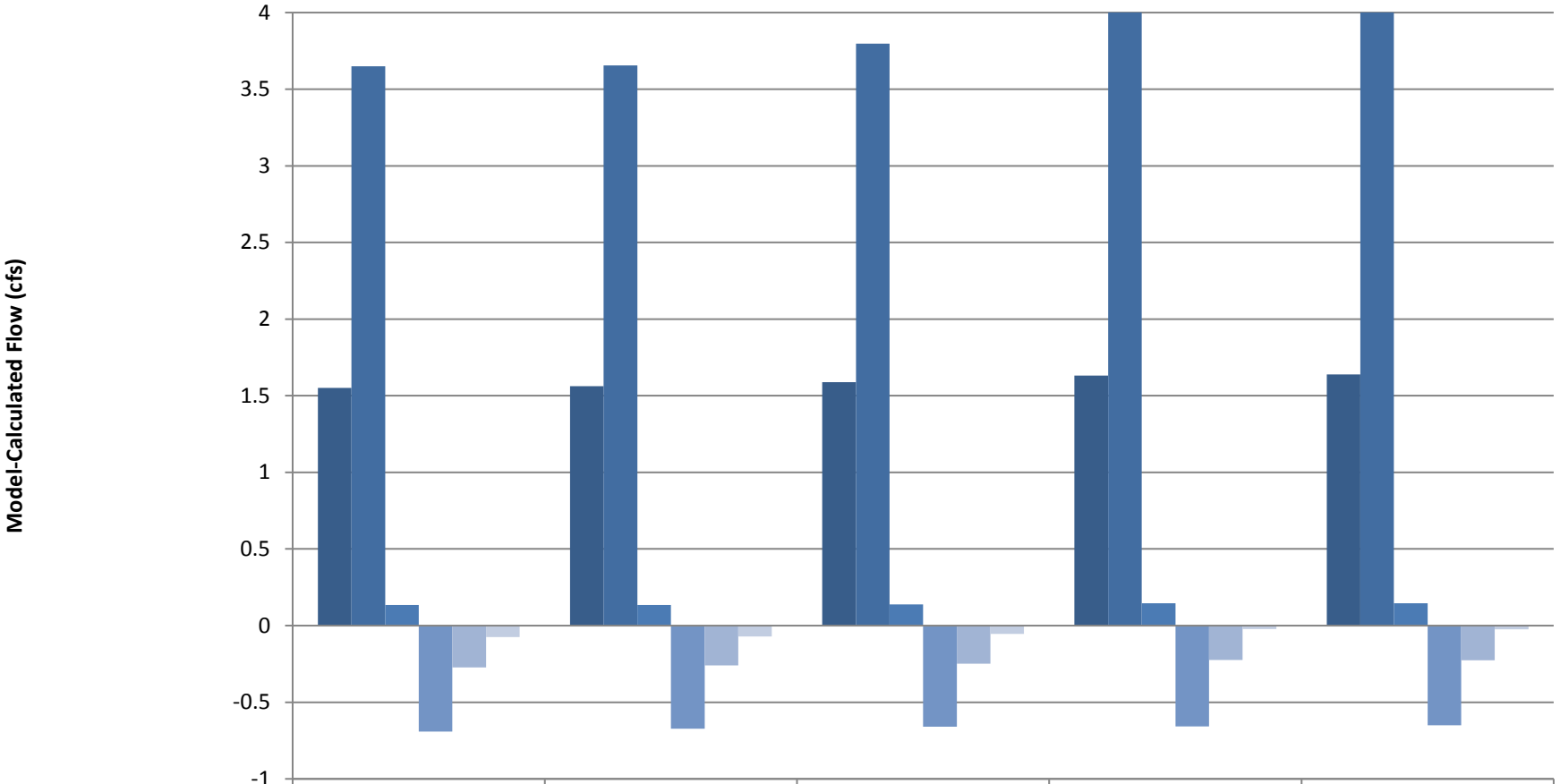


Figure 20
Baseline Groundwater Balance Over Time - Overall
DuPont Groundwater Model Report



	Baseline	Step 1	Step 2	Step 3	Step 4
Infiltration from BHM	1.6	1.6	1.6	1.6	1.6
Infiltration from East EM	3.6	3.7	3.8	4.1	4.0
Infiltration from West EM	0.1	0.1	0.1	0.1	0.1
Discharge to BHM	-0.7	-0.7	-0.7	-0.7	-0.6
Discharge to East EM	-0.3	-0.3	-0.2	-0.2	-0.2
Discharge to West EM	-0.1	-0.1	-0.1	0.0	0.0

Figure 21
Average Groundwater Balance Comparison - Wetlands
DuPont Groundwater Model Report

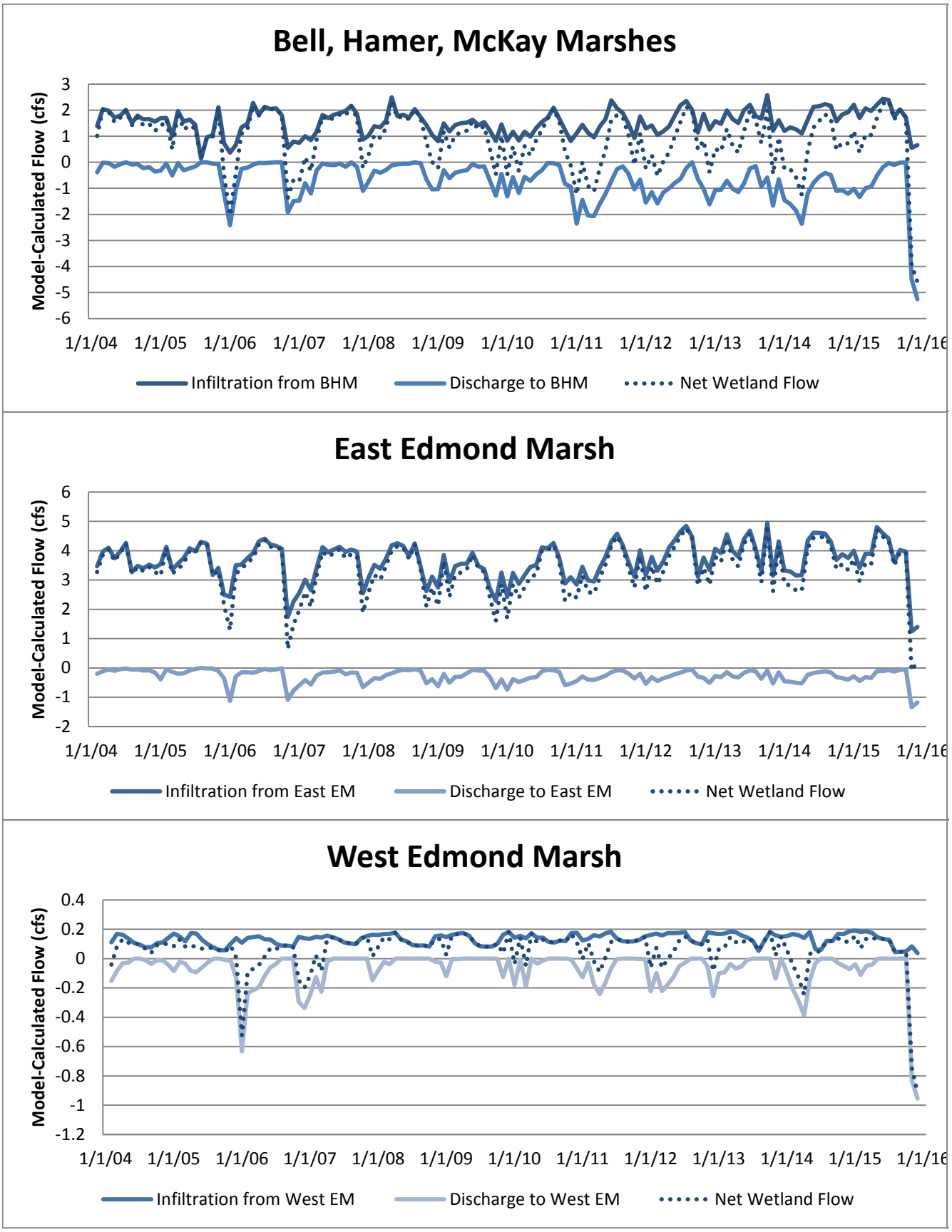
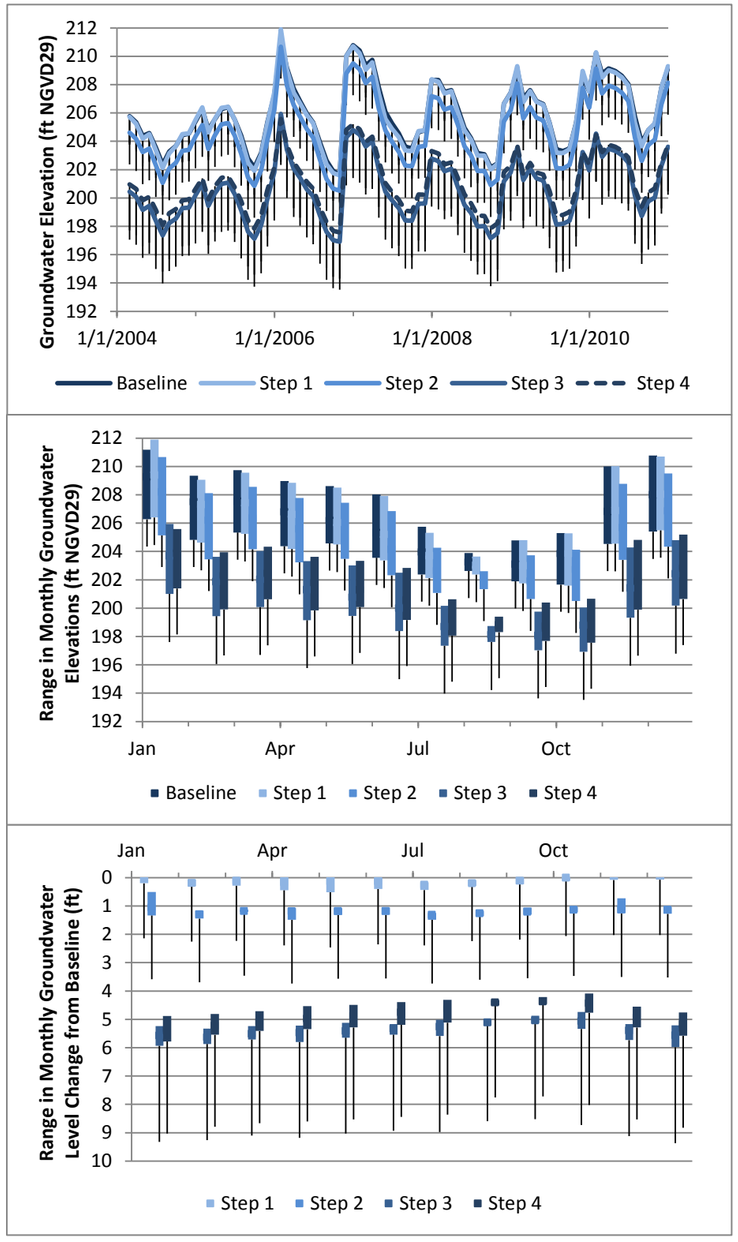
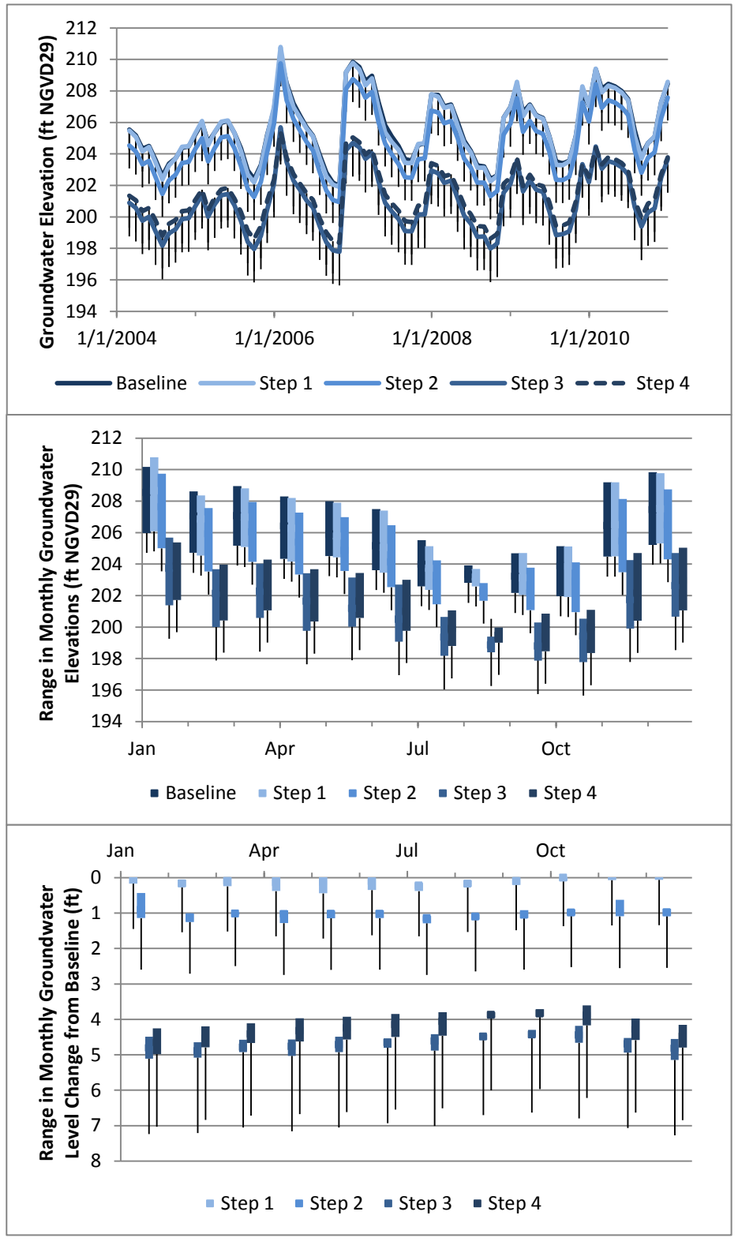


Figure 22
Baseline Groundwater Balance Over Time - Wetlands

MW-EM-1S



MW-EM-1D



MW-EM-2S

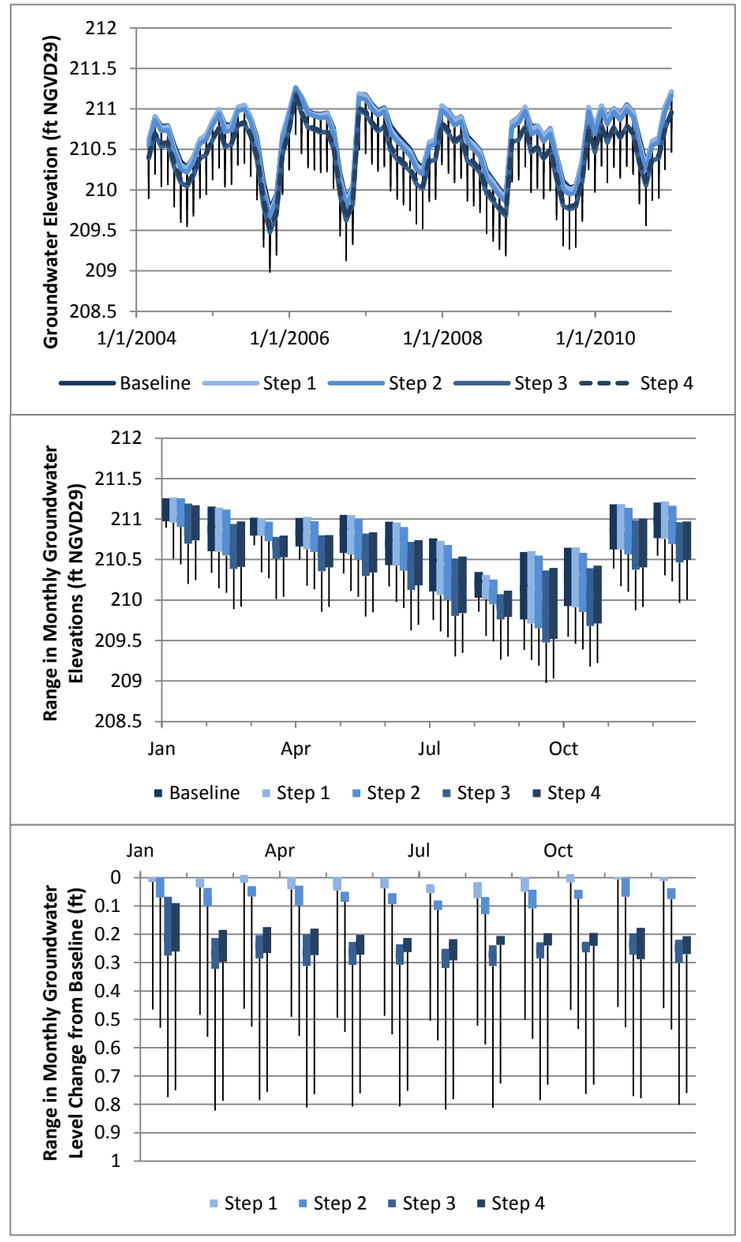


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Figure 23
Predicted Changes and Ranges in Groundwater Levels
Dupont Groundwater Model Report

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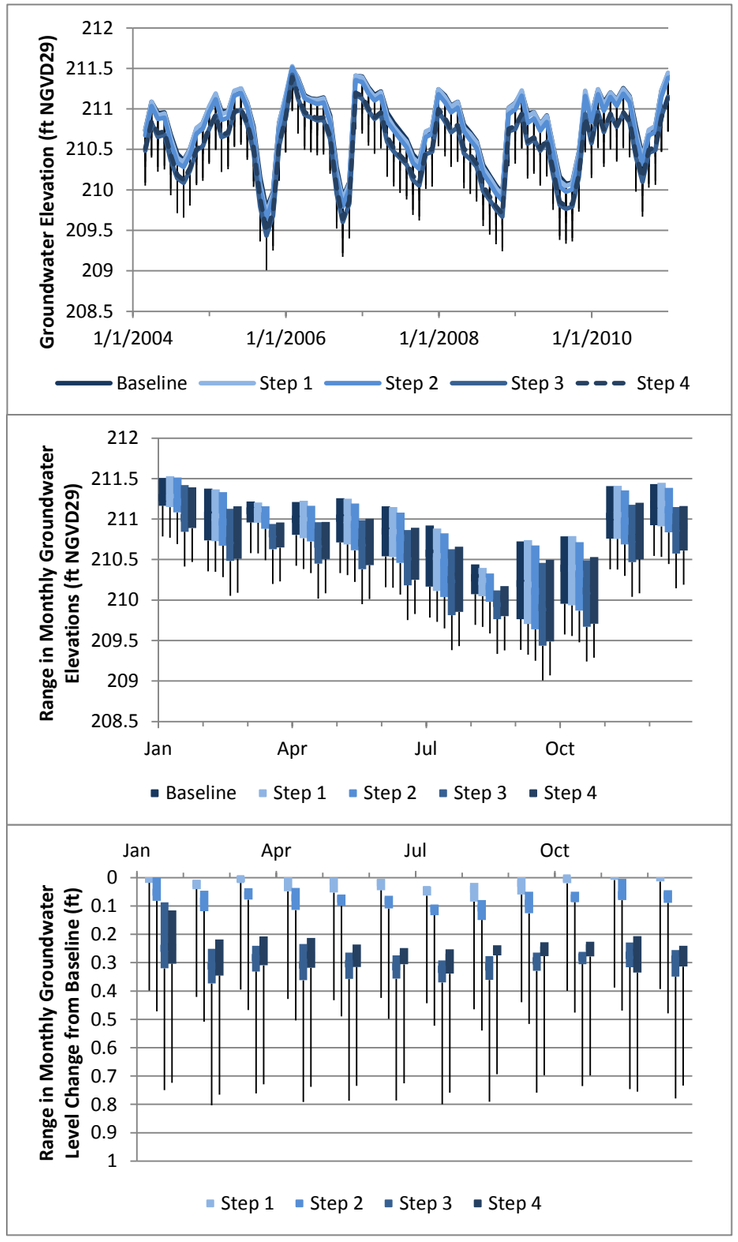

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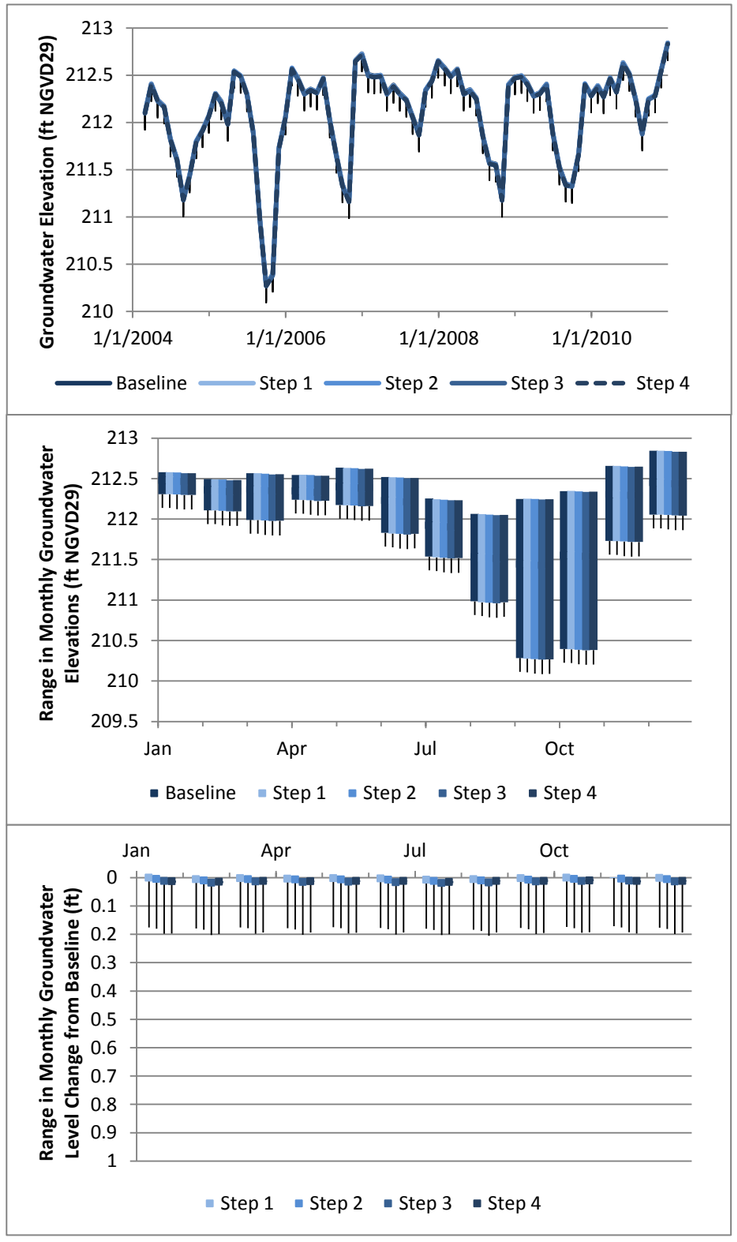

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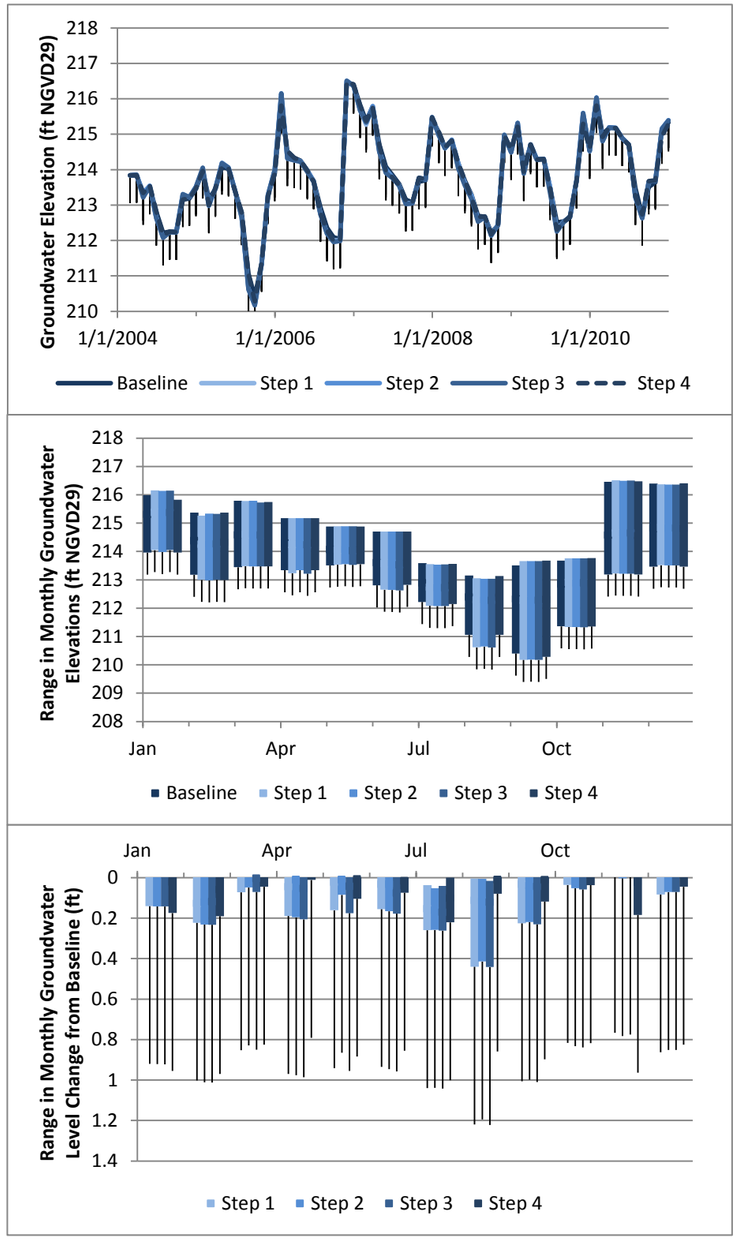

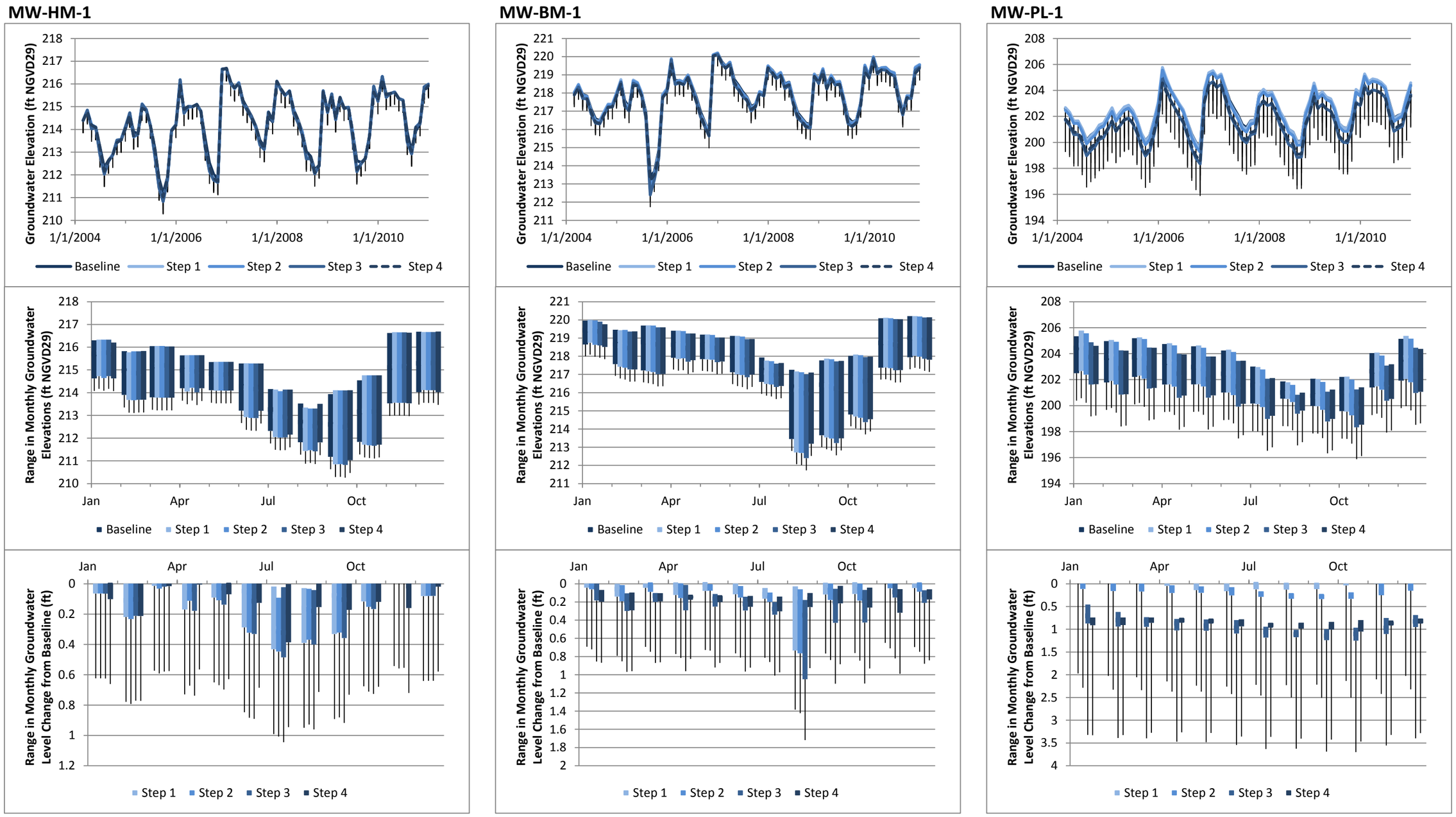

Figure 23
Predicted Changes and Ranges in Groundwater Levels
Dupont Groundwater Model Report

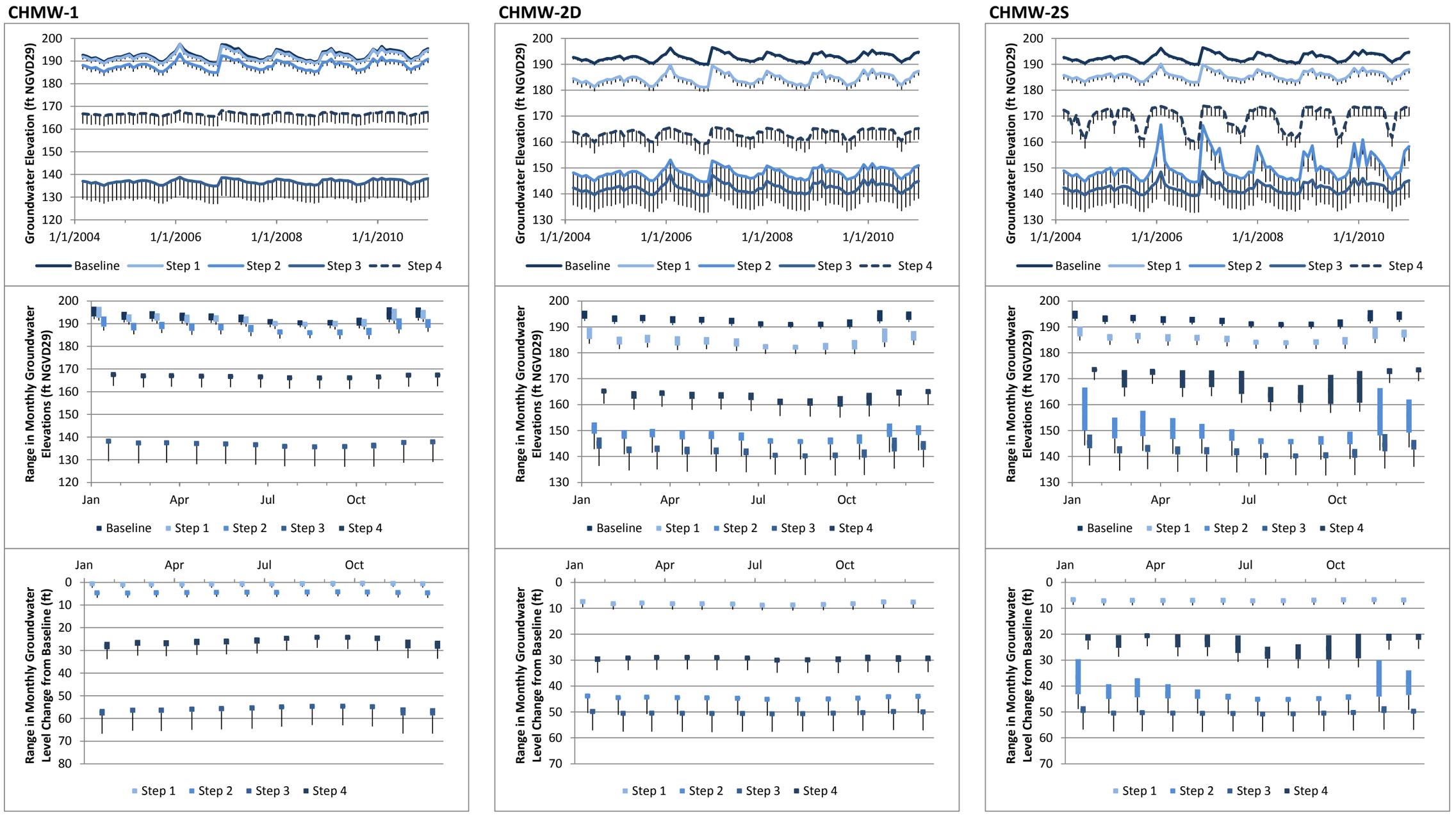

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Figure 23
Predicted Changes and Ranges in Groundwater Levels
Dupont Groundwater Model Report

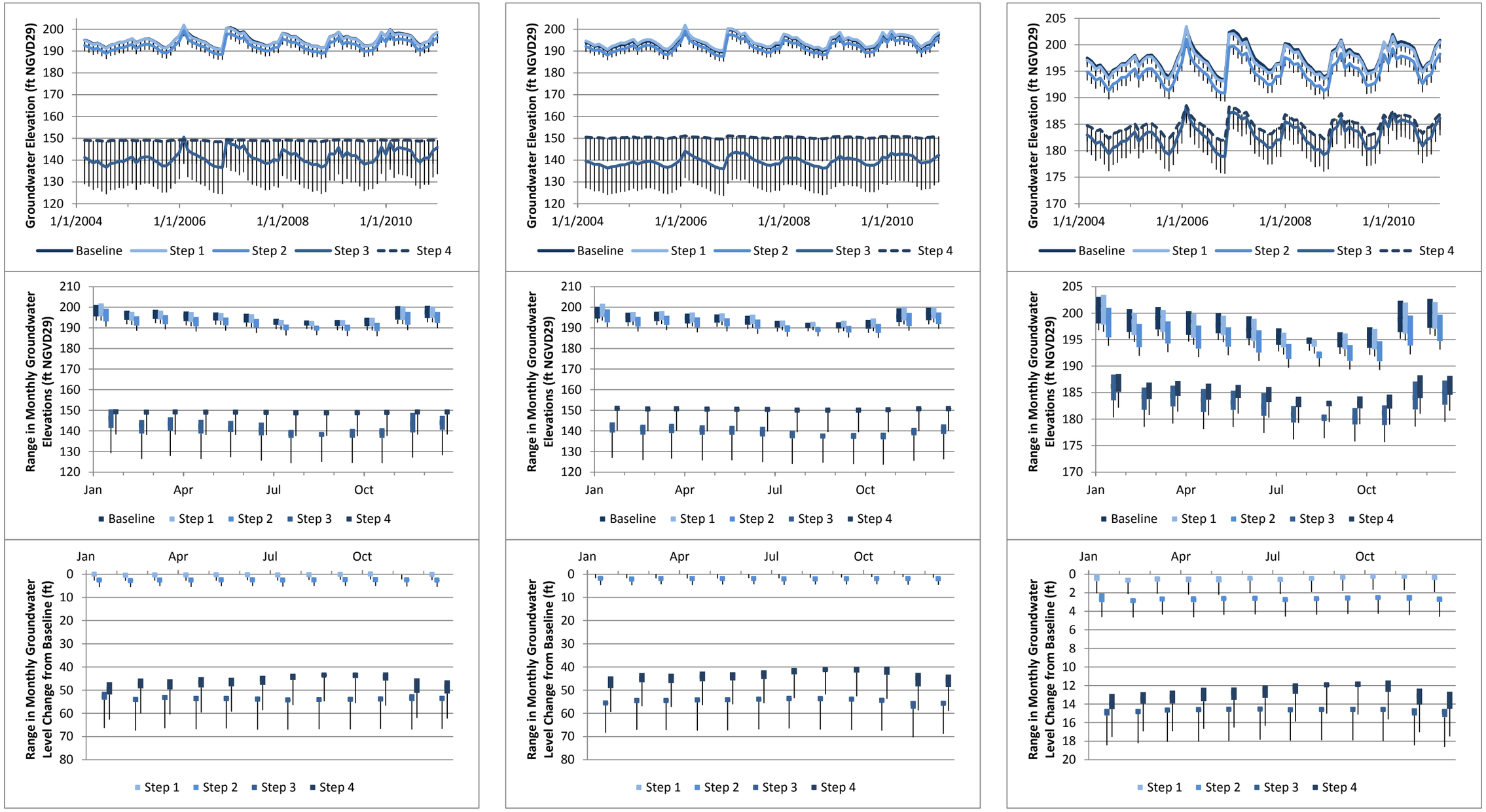

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Figure 23
Predicted Changes and Ranges in Groundwater Levels
Dupont Groundwater Model Report

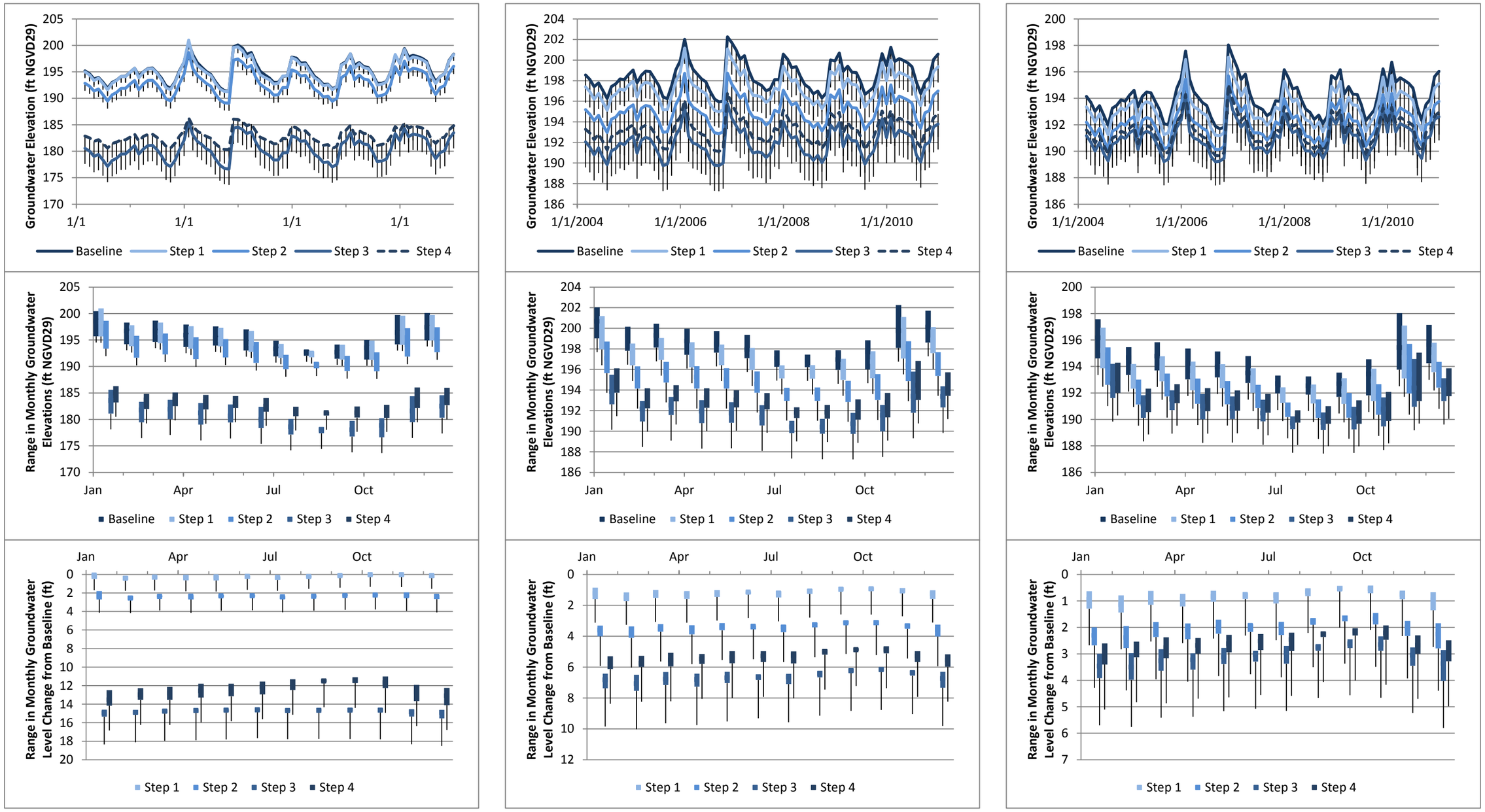

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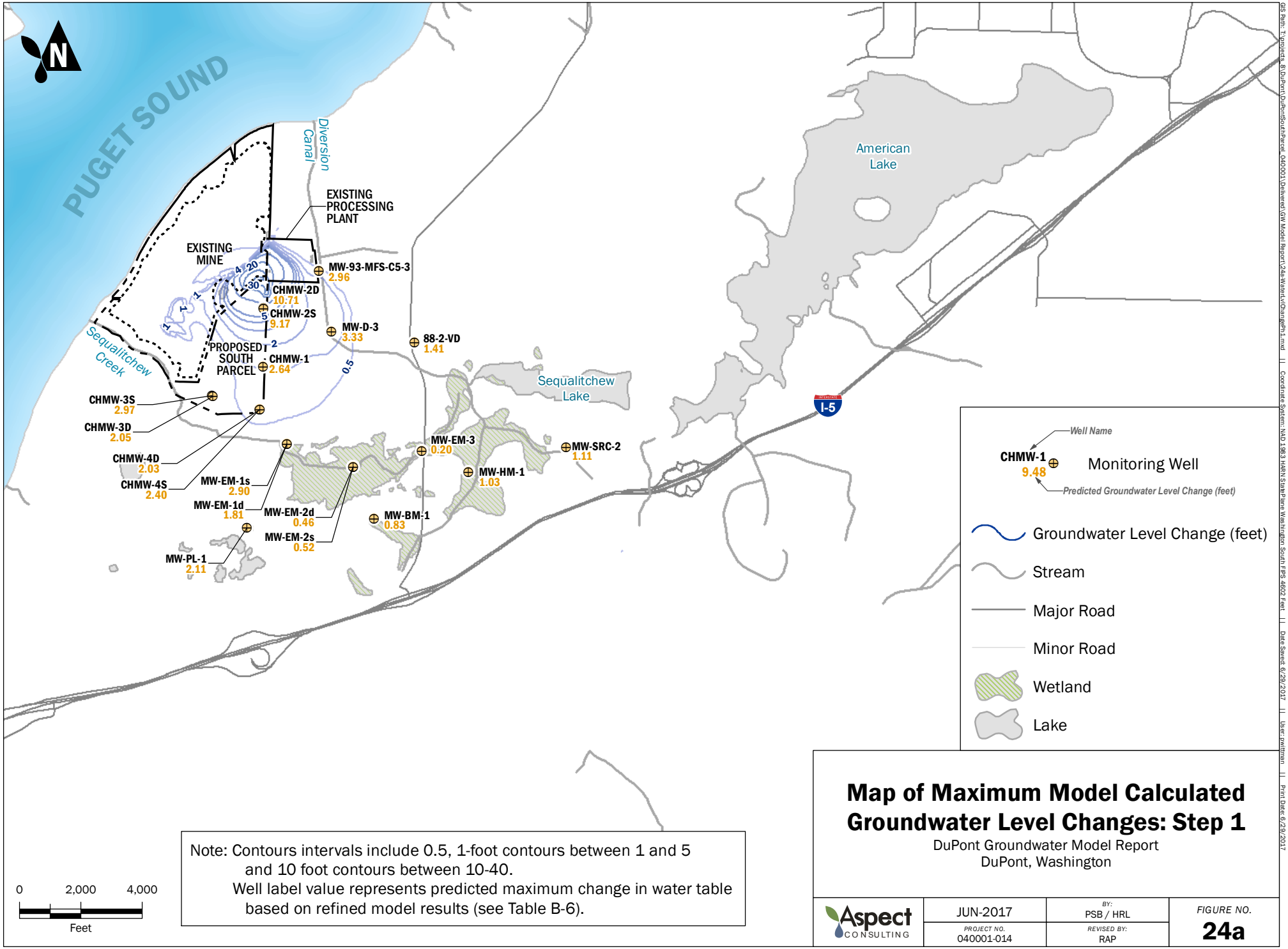
Figure 23
Predicted Changes and Ranges in Groundwater Levels
Dupont Groundwater Model Report



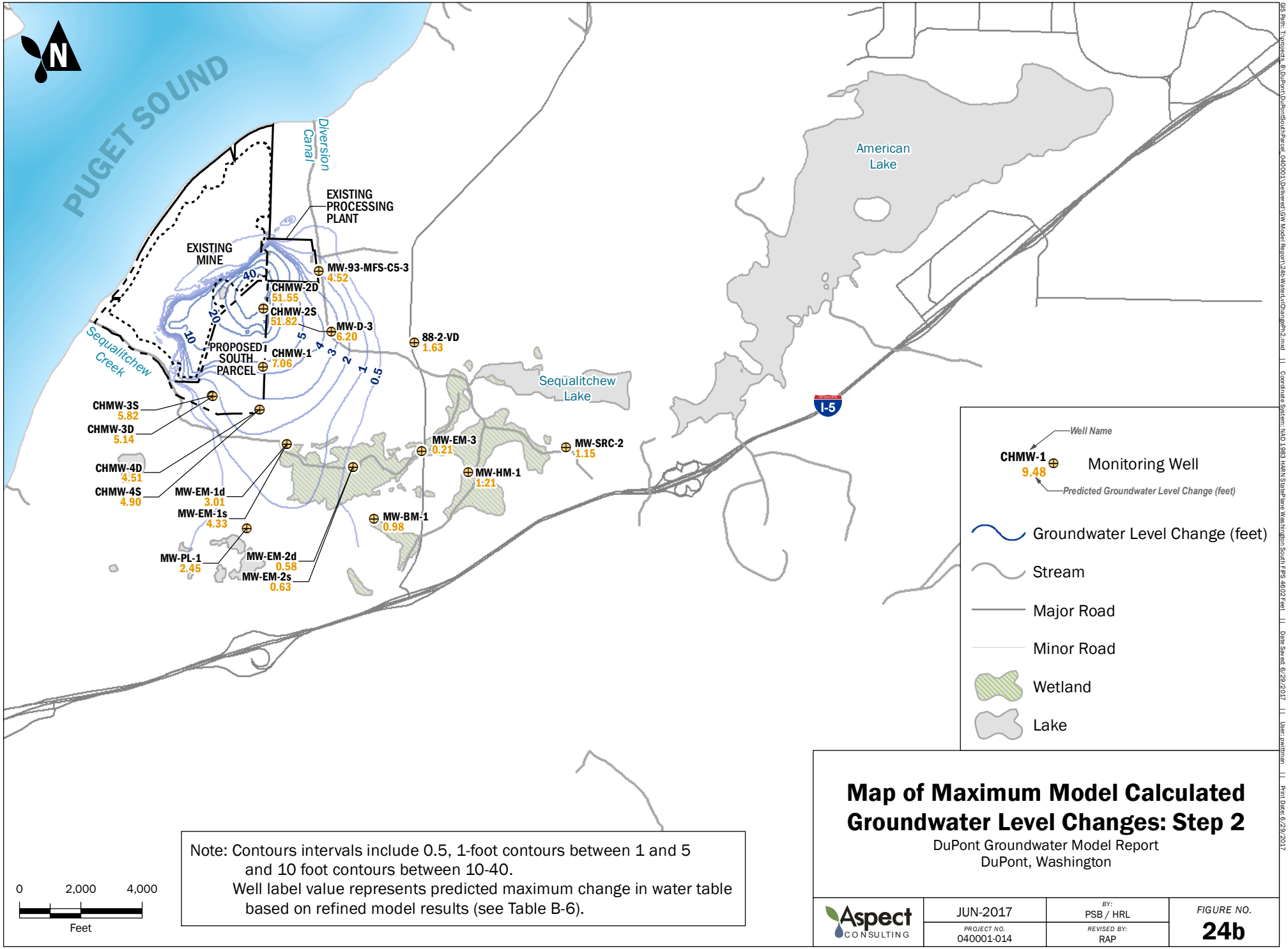
Note: Contours intervals include 0.5, 1-foot contours between 1 and 5 and 10 foot contours between 10-40.
Well label value represents predicted maximum change in water table based on refined model results (see Table B-6).

Map of Maximum Model Calculated Groundwater Level Changes: Step 1

DuPont Groundwater Model Report
DuPont, Washington

Aspect CONSULTING	JUN-2017	BY: PSB / HRL	FIGURE NO. 24a
	PROJECT NO. 040001-014	REVISED BY: RAP	

GIS Path: T:\projects_8\DuPont\DuPontSouthParcel_040001\Deliverable\GW Model Report\24a-WaterLvlChangePh1.mxd || Coordinate System: NAD 1983 HARN State Plane Washington South FIPS 4602 Feet || Date Saved: 6/29/2017 || User: pwittman || Print Date: 6/29/2017



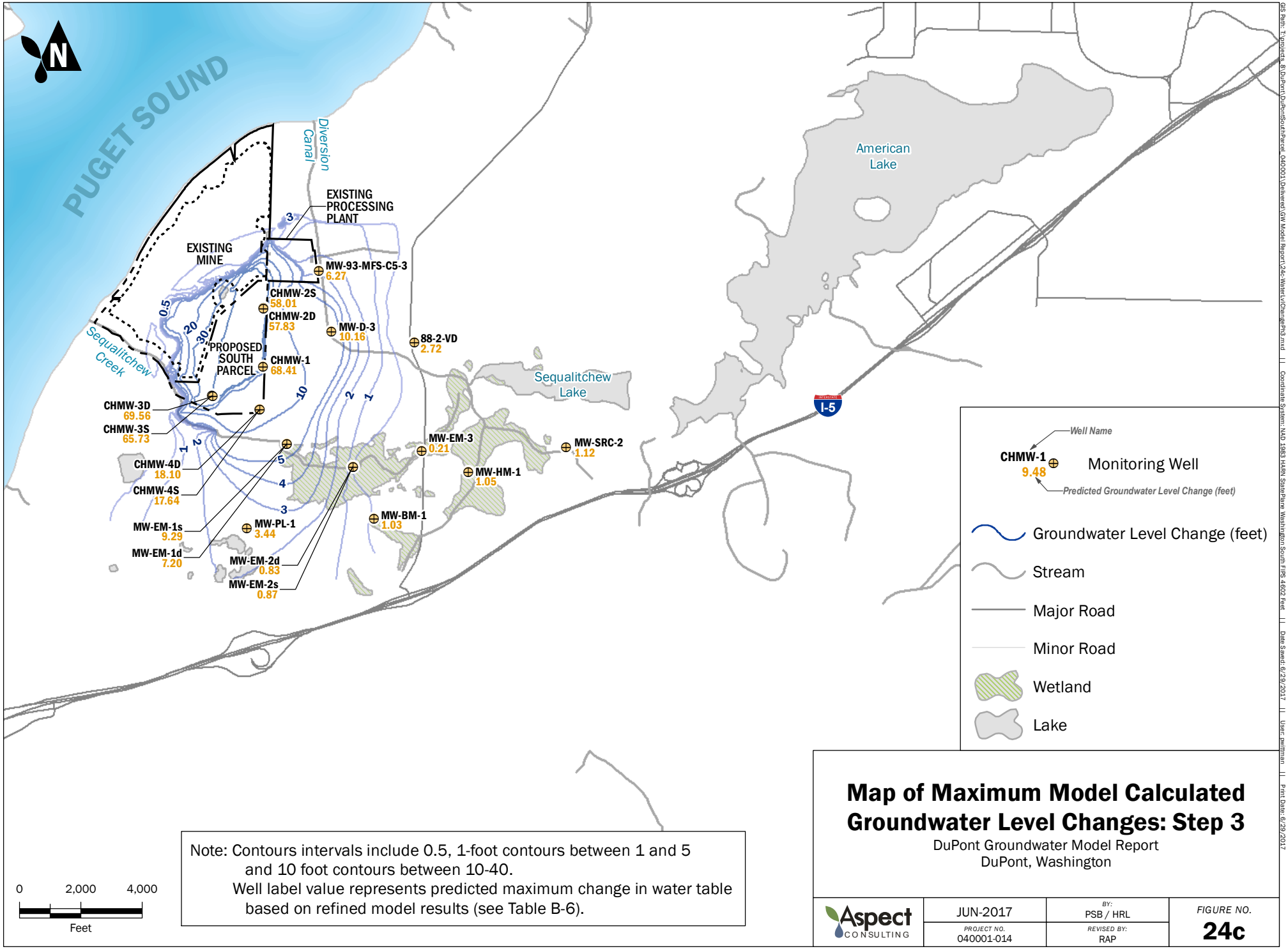
Note: Contours intervals include 0.5, 1-foot contours between 1 and 5 and 10 foot contours between 10-40.
Well label value represents predicted maximum change in water table based on refined model results (see Table B-6).

Map of Maximum Model Calculated Groundwater Level Changes: Step 2

DuPont Groundwater Model Report
DuPont, Washington

Aspect CONSULTING	JUN-2017	BY: PSB / HRL	FIGURE NO. 24b
	PROJECT NO. 040001-014	REVISED BY: RAP	

GIS Path: T:\projects_8\DuPont\DuPontSouthParcel_040001\Deliverable\GW Model Report\24b WaterLvlChangePh2.mxd || Coordinate System: NAD 1983 HARN StatePlane Washington South FIPS 4602 Feet || Date Saved: 6/29/2017 || User: pwittman || Print Date: 6/29/2017



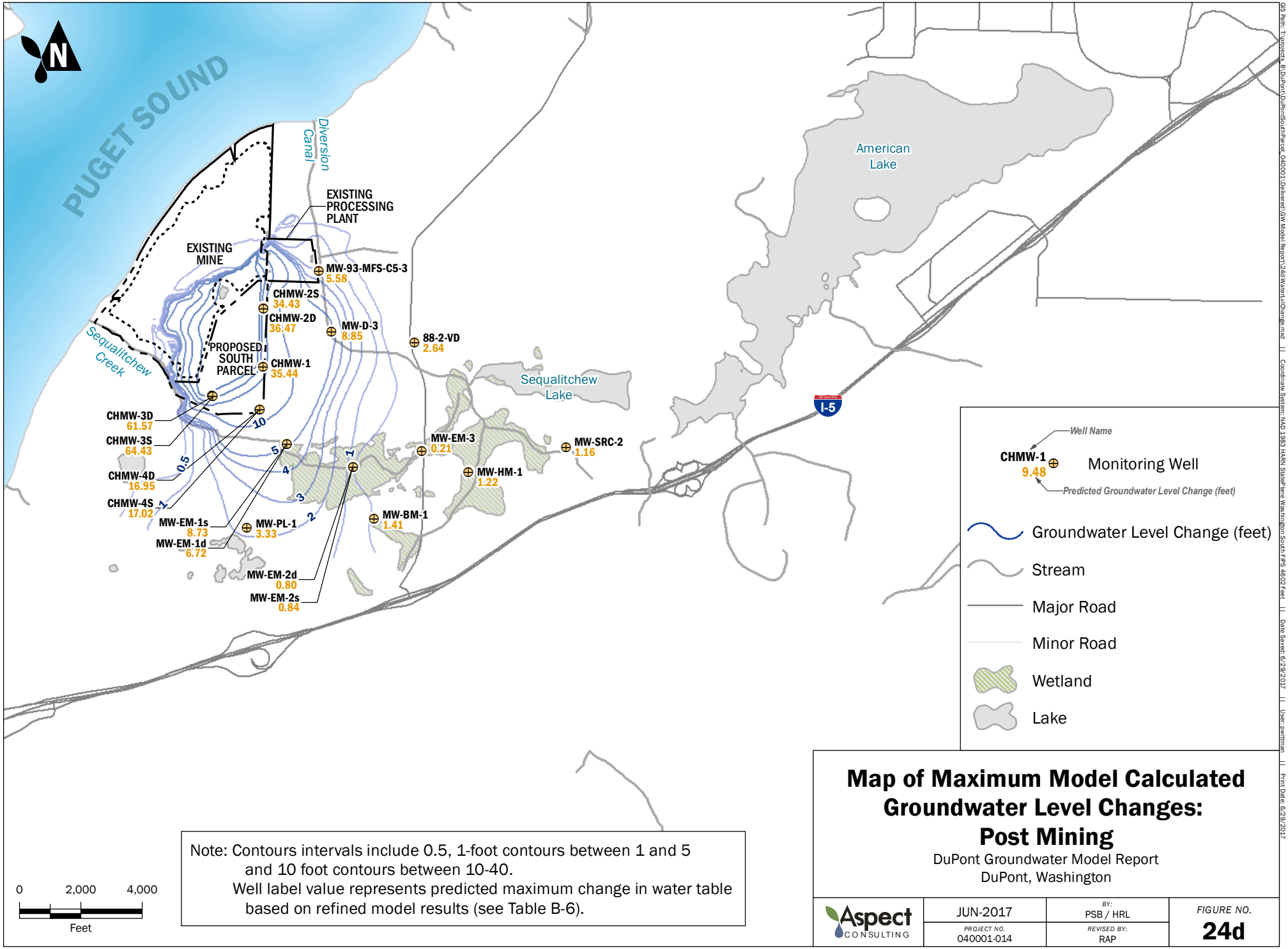
Note: Contours intervals include 0.5, 1-foot contours between 1 and 5 and 10 foot contours between 10-40.
Well label value represents predicted maximum change in water table based on refined model results (see Table B-6).

Map of Maximum Model Calculated Groundwater Level Changes: Step 3

DuPont Groundwater Model Report
DuPont, Washington

Aspect CONSULTING	JUN-2017	BY: PSB / HRL	FIGURE NO. 24c
	PROJECT NO. 040001-014	REVISED BY: RAP	

GIS Path: T:\projects_8\DuPont\DuPontSouthParcel_040001\Deliverable\GW Model Report\24c-WaterLvlChangeStp3.mxd LL Coordinate System: NAD 1983 HARN StatePlane Washington South FIPS 4602 Feet LL Date Saved: 6/29/2017 LL User: pwittman LL Print Date: 6/29/2017



Note: Contours intervals include 0.5, 1-foot contours between 1 and 5 and 10 foot contours between 10-40.
Well label value represents predicted maximum change in water table based on refined model results (see Table B-6).

Map of Maximum Model Calculated Groundwater Level Changes: Post Mining

DuPont Groundwater Model Report
DuPont, Washington

Aspect CONSULTING	JUN-2017	BY: PSB / HRL	FIGURE NO. 24d
	PROJECT NO. 040001-014	REVISED BY: RAP	

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Appendix F

South Parcel Monitoring Plan

SOUTH PARCEL MONITORING PLAN

DuPont Mine South Parcel Expansion Area

Project No. 040001-014-02 • November 22, 2017

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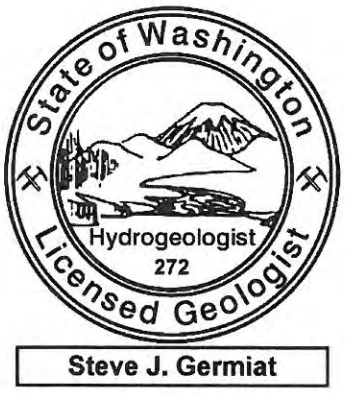
earth + water

SOUTH PARCEL MONITORING PLAN

DuPont Mine South Parcel Expansion Area

Project No. 040001-014-02 • November 22, 2017

Aspect Consulting, LLC



Steve Germiat, LHG
Principal Hydrogeologist
sgermiat@aspectconsulting.com

Owen Reese, PE
Senior Associate Water Resources Engineer
oreese@aspectconsulting.com

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1 Introduction

This document presents the Monitoring Plan for dewatering of the South Parcel of CalPortland's DuPont Mine. The South Parcel is a 177-acre property located southeast of the existing mine, shown on Figure 1. CalPortland proposes to expand the existing mine by extracting sand and gravel from the South Parcel. Groundwater saturates the lower level of gravels that are proposed for extraction. For mining to occur, these gravels of the South Parcel would need to be dewatered by installing a series of pumping wells to capture groundwater. The dewatering activity would affect groundwater levels in the surrounding area.

In 2011, CalPortland, the City of DuPont, Washington State Department of Ecology (Ecology), and a group of seven environmental organizations collectively known as the Environmental Caucus entered into a Settlement Agreement to define the conditions under which mining of the South Parcel could occur. The Settlement Agreement requires the development and permitting of a Restoration Plan for the Sequalitchew Creek watershed. It also requires the development of a Monitoring Plan for ensuring that changes in groundwater levels resulting from dewatering are within expected (and agreed-upon) limits.

Section 7.3 of the 2011 Settlement Agreement specifies that the Monitoring Plan will *"…include a series of monitoring actions to allow a comparison of predicted and actual changes in groundwater draw-down levels, and a process for the Parties to meet and confer if groundwater monitoring results do not meet the criteria provided in the Monitoring Plan."* This document was developed to meet that requirement.

The aim of the Restoration Plan is to increase available habitat for aquatic species through the restoration and enhancement of creek flow from Sequalitchew Lake to the Puget Sound. The Restoration Plan includes the following restoration actions, among others: comprehensive beaver management to restore flow from Sequalitchew Lake to West Edmond Marsh, improvements to the outlet of Sequalitchew Lake to reduce barriers to flow down the creek system, rehabilitating fish passage through the DuPont Railroad Trail by replacing a section of trail that is built on fill with a pedestrian bridge, culvert evaluation and replacement, and habitat restoration in Sequalitchew Creek downstream of Edmond Marsh. Implementing these actions will involve changes to marsh water levels and increases in Sequalitchew Creek flows.

The Restoration Plan actions are intended to occur concurrently with South Parcel mining activities. Under the terms of the Settlement Agreement, mining of the South Parcel cannot commence until all necessary permits for the Restoration Plan have been obtained. The Restoration Plan will include a monitoring component aimed at measuring the success of restoration actions and adaptively responding if goals are not met.

As specified in the Settlement Agreement, this Monitoring Plan focuses on observing and responding to changes in groundwater levels. Marsh water levels and streamflows will

also be monitored (as required by Section 7.2 of the Settlement Agreement), but they are not the focus of the adaptive management actions identified in the Monitoring Plan.

This Monitoring Plan consists of three components:

1) The main text, which outlines the framework for monitoring and decision making at a conceptual level.

2) A set of figures illustrating the performance thresholds for each month at each well in each dewatering step (Appendix A).

3) A sampling and analysis plan (SAP; Appendix B), which provides the specific details of monitoring, such as identification of monitoring locations, parameters, and frequency, as well as monitoring methods.

The parties acknowledge that the Monitoring Plan may be updated or amended by mutual agreement of the parties.

2 Goals and Objectives

This Monitoring Plan strives to monitor and respond to maintain groundwater at or above predicted levels beneath the marshes and Sequalitchew Creek, and manage groundwater to maintain conditions conducive to safe and efficient mining in the South Parcel.

Articulating the specific goals, objectives, and performance thresholds of a plan provides clarity in measuring the success of the actions taken and guidance for managing unanticipated circumstances. Goals are the overarching principles behind the Monitoring Plan. Objectives identify specific, measurable elements that are undertaken to meet the goal(s) of a project. They provide more detail on how the goals will be achieved, and criteria for determining when their achievement has occurred.

For each objective, a performance threshold is identified to measure success in meeting that objective. Failure to meet the performance threshold will trigger the adaptive management process and require iterative additional actions until it is met. If monitoring indicates that a performance threshold is not being met, additional action will be necessary and the adaptive management process (described in Section 4) will be used iteratively to identify and implement actions intended to improve conditions until the performance threshold has been met.

The goals, objectives, and thresholds of the Monitoring Plan are:

Goal 1. Maintain groundwater at or above predicted levels beneath Edmond Marsh and Sequalitchew Creek.

> **Objective 1A**. Groundwater levels at monitoring wells near Edmond Marsh and Sequalitchew Creek are at or above predicted levels.
>
> **Performance Threshold**: Monthly groundwater level measurements are at or above target levels established for each step of the dewatering process at each well and for each month of the year, based on statistical analysis of groundwater model predictions over a range of historical climate conditions. Initial target levels are included in Tables 4, 6, 8, and 10.

Goal 2. Maintain groundwater conditions conducive to safe and efficient mining and processing of the South Parcel aggregates.

> **Objective 2A**. Moisture content of mined aggregate is at appropriately low levels for safe and efficient mining and processing.

3 Dewatering Plan Overview

The entire mining process will take many years and is designed to proceed slowly from areas of least potential impact toward areas of increasing potential impact, allowing time and opportunity to confirm predictions and adaptively manage the mining and dewatering effort before irreversible changes occur.

Mining of the South Parcel will proceed slowly from the north to the south over a period of 5 to 8 years, extracting gravel to create a broad trough along the eastern property boundary. Wells will be installed and pumped in advance of mining to intercept groundwater and dry out the gravels for mining. The purpose of mining a trough is to minimize the amount of time that active dewatering by pumping wells is required. Once mining of each section of trough is completed, the adjacent wells can be turned off, allowing groundwater to passively seep from the stable mine slope and flow by gravity to an infiltration facility on floor of the existing mine. After mining the trough along the perimeter, gravel will be extracted from the interior area.

The following section describes four steps of the dewatering plan, but it is important to recognize that these steps occur on very different time scales. Figure 2 provides an overview of the timeline for the four steps of dewatering, assuming that mining proceeds rapidly during the period of active dewatering (Step 3).

The initial step is a 60-day pumping test that is completely reversible (i.e., no gravel will be extracted during the test). The results of that test will be analyzed and evaluated, and plans adjusted as necessary prior to commencing the next phase.

The second step involves installing and pumping additional dewatering wells to lower water levels in the first mine segment in preparation for mining. This step would last about six months and functions as a greatly expanded pumping test. As with the first step, it is also completely reversible.

The third step—active dewatering during mining—involves mining the trough described above. Additional dewatering wells will be installed and pumped as mining progresses. Mining will begin at the location farthest from the Edmond Marsh and Sequalitchew Creek and proceed slowly south. Completing the trough would require 5 to 8 years depending on market conditions and the success in meeting predicted groundwater levels. The potential impact on groundwater levels builds slowly over time as wells are added and mining progresses south. This allows ample opportunity to monitor and adapt to the conditions observed before mining proceeds into each dewatered segment.

The final step—passive dewatering—begins when mining of the trough described above is complete and the last dewatering well is turned off. Passive dewatering represents the groundwater condition that will continue in perpetuity. Groundwater, no longer intercepted by wells, would form seeps at the toe of the eastern mine slope. It would flow by gravity through newly created wetlands and a vegetated swale to an infiltration pond located at the bottom of the existing mine. Once this step has begun, further mining activities in the interior of the South Parcel would not affect groundwater.

Additional detail about each of these steps is described in the following section.

3.1 Four Steps of Dewatering Plan

The dewatering necessary to accomplish the mine expansion will occur in four steps as outlined below to address the needs of the mining operations and to provide an opportunity for adaptive management, as described in Section 4. Figure 3 depicts locations of the wells planned for installation in each step. All water generated during dewatering will be infiltrated within the footprint of the current mine, west of the expansion area. Infiltrated water will travel vertically into the ground to the aquifer then flow westward and discharge as seeps to Puget Sound

Step 1. Initial Pumping Test: The first step is a 10-well pumping test, conducted for a minimum of 60 days, to validate model predictions of dewatering effectiveness in the local vicinity of the test wells and make any necessary changes to the model parameters and/or plans for subsequent dewatering and mining activities. The 10 wells will be located in the northeastern portion of the South Parcel as shown on Figure 3. Monitoring will be conducted throughout the test in the pumping wells and existing monitoring wells. The combined pumping rate during Step 1 is predicted to be approximately 3.5 cubic feet per second (cfs) on average, and up to approximately 5 cfs if pumping during the wet season. The model predicts that groundwater level changes will stabilize within approximately 60 days of the start of pumping. No mining will occur in the South Parcel during this step. Step 1 could occur at any time prior to mining; it is not anticipated that all permits for mining would need to be obtained before Step 1 could occur.

Step 2. Preparation for Mining/ Dewatering Test: Following completion of the initial pumping test, the next step of the dewatering plan involves expanding the dewatering well network along the eastern edge of the mine area with two purposes: 1) to evaluate model predictions across a wider extent (making any necessary changes to model parameters and/or to subsequent dewatering/mining activities); and 2) to dewater gravels for the first segment of mining. No mining will occur in the South Parcel before this step is completed.

During Step 2, an expected 14 additional dewatering wells will be installed along the South Parcel mine boundary, including wells located interior to the mine, as shown on Figure 3. The dewatering wells will be arranged in two lines on either side of the initial mine trough, including 19 boundary wells and 5 interior wells. Two additional monitoring wells will also be installed to measure drawdown within the mine interior. Step 2 is expected to last for up to 6 months,with the first two months being a second pumping test again lasting a minimum of 60 days, followed by an estimated four additional months of pumping to dry gravels in the Segment 1A in preparation for mining. The results from the first 60 days would be used to evaluate the model; this evaluation would occur concurrently with the continued dewatering in preparation for mining. The predicted total system pumping rate of approximately 5.1 cfs on average and up to approximately 8 cfs during the wet season.

Since a key component of Step 2 is preparation of the site for mining, pumping during Step 2 would only occur once mining and restoration permits have been obtained.

Step 3. Active Dewatering during Mining: Step 3 is active dewatering as mining begins to form a broad trough in the northeastern corner of the site. Over the next 5 to 8 years,

mining will then proceed from north to south along eastern boundary of site. Step 3 dewatering is predicted to use 66 dewatering wells arranged in two lines on either side of the initial mine trough, with 54 boundary wells and 12 inner wells, as shown on Figure 3. The wells are installed and pumped ahead of the trough's southern progression; as mining of an area is completed, wells along that portion of the trough are shut off, allowing groundwater to begin seeping from the newly mined slope. Groundwater seeping into the mine will be collected in a vegetated swale and conveyed to the infiltration pond located at the bottom of the existing mine.

If all 66 dewatering wells were operating, the combined pumping rate is predicted to be approximately 6.8 cfs on average and up to approximately 11 cfs during the wet season. However, it is unlikely that all dewatering wells would need to be operated at any one time as wells will be phased off as mining progresses.

Step 4. Cessation of Active Dewatering: During Step 4, pumping from the dewatering well network will cease, and the post-mining groundwater flow condition will be established consistent with reclamation objectives. Once all dewatering wells are off, mining above the water table will continue in the interior of the South Parcel. Groundwater will flow from the toe of the newly mined slope on the eastern boundary of the property and be collected and conveyed to an infiltration pond in the bottom of the existing mine, from where it will continue its westward flow, ultimately entering Puget Sound. Groundwater levels will increase slightly following the cessation of active dewatering as they adjust to long-term equilibrium with the new spring locations that will form along the toe of the mined slope. Step 4 lasts through mining of the remaining interior areas and through the post-mining period.

3.2 Dewatering Well Construction

The dewatering wells are designed to accommodate large drawdowns (up to 70 feet), and operate under a wide range of flow rates against a wide range of heads. All dewatering wells will be screened to the depth of the Olympia Beds, with nominal 10-foot sumps installed into the top of the Olympia Beds. Expected well depths will range from about 75 to 115 feet to accommodate the variation in aquifer thickness (between ground surface and the Olympia Beds contact) and the 10-foot sump into the Olympia Beds. The dewatering wells will be screened across the lower zone and a portion of the upper aquifer zone (generally 40- to 50-foot screen lengths). Continuous slot, v-wire wrapped stainless-steel well screens will be used for maximum dewatering efficiency (low head loss). Anticipated well flows range from approximately 400 gallons per minute (gpm) initially to an average of approximately 50 to 200 gpm to maintain drawdown once storage is depleted.

3.3 Predicted Effects of Dewatering on Groundwater Levels

The effects of the four-step dewatering plan on groundwater levels have been evaluated using a numerical, three-dimensional, groundwater model developed specifically for the project (DuPont model). The model is transient, meaning that it simulates changes in groundwater levels over time, and runs on a monthly time step for a roughly 12-year period from March 2004 to December 2015 that includes wet and dry climate conditions.

This allows the model to be used to analyze the effects of the proposed dewatering plan over a range of weather conditions.

The model was developed using data from 2004 to 2010 and calibrated to observed water levels at 19 wells. The calibrated model achieved a "good fit" with a mean residual (difference between predicted and observed) of 1.7 feet or about 6 percent of the difference in minimum and maximum groundwater levels at the calibration targets. The model was validated over 2004 to 2015 (after a change in the precipitation data source) and the validation statistics were similar to the calibration with a mean residual of 1.87 feet providing confidence in its use to simulate groundwater conditions. Additional detail on groundwater model development, calibration, validation and predictive results is available in the Groundwater Model Update (Aspect, 2017).

The DuPont model was used to predict changes in groundwater conditions during the four sequential steps of proposed dewatering and mining activity in the South Parcel. These predictive runs used the same weather and boundary conditions as model calibration with the only change being the addition of pumping wells and changes in surface topography with mining. Dewatering Steps 1, 2, and 3 simulated 10, 24, and 66 active dewatering wells, respectively. Step 4 simulated the post-mining condition with pumping terminated and groundwater passively discharging at the toe of the newly mined slope.

Results of the predictive models are discussed below by dewatering step, in terms of predicted changes in groundwater levels. Baseline groundwater levels are sensitive to seasonal and longer-term precipitation patterns, and the model indicates that groundwater levels during the four dewatering steps will likewise remain sensitive to precipitation patterns. Monitoring well locations are shown on Figure 4.

In Step 1, the changes in groundwater levels are most evident at the monitoring wells closest to the pumping test (CHMW-2S and CHMW-2D). The maximum groundwater level change at CHMW-2D is predicted to be approximately 9 feet, whereas minimal groundwater level change (less than 0.5 foot) is predicted at monitoring wells in Edmond Marsh (MW-EM-1D and MW-EM-2D).

During Step 2, the maximum change in groundwater level is approximately 45 feet and would occur at CHMW-2D located on the northeastern edge of the South Parcel and within the dewatering well network. The maximum groundwater level changes in the closest monitoring wells in Edmond Marsh (MW-EM-1D and MW-EM-2D) are predicted to be approximately 1.3 feet and 0.2 feet, respectively.

During Step 3, maximum groundwater level changes of up to about 60 feet are predicted at wells within the mine area. The maximum groundwater level changes at MW-EM-1D and MW-EM-2D (Edmond Marsh) are predicted to be approximately 5.2 feet and 0.4 feet, respectively. The groundwater levels during Step 3 are predicted to be approximately 10 to 20 feet above the Olympia Beds along the mine trough.

During Step 4, following cessation of active pumping, the maximum change in groundwater levels along the eastern slope of the mine ranges from about 14 to 49 feet. The maximum groundwater level changes at the closest Edmond Marsh Wells (MW-EM-1D and MW-EM-2D) are predicted to be approximately 5.0 feet and 0.4 feet,

respectively. A map of the predicted contours of groundwater drawdown after cessation of active pumping is shown on Figure 5. Solid drawdown contours on Figure 5 indicate areas of greater certainty closer to the monitoring well network and model calibration targets, dashed drawdown contours indicate areas of lesser certainty.

The groundwater model was used to develop performance thresholds for each well in each month during each dewatering step. The thresholds are based on the predicted range in water levels under seasonal and annual variation in climate. The performance thresholds were established at the lower 95th-percentile confidence interval for the predicted water levels.

As an example, Figure 6 provides the range of model predictions (groundwater elevation, and change from baseline water levels) over varying climate conditions for well CHMW-2D, located near the proposed location of the pumping test. The vertical lines in Figure 6 indicate the lower end of the predicted range. The bottom of the vertical line is the performance threshold. The performance threshold will change by well, by month (to account for annual seasonal patterns), and by dewatering steps. Similar figures have been prepared for each monitoring well and are presented in Appendix A.

4 Adaptive Management

This Monitoring Plan implements adaptive management to observe and respond to changes in groundwater levels occurring during mining of the South Parcel. This section first introduces the fundamental steps of effective adaptive management, then establishes key commitments by CalPortland to be met throughout the adaptive management process, and then walks through the detailed adaptive management plan, including the groundwater performance thresholds, for each dewatering step.

4.1 Process of Adaptive Management

Adaptive management has been described as "*a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs"* (Nyberg, 1999). Adaptive management typically consists of a monitoring system to identify changes in the environment coupled with a response system to adjust the activities in response to monitoring results. The adaptive management system proposed for implementation on this project was developed as a combination of the systems proposed by Ralph and Poole (2003) and Nyberg (1999). It consists of five key sequential elements, as illustrated on Figure 7:

A. **Assess:** Information is compiled from monitoring data, geologic investigations, groundwater modeling, and other available sources. The compiled information is used to identify issues, refine objectives, and screen potential alternative approaches. Predictions of the potential effects of the action on groundwater levels are developed.

B. **Design:** Based on the results of the assessment stage, design of the proposed action proceeds. Design will result in a specific plan of action, and supporting evaluations to ensure that the anticipated results are consistent with the identified objectives, the Monitoring Plan, and prior environmental assessments. Predictions of groundwater levels are refined as the design evolves. Analyses conducted during the design stage could result in an iterative process of assessment and design. Any required permitting is also included in the design stage.

C. **Implement and Monitor:** The approved plan is put into action, concurrently with monitoring focused on key indicators tied to the identified objectives. Monitoring data indicating conditions worse than forecasted are acted on rapidly, moving into the evaluation and adjustment stages.

D. **Evaluate:** Monitoring data are evaluated relative to the objectives and forecasted results developed in the assessment and design stages. Differences between forecasts and results are identified and the causes for those differences investigated.

E. **Adjust:** Information learned in previous steps is used to adjust the actions, if necessary. The Monitoring Plan provides an initial identification of potential adjustments in each dewatering step, but additional adjustments could be developed to fit specific situations.

The adaptive management process is iterative and would repeat until the mining project is completed. If an adjustment is identified, the process would begin again from the assessment and design stages, followed by implementation of the adjustment and associated monitoring, then evaluation and further response (if necessary). If an adjustment is not necessary, then the process still repeats. In this case, the assessment and design stages would largely rely on the previously approved plans, but there is still potential for more minor refinements based on the information learned.

Throughout the adaptive management process, status updates, monitoring data, and final reports will be shared with the Environmental Caucus. Should groundwater levels not meet the performance thresholds established in this plan, then CalPortland would notify the Environmental Caucus and plan and implement adjustments. If adjustments are unsuccessful in meeting predicted groundwater levels, CalPortland and the Environmental Caucus would initiate a technical review conference and, if necessary, meet and confer to share information and determine the appropriate additional steps.

4.2 Key Adaptive Management Commitments

This section establishes the commitments related to key components of adaptive management. First, an overview of the anticipated schedule for the four dewatering steps is presented. Then the commitments to the frequency that groundwater levels will be compared with the performance thresholds is established, followed by a summary of the notifications that will be provided if certain events occur (such as starting to pump new wells, or measurements of groundwater levels that are below performance thresholds). The next section summarizes the reports that will be provide throughout the process, ranging from relatively simple progress updates to detailed reports on the pumping tests. Then several overall limitations on advancement of mining and dewatering are established. Finally, the meet and confer process for resolving disputes is defined.

Additional detail about the adaptive management process as it applies to each dewatering Step is presented in Section 4.3.

4.2.1 Anticipated Schedule

Mining of the South Parcel will occur over many years, and the anticipated project schedule has been designed to include sufficient time for the adaptive management process to succeed in meeting performance thresholds before mining or dewatering advances. An overview of the anticipated schedule is presented on Figure 8; additional schedule detail is presented in the detailed adaptive management plan for each Step presented in Section 4.3.

Mining and dewatering activities would not begin until a series of conditions identified in Section 4.3 of the 2011 Settlement Agreement have been met. Those conditions include: 1) environmental review (SEPA) has been completed; 2) permits for the Restoration Plan have been issued [including the required authorizations and approvals from Joint Base Lewis-McChord (JBLM) for restoration activities on JBLM property], and applicable appeal periods have expired (except for federal permits); and 3) all necessary permits and approvals for South Parcel mining have been obtained. This paragraph is intended as a summary only; to the extent that it is inconsistent with the Settlement Agreement, the Settlement Agreement shall govern.

Step 1 is anticipated to require a year to complete from initial planning through reporting and discussion of the results and any resulting adjustments to the dewatering plan. Planning and well installation for Step 2 would overlap with completion of the reporting and review components of Step 1. Once Step 1 has been completed, the pumping test component of Step 2 would begin.

Step 2 is anticipated to require 6 months of active pumping—the first 2 months would be a larger-scale pumping test, and dewatering would continue over the subsequent 4 months in preparation for the start of mining. Reporting and review of results would be performed while dewatering continues.

Step 3 would only commence when groundwater levels are above the performance thresholds and water levels are at appropriately low levels for safe and efficient mining and processing. If groundwater levels meet performance thresholds, Step 2 would flow into Step 3 and the start of mining. Otherwise, Step 2 may require a longer period to perform the necessary adjustments to achieve sufficient dewatering for mining while maintaining groundwater levels consistent with the performance thresholds and prior environmental analyses, or update the environmental analyses, if necessary.

Mining would proceed south over a period of multiple years. The actual rate of mining depends on market demand. CalPortland expects that mining the first four segments (1A through 1D) would take 4 to 8 years and has committed (see Section 4.2.5) to completing those four segments in no less than 3 years total, or a minimum of 9 months for each segment. Figure 8 shows the timeline for mining of the South Parcel in the unlikely event that mining were to progress at this accelerated pace and the first four segments were to be completed in three years.

Step 4 will begin after active dewatering ceases. Depending on market demand for aggregate products, mining of the remainder of the South Parcel is expected to occur over 5 to 8 years after cessation of active dewatering.

4.2.2 Comparison of Groundwater Levels with Performance Thresholds

Success of the dewatering plan is evaluated by comparing groundwater levels with the performance thresholds.

A summary of the monitoring events where comparisons with the predicted ranges will be performed is provided in Table 1. The frequency of these comparisons will vary over time with more frequent evaluations at the start of each dewatering step or when changes to dewatering are made. If any of these monitoring results indicate groundwater levels are not above the performance thresholds, CalPortland will notify the Environmental Caucus according to the timelines described in Section 4.2.3, which vary by dewatering Step, and begin the adjustment process.

Table 1. Frequency of Comparison to Performance Thresholds

Dewatering Step	Frequency of Comparison
Step 1 – Initial Pumping Test	Changing frequency during test: hourly -> daily -> weekly
Step 2 – Preparation for Mining/ Dewatering Test	Changing frequency during first 2 months/ pumping test: daily -> weekly, then Weekly at key wells, Twice monthly at all others
Step 3 – Active Dewatering during Mining	For 3 months when new wells start pumping: weekly at key wells and twice monthly at all others, then Monthly.
Step 4 – Cessation of Active Dewatering	Monthly

Note: Key wells are the monitoring wells in the South Parcel (CHMW-1 through 4) and the closest marsh monitoring stations (EM-1 and -2), including both shallow and deep wells at those locations.

4.2.3 Notifications

Notifications are intended to alert the Environmental Caucus to the occurrence of an event. Routine reporting, including project status updates, data summaries, pumping test analyses, are described in the next section (Section 4.2.4).

CalPortland will inform the designated representative of the Environmental Caucus of each of the following types of events:

1) At the start of each dewatering step;

2) Major milestones within each step (such as addition of new pumping wells);

3) Upon collection of monitoring data indicating actual groundwater levels are lower than the performance thresholds; and

4) Implementation of response actions.

The Environmental Caucus will provide timely notice of any changes in its attorney, consultant, or designated representative or their contact information.

Notification points in each of the dewatering steps are summarized in Table 2, except for routine reporting milestones (which are summarized in Table 3). Notifications will be provided in writing by email, letter, or memorandum/report, as appropriate for the nature of the notification. It is anticipated that most notifications will be provided by email.

Groundwater monitoring data (including raw data) would be provided within 2 days of any notification that monitoring results are below performance thresholds.

Table 2. Summary of Notifications by Dewatering Step

Dewatering Step	Events Triggering Notification of Environmental Caucus	Timeline for Notification
Step 1 – Initial Pumping Test	Updates to pumping test plan	Within 3 days of updating plan
	Installation of pumping test wells	1 week prior to start of drilling
	Start of pumping test	1 week prior to start of pumping
	Monitoring results below performance thresholds	Within 24 hours of measurement
	Any adjustments implemented during pumping test	Within 24 hours of change
	End of pumping test	Within 24 hours
Step 2 – Preparation for Mining/ Dewatering Test	Updates to dewatering plan based on Step 1 results	Within 3 days of updating plan
	Installation of Step 2 dewatering wells	1 week prior to start of drilling
	Start of dewatering	1 week prior to start of pumping
	Monitoring results below performance thresholds	Within 48 hours of measurement
	Any adjustments implemented during dewatering	Within 24 hours of change
Step 3 – Active Dewatering during Mining	Commencement of mining in the South Parcel	1 month prior to start of mining
	Initiation of pumping at new wells	1 week prior to start of pumping
	Monitoring results below performance thresholds	Within 3 days of measurement
	Any adjustments implemented during dewatering	Within 3 days of change
	Cessation of active dewatering	Within 1 week of ceasing dewatering
Step 4 – Cessation of Active Dewatering	Monitoring results below predicted values	Within 3 days of measurement
	Completion of mining in South Parcel	Within 1 month of completion

The timeline for notification that monitoring results are below performance thresholds increases from 24 hours in Step 1 to 48 hours in Step 2 to 3 days in Steps 3 and 4 for four reasons:

1) the rate of change in groundwater levels will slow as mining progresses;

2) confidence increases over time as the number of wells pumping and set of successful groundwater measurements grows (mining and dewatering only advance when performance thresholds are met; see Section 4.2.5 for the specific limitations);

3) new wells begin pumping substantially in advance of mining both in time and space and dewatering proceeds from farthest away towards the creek and

marshes, which allows for the marginal impact of adding new wells to be reversible, even in during Step 3; and

4) Gravel would continue to be mined, but the volume that could be mined during the notification period is nominal compared with the volume of each mine segment, which are expected to require 1.5 to 2 years of mining to complete.

4.2.4 Routine Reporting

CalPortland will routinely share information about mining, dewatering, and the adaptive management process with the Environmental Caucus to achieve a variety of purposes, including sharing and interpreting monitoring data, documenting actions taken during a dewatering step, providing updated model predictions and analysis, and response actions, if necessary.

The specific reports required during each step of dewatering are summarized in Table 3. Additional detail about the individual reports and their role in the adaptive management process is presented in the Detailed Adaptive Management Plan in Section 4.3.

Table 3. Summary of Reporting by Dewatering Step

Dewatering Step	Reports	Minimum Frequency of Reporting
Step 1 – Initial Pumping Test	Pumping Test Design	One time
	Pumping Test Progress	Weekly during test
	Pumping Test Results	One time
Step 2 – Preparation for Mining/ Dewatering Test	Dewatering Plan for Step 2, if revised.	One time
	Pumping Test Progress	Weekly for first 2 months
	Pumping Test Results	One time – 4 months after start of Step 2
	Dewatering Summary Memos	Monthly
Step 3 – Active Dewatering during Mining	Dewatering Plan, Mining Plan, or SAP, if revised.	One time
	Dewatering Summary Memos,	Monthly for 3 months after each new set of dewatering wells, then quarterly
Step 4 – Cessation of Active Dewatering	Dewatering Summary Memos for first year	Quarterly for 2 years, then annually

The purpose and contents of each report are outlined below:

- Pumping Test Design/Dewatering Plans will provide the plan for performing the pumping tests and/or dewatering. These plans will include the proposed well pumping and observation well locations, depths, well construction, drilling methods, data collection, and timelines.

- Pumping Test Progress will provide a status update during the pumping test including an overview of progress toward completing the test, identifying which wells are pumping and pumping rates, locations and frequency of monitoring, any changes to the pumping test plan, and notes on how the test is proceeding.

- Pumping Test Results will present a detailed reporting of the execution of the pumping test, a summary of the data collected, including figures showing groundwater levels and pumping rates over time, comparisons of groundwater levels with performance thresholds, data analysis and results (estimates of key hydrogeologic parameters), and a comparison between model predictions and pumping test results for the purpose of model evaluation and validation.

- Dewatering Summary Memos will provide a summary of mining and dewatering progress, including information on any new wells installed, initiation of pumping at new wells, overview of wells that are pumping and pumping rates, cessation of pumping at wells, areas of active mining, and reclamation activities.

Reports will be prepared by a third-party consultant to be selected and paid for by CalPortland. The reports will be distributed to the Environmental Caucus electronically in protected documents, with hard copies available on request. Raw monitoring data will be provided with any groundwater measurement below a performance threshold, or when requested by the Environmental Caucus.

4.2.5 Limitations on Mining

In order to establish bounds on the pace and advancement of mining that will allow time for the adaptive management process to succeed, CalPortland commits to the following limitations on mining and dewatering activities in the South Parcel:

1) Mining associated with active dewatering (i.e., mining of the trough along the eastern boundary of the South Parcel; Figure 3) will last at least 3 years.

2) The mine trough has been divided into four segments (1A to 1D; Figure 3). Mining of each segment will last at least 9 months.

3) Mining will not advance into the next segment, unless groundwater levels meet performance thresholds.

4) Dewatering activity will not intensify through commencing pumping at new wells or increasing pumping rates at existing wells (except for normal seasonal changes in pumping rates), unless groundwater levels meet performance thresholds.

These limitations do not apply to operations of the existing mine and processing area, or extraction of gravel from areas west of the Olympia Bed truncation within the existing mine or North Parcel as these areas do not require dewatering.

4.2.6 Meet and Confer Process

Section 7.3 of the Settlement Agreement states that the Monitoring Plan will include a "process for the Parties to meet and confer if the groundwater levels do not meet the criteria provided in the Monitoring Plan." The process described below involves two steps for the parties (CalPortland and the Environmental Caucus) to follow with respect to groundwater information and data obtained during the monitoring process. The first step is for the parties' technical consultants to engage in one or more technical review conferences. If necessary, the second step would involve one or more meetings between the parties' designated representatives to discuss any differences of opinion or interpretation that the technical consultants are unable to resolve. Each of these two steps is discussed further below. This two-step process may be invoked at any time, including but not limited to the various specific points in the adaptive management process identified in Section 4.3 below.

Technical Review Conferences. The Environmental Caucus may initiate a request for a technical review conference of the parties' technical consultants at any time to discuss any questions or concerns it might have about any aspect of the groundwater monitoring data. The conferences may be in person or via conference call or other communications technology, and there may be multiple conferences to discuss any issues identified by the Environmental Caucus. The technical consultants would work in good faith during these review conferences to resolve any differences in interpretation of the groundwater monitoring data.

Party Representative Discussions. If the good-faith efforts of the technical consultants are unable to resolve any differences of opinion regarding the interpretation of the groundwater data, including but not limited to what the data shows regarding groundwater levels, either CalPortland or the Environmental Caucus may request a meeting of the parties' designated representatives or principals by providing notice to the other party of the desire to meet, and a brief explanation of the reasons for the request.

Once noticed is provided, CalPortland and the Environmental Caucus would work collaboratively to agree on a meeting format, date, time, and place to be held within 30 days of the request to hold a Technical Review Conference or a Party Representative Discussion. Meetings may be in person or via conference call or other communications technology, and there may be multiple meetings. This paragraph is intended to generally describe, but not constrain, the ways that the parties may choose to meet. Based on the issue raised, CalPortland would prepare and provide appropriate information summarizing the issue and current status of mining and dewatering activities, sharing related monitoring data (including raw data, if requested), and identifying potential responses.

Representatives of CalPortland and the Environmental Caucus will confer during the meeting on the most appropriate response with the goal of reaching consensus. If consensus cannot be reached, the parties would enter mediation, making good-faith efforts to hold a meeting with a mutually agreed-upon mediator within 45 days of the initiation of any request to the other party for mediation.

4.3 Detailed Adaptive Management Plan

This section is the core of the Monitoring Plan. It walks through each step of the dewatering plan providing conceptual details about how the stages of adaptive management would apply to that step. Specifically, this section establishes the objectives, provides an overview of monitoring activities, outlines an approximate schedule, summarizes the approach for data evaluation, and provides initial identification of potential response actions for each step of the dewatering plan.

Specific details of the monitoring activities (e.g., monitoring locations, frequency, and methods) are provided in the SAP in Appendix B.

Although the stages of adaptive management are presented sequentially in each step, it is important to recognize that the adaptive management process will be implemented iteratively within the step, particularly for Steps 2 and 3. For example, evaluation will be conducted each time monitoring data is collected, and that evaluation could trigger adjustment and looping back through the process during the same dewatering step. Alternately, if the monitoring data consistently indicate that performance thresholds are being met, the adaptive management process for a step could be completed without requiring iteration or adjustments.

4.3.1 Step 1 – Initial Pumping Test

Step 1 is envisioned as a 10-well pumping test, conducted for a minimum of 60 days, to validate model predictions of dewatering effectiveness in the local vicinity of the test wells, and make any necessary changes to the model parameters and/or to plans for subsequent dewatering and mining activities. No mining will occur in the South Parcel during Step 1.

The adaptive management process in Step 1 is illustrated on Figure 9.

A. Assess

The assessment stage for Step 1 will include compilation of existing monitoring data, geologic information, results from prior pumping tests conducted by CH2M Hill (2000), and the latest groundwater modeling simulations of the Step 1 pumping test. Monitoring data will continue to be collected and will be incorporated into the assessment for the pumping test.

Two initial objectives have been identified for the Step 1 pumping test:

1) Evaluate model predictions near the test wells.

2) Test dewatering design for meeting mining needs (i.e., achieving necessary drawdown), collecting information to refine the dewatering design, such as the number, screening, and spacing of wells.

B. Design

Based on the information collected during the assessment phase, CalPortland, and its consultants, will prepare a detailed plan for the pumping test. The plan will identify the number and location of pumping and observation wells, well drilling and construction, pumping rates, duration, monitoring locations, equipment, and frequency, etc.

The pumping test plan will be provided to the Environmental Caucus.

C. Implement and Monitor

CalPortland will install the pumping wells and any new observation wells, and conduct the pumping test. The minimum duration of pumping during the test will be 60 days.

Monitoring would consist of two components: 1) high-frequency automated monitoring at wells that are expected to be affected by the pumping test and at sensitive receptors, and 2) continuation of routine manual monitoring at other groundwater and surface water locations.

High-frequency monitoring using pressure transducers would be performed in observation wells near the pumping test location (CHMW-2D, -2S, and MW-D-3), and at wells located nearest to Sequalitchew Creek and West Edmond Marsh (CHMW-3S &-3D and MW-EM-1D). Typically, the frequency of data collection is programmed to vary throughout a pumping test with rapid data collection at the start tapering to less frequent as groundwater levels near stabilization.

Routine monitoring would continue to occur at the normal monitoring locations, including wetland, stream, and groundwater locations outside the area of influence of the pumping test. The streamflow monitoring stations are continuously recording. Manual measurements will be used at the wetland and groundwater locations not near the pumping test.

The Environmental Caucus will be notified of the installation of wells and the start and end of the pumping test. CalPortland will also provide weekly summaries of pumping test progress, and notification (within 24 hours) of any monitoring results below the performance thresholds. Routine reporting is summarized in Table 3 and notifications are outlined in Table 2.

D. Evaluate

Data will be screened as they are collected to determine if immediate action is required. In such an event, the Environmental Caucus would be notified within 24 hours, and the project would move immediately to the adjustment stage.

As monitoring data are collected, they also will be evaluated to see if the test is well-designed and the monitoring network is effective. If necessary, the project may enter the adjustment step to improve the pumping test to collect better information.

Once representative monitoring results are being collected, they will be screened against performance thresholds in Table 4 for the appropriate well and month. The performance thresholds were established at the lower 95th-percentile confidence interval for the predicted water levels [see Section 3.3 and the Groundwater Model Update (Aspect, 2017)]. The frequency of screening will vary during the test beginning with hourly at the start and reducing to daily then weekly as the test progresses, as outlined in Table 1.

If the monitoring results indicate that groundwater levels near the marshes are lower than the performance thresholds, CalPortland would develop and implement appropriate adjustments during the pumping test.

If monitoring results indicate groundwater levels are lower than the performance thresholds in wells that are not near the marshes or other sensitive receptors (i.e., monitoring wells on the South Parcel), then the test would be completed as planned. These results would be evaluated and any anticipated adjustments for future steps identified.

Even if the observations made during the test are above the performance thresholds, they still may provide valuable information for refining the model, mine plan, and Monitoring Plan. Those observations will be considered during assessment and design for Step 2.

The evaluation will also include comparison of climate and water level conditions prior to the test with the range of conditions experienced during the model calibration and validation period.

E. Adjust

Adjustments during the pumping test could occur for two reasons:

1) The monitoring data indicate that data collected are not sufficient to achieve the objectives of the test; or

2) The monitoring data indicate that groundwater levels are below the performance thresholds.

Potential adjustments consist of modifying or terminating the pumping test, and are listed in Table 5. Since no mining below the pre-project groundwater elevation would occur during this dewatering step, any change in groundwater could be reversed by turning the dewatering wells off.

Table 5. Potential Response Actions during Step 1 – Initial Pumping Test

Modify pumping test:
Changing pumping rates
Changing the number of pumping wells
Changing the duration of pumping
Changing monitoring locations including installing new wells
Performing additional testing
Cease pumping test.

CalPortland will notify the Environmental Caucus of any adjustments to the pumping test within 24 hours of the change.

Reporting and Discussion

At the conclusion of the Step 1 pumping test, whether completed as planned, adjusted, or terminated, CalPortland will prepare an interpretative report documenting the pumping test, summarizing the monitoring data, comparing monitoring results with prior model predictions, and making recommendations for the assessment and design phases of the next step.

The report will be provided to the Environmental Caucus, with a 3-month period for review and discussion of the results. CalPortland commits to meeting with the Caucus as often as necessary during the review period to facilitate open communications and timely review. Should the Environmental Caucus and CalPortland have different interpretations

of the dewatering test results, either party may request technical review conferences of the parties' technical consultants, followed by, if necessary, meetings of the parties' representatives, as described in Section 4.2.6 above.

Anticipated Schedule
The schedule for Step 1, in the context of the overall mining schedule, is illustrated in Figure 8. It is expected to require about a year to complete Step 1, with the following anticipated schedule:

- Planning the Pumping Test 1 month
- Installing and Developing Wells 2–3 months
- Performing the Pumping Test 2 months
- Evaluating Results and Reporting 2 months
- Model Updates (if necessary) 2–3 months
- Review by and discussion with Environmental Caucus 3 months

Incorporation of the results into the design of future steps could require additional time.

4.3.2 Step 2 – Preparation for Mining/ Dewatering Test

In Step 2, additional dewatering wells will be installed and will be pumped for several months to draw down groundwater until the gravel in the first mine segment of the South Parcel is dry enough to mine. If monitoring results are above performance thresholds during Step 2, the intent is to continue dewatering from those wells and transition smoothly into Step 3 – Active Dewatering during Mining. Step 3 would only commence when groundwater levels are above the performance thresholds.

The dewatering activity will also serve as a greatly expanded pumping test, the effects of which are completely reversible. The information collected in the first 60 days is most valuable as a pumping test, so evaluation and reporting on the test will focus on this period. The pumping test portion of Step 2 will occur for a minimum of 60 days.

The adaptive management plan for Step 2 is illustrated on Figure 10.

A. Assess
The planning for Step 2 will incorporate the results of Step 1, including any updates to the groundwater model, this Monitoring Plan, or mine plan resulting from Step 1.

In the assessment phase for Step 2, the results of the pumping test in Step 1 will be compared with the groundwater model. If they agree, then design would move forward as planned. If there are notable differences, the groundwater model would be evaluated and potentially modified.

The first level of model evaluation and modification would consist of updating the model to reflect the specific conditions of the Step 1 test (well locations, well construction, pumping rates, antecedent weather conditions, etc.) and developing a set of model predictions specific to the actual test conditions. These updates only modify the scenario for Step 1 and would not require recalibration of the model.

If the predictions from the updated model are notably inconsistent with the results of the pumping test, then the model parameters would be modified and calibrated to the observed data. Then, the full suite of predictive scenarios would be evaluated and compared with the groundwater levels included in the environmental analyses and permitting. If within the contemplated range, the project would move forward to the design phase with the revised model. If not, additional environmental analysis may be necessary.

The initially identified objectives for Step 2 are:

1) Evaluate whether groundwater levels at monitoring wells are above the performance thresholds; and,

2) Confirm that groundwater levels are low enough within the material to be mined to allow for safe and efficient mining and processing.

B. Design

Based on the results of the assessment step, the dewatering plan for Step 2 and the associated monitoring will be designed by CalPortland. Updates to the design will be simulated with the groundwater model and compared with prior environmental analyses as described above. If the model was updated in Step 1 or the assessment stage of Step 2, the predictive results from the updated model will be used to establish new performance thresholds.

Updates to the design and predictions of its impacts on groundwater will be provided to the Environmental Caucus.

C. Implement and Monitor

The additional dewatering wells for Step 2 will be installed and begin pumping. Pumped water will be discharged to an infiltration facility on the floor of existing mine. Pumping will occur for a minimum of 60 days to complete the dewatering test plus an estimated four additional months to dry gravels in Segment 1A sufficiently for mining.

Monitoring would consist of weekly monitoring at the key wells on the South Parcel in the portions of Edmond Marsh closest to the mine (key wells are defined in Table 1) and twice monthly monitoring at the other well, staff gage, and flow monitoring stations. Stations with continuously recording instrumentation, such as the flow monitoring stations, will be downloaded during these visits. Pressure transducers would also be installed to allow for continuous monitoring in key monitoring wells. Manual measurements will be collected from the other locations, such as staff gages and more distant wells.

The Environmental Caucus will be notified of the installation of wells and the start of dewatering. CalPortland will also provide weekly summaries of dewatering progress during the first two months, then monthly summaries. CalPortland will notify the Environmental Caucus (within 24 hours) of any monitoring results below the performance thresholds. Routine reporting is summarized in Table 3 and notifications are outlined in Table 2.

D. Evaluate

The evaluation stage in Step 2 is very similar to the evaluation stage of Step 1, as both actions are essentially pumping tests at different spatial scales.

Data will be screened as they are collected to determine if immediate action is required. In such an event, the Environmental Caucus would be notified and the project would move immediately to the adjustment stage.

Monitoring results will be screened against the performance thresholds in Table 6 for the appropriate well and month. The performance thresholds were established at the lower 95th-percentile confidence interval for the predicted water levels [see Section 3.3 and the Groundwater Model Update (Aspect, 2017)]. If the monitoring results indicate that groundwater levels are lower than the performance thresholds, CalPortland will develop and implement appropriate adjustments.

Even if the groundwater levels are above the performance thresholds, they still may provide valuable information for refining the model, mine plan, and/or this Monitoring Plan. Those observations will be considered during assessment and design for the next dewatering step.

The evaluation will also consider the effect of conditions occurring at the time of monitoring (such as climate conditions, development, and Restoration Plan activities) with the range of conditions experienced during the model calibration and validation period, and include that information in the interpretation of results.

E. Adjust

Adjustment during the pumping test could occur for two reasons:

1) The monitoring data indicate that dewatering could cause groundwater drawdown beyond that previously contemplated and permitted; or

2) The monitoring data indicate that groundwater levels are not sufficiently low within the mine to allow for safe and efficient mining and processing in Step 3.

The first case would trigger rapid development and implementation of adjustments by CalPortland. If adjustments are not feasible or are exhausted without success, CalPortland would request to initiate the technical review conference of the parties' technical consultants, followed by, if necessary, meetings of the parties' representatives, as described in Section 4.2.6. The Environmental Caucus may also initiate this process.

In the second case, CalPortland would refine the dewatering plan while pumping continues. Potential adjustments include modifying or terminating the pumping test, and are listed in additional detail in Table 7. The list of adjustments provided in Table 7 is not intended to limit the range of potential responses.

CalPortland will notify the Environmental Caucus of any adjustments within 24 hours of the change.

Step 2 is completely reversible as no mining below the pre-project groundwater elevation would occur. Any change in groundwater could be reversed by ceasing to pump from the dewatering wells.

Table 7. Potential Response Actions during Step 2 – Preparation for Mining/Dewatering Test

Revise monitoring (change frequency of monitoring, or monitoring locations).
Install additional monitoring locations.
Change pumping rates.
Change pumping locations (adding or decommissioning) wells.
Modify the duration of pumping.
Cease dewatering.

Reporting and Discussion

In addition to the dewatering summaries described above, an interpretative report will be prepared in the third month of pumping for Step 2. The report will summarize the pumping-test portion of Step 2 by summarizing the first 2 months of data, comparing monitoring results with prior model predictions, documenting any response actions taken, and making recommendations for the assessment and design phases of the next step.

The report will be provided to the Environmental Caucus, with a 2-month period for review and discussion of the results. CalPortland commits to making its technical consultant available to meet with the Caucus's technical consultant as often as necessary during the review period to facilitate open communications and timely review. Should the parties' technical consultants be unable to resolve any difference in opinion in interpreting the dewatering test results, either party may request a meeting of the parties' designated representatives, as described in Section 4.2.6 above.

Anticipated Schedule

Step 2 is expected to require a about a year to complete, though the planning and well installation stages may overlap with the later reporting and discussions related to Step 1. The schedule for Step 2 and relationship with the Step 1 pumping test are shown on Figure 8. The anticipated schedule for key elements of Step 2, assuming performance thresholds are met, is:

Planning the Dewatering	2 months	
Installing and Developing Wells	2–3 months	
Performing the Pumping Test	2 months	
Evaluating Results and Reporting	2 month	Simultaneously: Continue Dewatering in Preparation for Mining
Update Model (if necessary)	1 month	
Review by and discussion with EC	2 months	4 months

If groundwater levels meet performance thresholds, Step 2 would flow into Step 3 and the start of mining. Otherwise, Step 2 may require a longer period to perform the

necessary adjustments to achieve sufficient dewatering for mining while maintaining groundwater levels consistent with the performance thresholds and prior environmental analyses, or update the environmental analyses, if necessary.

Step 3 would only commence when groundwater levels are above the performance thresholds and water levels are at appropriately low levels for safe and efficient mining and processing.

4.3.3 Step 3 – Active Dewatering during Mining

During Step 3, mining will begin in the northeastern portion of the South Parcel and proceed south to mine a trough along the eastern boundary. Additional dewatering wells will be installed and pumped to dewater gravel in subsequent mine segments in the South Parcel. CalPortland would not start pumping additional dewatering wells until groundwater levels are at or above performance thresholds.

As mining is completed, reclamation of the eastern mined slope will begin. Pumping wells adjacent to mine segments that are under reclamation will be turned off incrementally to allow natural springs to form at the toe of the mined slope and vegetation to become established.

Steps 3 and 4 are different from the first two steps in that changes to groundwater in these steps are not as easily reversed. As such, the adaptive management plan is focused on identifying when adjustments are necessary.

The adaptive management plan for Step 3 is iterative, and activities would loop continuously through the adaptive management stages throughout implementation of Step 3. The adaptive management plan for Step 3 is illustrated on Figure 11.

A. Assess

The planning for Step 3 will begin prior to the completion of Step 2 to allow for a potentially smooth transition, if performance thresholds are being met. The planning stage will incorporate previously collected monitoring data as well as any updates to the groundwater model, monitoring plan, or dewatering and mining plans.

If monitoring data from prior steps meet the performance thresholds, the planning for Step 3 is expected to move forward in accordance with the mine plan.

Differences between monitoring results and predictions would result in re-evaluation of the groundwater model. The re-evaluation would first simulate the specific conditions of Step 2, then more broadly update the model if predictions still do not match observations. If significant model updates are required, the full suite of scenarios would be simulated and results compared with the prior environmental analyses and permitting. Only if model results are within the predicted range may the project move forward to the design phase with the revised model.

The initially identified objectives for Step 3 are:

1) Evaluate whether groundwater levels at monitoring wells are above the performance thresholds for the appropriate month; and

2) Confirm that groundwater levels are low enough within the material to be mined to allow for safe and efficient mining and processing.

B. Design

Based on the results of the prior steps and assessment for Step 3, the dewatering plan, mining plan, and the associated monitoring will be updated by CalPortland, if necessary. Updates to the design will be simulated with the groundwater model and compared with the performance thresholds. Updated documents will be provided to the Environmental Caucus.

C. Implement and Monitor

Mining will begin at the northern edge of the South Parcel in the area dewatered in Step 2. As mining progresses, additional dewatering wells will be installed to the south of the current wells and begin pumping. As mining is completed in an area, the nearby wells will be turned off, allowing groundwater to emerge from springs from the toe of the completed slope. Both pumped groundwater and spring flow will be conveyed to an infiltration pond installed on the floor of the existing mine.

Monitoring would continue at all normal well, wetland, and streamflow monitoring stations. Streamflow and select well monitoring stations would have continuous recording instruments installed. Other locations would use manual measurements.

The frequency of monitoring would vary during Step 3. In the 3 months after the start of pumping for each new group of monitoring wells, monitoring would be weekly at key wells (defined in Table 1) and twice monthly monitoring at the other well, staff gage, and flow monitoring stations. After that, monitoring will be performed monthly.

D. Evaluate

As with prior steps, monitoring results will be screened against performance thresholds for Step 3 (Table 8) for the appropriate well and month. The performance thresholds were established at the lower 95th-percentile confidence interval for the predicted water levels [see Section 3.3 and the Groundwater Model Update (Aspect, 2017)]. If the model was previously updated, performance thresholds based on predictive results from the updated model will be used for the comparison. The evaluation will also consider the effect of conditions occurring at the time of monitoring (such as climate conditions, development, and Restoration Plan activities) with the range of conditions experienced during the baseline period.

If the monitoring results indicate that groundwater levels are lower than the performance thresholds, CalPortland would evaluate and implement appropriate adjustments.

Although the primary focus is on changes in groundwater levels, streamflow and surface water monitoring results will also be reviewed. By this point in the project, streamflow and surface water monitoring results will be affected by Restoration Plan activities, which are likely to have a larger effect than mining on the surface water bodies. The Restoration Plan will incorporate its own adaptive management process.

E. Adjust

Step 3 involves mining below the current aquifer level. As such, it is more difficult to reverse than prior steps; however, mining is designed to begin away from the marshes

and Sequalitchew Creek and proceed southward toward them over a period of years. This will slowly change water levels beneath the marshes and creek and allow time for response actions should the monitoring data and evaluations indicate they are necessary.

If groundwater levels are below the performance thresholds, CalPortland would develop and implement adjustments. Unlike in the prior steps, re-examination of the groundwater model is not a first element of evaluating potential response actions in Step 3.

Either party may initiate a request for a technical review conference and, if necessary, meetings of the parties' representatives, as described under Section 4.2.6 above. If adjustments are not feasible or are exhausted without meeting performance thresholds, CalPortland would initiate the process to discuss alternative approaches and next steps.

Selection of potential response actions is shown in Table 9. The suite of appropriate response actions will change over time as mining progresses. For example, early in Step 3 there is more flexibility to alter the mine plan. As mining progresses further south, the ability for alterations to the mine plan to produce a meaningful change in groundwater levels is reduced.

Table 9. Potential Response Actions during Step 3 – Active Dewatering during Mining

Revise mine phasing to allow time for additional monitoring, analyses, testing, and planning.
Revise dewatering plan (number of wells, spacing, alignment, pumping duration).
Revise mining plan to change depth or extent of mining.
Install partial slurry cutoff wall.
Provide additional mitigation.
Cease dewatering and mining.

Reporting and Discussion

During Step 3, CalPortland will prepare summary memos providing comparison of observed groundwater levels over the past 3 months with model predictions, as well as an update on dewatering and mining status, and any response actions taken. The summary memos will be prepared monthly for 3 months after each new set of dewatering wells begins pumping, then quarterly. The memos will be provided to the Environmental Caucus.

Anticipated Schedule

Mining would proceed south over a period of years. Completion of Step 3 is expected to take 4 to 8 years. The mining schedule is, in part, driven by the market demand for aggregate. CalPortland has committed to complete Step 3 in no less than 3 years, or a minimum of 9 months per each of the first four segments (1A to 1D). The minimum timeline for completion of Step 3 is illustrated in Figure 8.

4.3.4 Step 4 – Cessation of Active Dewatering

This final step of dewatering commences once mining and reclamation advances to the point that the last dewatering wells installed in Step 3 have been turned off. At that point, groundwater will emerge from springs along the length of the toe of the mined (and reclaimed) slope along the eastern and a portion of the southern mine boundaries. Step 3 is expected to transition smoothly into Step 4, given the multiple-year duration of Step 3 and that ceasing to pump the dewatering wells will result in lower environmental impact.

Several steps of the adaptive management process (i.e., assess and design) are not as relevant in Step 4, because it is a largely passive step with respect to the effects on groundwater levels. Mining and reclamation activities will continue within the South Parcel, but those activities would no longer influence groundwater levels.

As such, this discussion focuses on ongoing monitoring, data evaluation, and potential response actions. The adaptive management plan for Step 4 is illustrated on Figure 12.

C. Monitoring

Monthly monitoring would continue for the duration of mining at the normal well, wetland, and streamflow monitoring stations. Continuous instrumentation will be maintained at streamflow monitoring stations. Staff gage and well monitoring locations will be manually measured.

D. Evaluate

Monitoring results would continue to be screened relative to the performance thresholds shown in Table 10, or as refined from the most recent groundwater model. The performance thresholds were established at the lower 95th-percentile confidence interval for the predicted water levels [see Section 3.3 and the Groundwater Model Update (Aspect, 2017)]. It is unlikely that events will result in short-term changes in groundwater levels in Step 4. Therefore, the evaluation will focus on longer-term comparisons with model predictions and observations of changes in the marshes and Sequalitchew Creek.

E. Adjust

If groundwater levels persist lower than the performance thresholds, CalPortland and the Environmental Caucus would hold one or more technical review conferences of the parties' technical consultants and, if necessary, meetings of the parties' representatives (as described in Section 4.2.6). to discuss and select appropriate adjustments. Either party may initiate this process.

Reporting

Quarterly summary memos will be prepared for the first year after cessation of dewatering. Annual reports will be prepared for the remaining duration of mining of the South Parcel.

Anticipated Schedule

Step 4 will begin after active dewatering ceases. Depending on market demand for aggregate products, mining of the remainder of the South Parcel is expected to occur over 5 to 8 years after cessation of active dewatering. Active adaptive management during Step 4 would cease when the following conditions are met:

- Mining of the South Parcel is complete, and

- Measured groundwater levels have been met performance thresholds for at least 3 consecutive years.

5 Relationship of Adaptive Management Process to Sequalitchew Creek Restoration Plan

Mining of the South Parcel and the restoration of Sequalitchew Creek are separate, but interacting, projects. Each project has its own adaptive management process tailored to achieving the goals and objectives of that project. The interaction between the two adaptive management processes is three-fold: 1) project schedules that encourage restoration in advance of the potential impacts from mining; 2) development of performance thresholds for mining that support restoration based on prior technical studies, including the cumulative effects analysis prepared in 2016 (Aspect and Anchor, 2016); and 3) coordinated monitoring and open sharing of information.

Project Schedules. The mining and restoration projects have been designed to facilitate restoration occurring in advance of the potential impacts from mining. This relationship between the project schedules is founded in key elements of the settlement agreement:

1) The mining project cannot begin until all permits for restoration have been obtained and the required authorizations or approvals from JBLM needed to implement the restoration elements on JBLM have been obtained.

2) The first actions of the mining project are pumping and dewatering tests (i.e., Steps 1 and 2) and are expected to take about 1.5 to 2 years to complete and no less than 9 months[1], as described in Section 4.2.1. The effects of Steps 1 and 2 on groundwater are completely reversible.

3) The first South Parcel mining segment is located furthest from the wetlands and Sequalitchew Creek. Mining and dewatering proceed slowly toward the Creek over a period of not less than 3 years, and more likely 4 to 8 years.

4) There are no schedule constraints or limits imposed on the pace of restoration activities.

The Restoration Plan schedule is anticipated to begin with the elements that immediately restore flow through the system—specifically, beaver management and improvements at the outlet of Sequalitchew Lake. The actions will be followed by improvements that enhance flows (e.g., connections from Hamer Marsh) and make it easier to maintain flows (e.g., installation of the Railroad Trail bridge and sealing\restoration of the losing reach). Finally, habitat restoration, through culvert replacements and enhancement of wetland and stream habitats, is the final component of the Restoration Plan.

Although a detailed schedule has not been developed for implementation of the Restoration Plan, it is anticipated restoration activities will begin immediately shortly after Restoration Plan permits are obtained and it should require no more than 6 years to complete construction and implementation of all elements of the Restoration Plan. The

[1] Minimum durations for the pumping test and review and discussion stages of Steps 1 and 2 are established in Section 4.3. The specified timeframes add up to a minimum duration of 9 months, however this duration is unrealistically short as it does not include time for other key steps, like well installation or report writing.

flow restoration actions should be completed within two years from the start of the project, and followed by flow maintenance and enhancement, which may require 3 years to complete, but could overlap with the flow restoration actions. Finally, construction of habitat restoration improvements could be completed within 3 years and could overlap or dovetail with the related flow maintenance and enhancement elements.

A timeline relating the anticipated schedules for restoration and mining is presented on Figure 13. Restoration activities should be successful in restoring flows to Sequalitchew Creek within the first 2 years. During this time, the mining project would complete the second pumping test (Step 2) and, if groundwater levels meet performance thresholds and mining progresses at the fastest allowable pace, mine Segment 1A and advance into Segment 1B. The anticipated increase in flow is much greater than the potential impact from the mining project, and the full benefit in flow quantity may be achieved in these first 2 years; whereas the impact from mining is minimal at first and increases slowly over time. The impact from mining is expected to peak during mining of Segment 1C, when the greatest number of wells are pumping[2].

Even if mining is proceeding rapidly, CalPortland has committed that mining of Segment 1 would not be completed in less than 3 years, with each segment lasting at least 9 months. At this pace, the peak impact from mining could be expected around 2 to 3 years after the start of restoration. Even if delayed, the flow restoration action should have occurred by this time and only a fraction of flow restoration is necessary to offset the impacts from mining.

Performance Thresholds that are Supportive of Restoration. The cumulative effects analysis (Aspect and Anchor, 2016) found that the changes in the marshes would be dominated by the Restoration Project (which requires lowering marsh water levels to achieve flow from Sequalitchew Lake to the ravine), rather than increased infiltration resulting from lower groundwater levels. The marshes would have significantly more water flowing through them than under current conditions, resulting in consistent water levels year-round at the target levels established in the Restoration Plan, except for some periods in the driest years.

The cumulative effects analysis also concluded that the predominant cumulative effect on Sequalitchew Creek would be an increase in annual average flows by approximately 10 cfs, with abundant year-round flow most of the time. By comparison, the stream flow reductions from mining is expected to be less than 1 cfs, and only apparent during limited periods in atypical summers.

The anticipated benefits to streamflow from restoration are much larger than the potential impacts from mining. As a result, the success of the restoration project is not expected to be particularly sensitive to the groundwater levels resulting from mining. Monitoring during mining will ensure that groundwater levels remain within the expected range that will support the anticipated increases in stream flow from the restoration project. If

[2] To be conservative, the potential impacts of mining described in the cumulative effects analysis (Aspect and Anchor, 2016) were based on all wells pumping at the same time. In practice, this condition is unlikely to occur as initial wells would be phased off as mining progresses.

groundwater levels are not maintained within the expected range, corrective actions will be implemented in accordance with the adaptive management plan for mining.

Coordinated Monitoring and Information Sharing. To facilitate the coordinated collection and exchange of information, the two projects share an integrated SAP (Appendix B). The SAP outlines the collection of information on groundwater levels, surface water levels, streamflow, and surface water quality to support both plans. Each plan also outlines how information will be shared so that plan implementers have the data necessary to make informed management decisions.

6 References

Aspect Consulting, LLC (Aspect), 2017, Groundwater Model Update, DuPont Mine South Parcel Expansion Area, Prepared for: CalPortland.

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7 Limitations

Work for this project was performed for CalPortland (Client), and this report was prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. This report does not represent a legal opinion. No other warranty, expressed or implied, is made.

All reports prepared by Aspect Consulting for the Client apply only to the services described in the Agreement(s) with the Client. Any use or reuse by any party other than the Client is at the sole risk of that party, and without liability to Aspect Consulting. Aspect Consulting's original files/reports shall govern in the event of any dispute regarding the content of electronic documents furnished to others.

TABLES

Table 4 - Performance Thresholds for Step 1 - Initial Dewatering Test

Project No. 040001-014-02, South Parcel, DuPont, Washington

Well	Performance Threshold = Groundwater Elevation in Feet (NGVD 29)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MW-EM-1S	203.6	202.4	202.9	202.2	202.3	201.4	200.4	200.4	199.5	199.5	202.1	202.9
MW-EM-1D	204.6	203.4	203.9	203.2	203.3	202.5	201.5	201.5	200.7	200.7	203.1	203.9
MW-EM-2S	210.6	210.3	210.4	210.3	210.2	210.0	209.7	209.6	209.3	209.5	210.2	210.4
MW-EM-2D	210.8	210.4	210.6	210.5	210.4	210.2	209.8	209.7	209.4	209.6	210.4	210.5
MW-EM-3	212.1	211.9	211.8	211.9	212.0	211.6	211.4	210.8	210.2	210.3	211.5	211.9
MW-SRC-2	213.2	212.4	212.7	212.6	212.8	212.0	211.4	210.2	209.6	210.5	212.3	212.7
MW-BM-1	218.0	217.0	216.6	217.4	217.3	216.6	216.1	213.1	213.3	214.2	216.8	217.4
MW-HM-1	214.2	213.5	213.3	213.8	213.6	212.7	211.8	211.2	210.6	211.1	213.1	213.6
MW-PL-1	200.8	200.1	200.4	200.1	200.0	199.4	198.6	198.7	198.0	197.7	199.6	200.2
CHMW-1	191.3	189.9	190.4	189.6	189.7	189.0	188.1	188.0	187.4	187.5	190.0	190.7
CHMW-2S	184.6	183.3	183.7	183.0	183.0	182.5	181.7	181.6	181.2	181.4	183.5	184.0
CHMW-2D	183.4	181.8	182.4	181.4	181.5	180.8	179.8	179.7	179.3	179.4	182.1	182.7
CHMW-3S	193.3	191.7	192.4	191.3	191.5	190.6	189.6	189.5	188.7	188.8	191.7	192.6
CHMW-3D	193.2	191.5	192.2	191.1	191.3	190.4	189.2	189.1	188.3	188.4	191.5	192.5
CHMW-4S	196.1	194.7	195.3	194.4	194.6	193.7	192.7	192.6	191.9	191.9	194.6	195.5
CHMW-4D	194.3	192.9	193.5	192.6	192.7	191.9	190.9	190.8	190.1	190.1	192.8	193.6
MW-D-3	196.5	195.3	195.7	195.0	195.1	194.6	193.9	193.7	193.3	193.5	195.6	195.9
MW-93-MFS-C5-3	192.3	191.2	191.7	191.0	191.0	190.5	190.0	189.9	189.5	189.8	191.6	191.7

Table 6 - Performance Thresholds for Step 2 - Preparation for Mining/Expanded Dewatering Test

Project No. 040001-014-02, South Parcel, DuPont, Washington

Well	Performance Threshold = Groundwater Elevation in Feet (NGVD 29)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MW-EM-1S	202.3	201.1	201.6	200.9	201.1	200.1	199.1	199.2	198.4	198.3	200.8	201.5
MW-EM-1D	203.4	202.3	202.8	202.2	202.3	201.4	200.5	200.5	199.7	199.7	202.0	202.7
MW-EM-2S	210.6	210.2	210.3	210.2	210.1	210.0	209.6	209.5	209.2	209.4	210.1	210.3
MW-EM-2D	210.8	210.4	210.5	210.4	210.3	210.1	209.7	209.6	209.3	209.5	210.3	210.5
MW-EM-3	212.1	211.9	211.8	211.9	212.0	211.6	211.4	210.8	210.2	210.3	211.5	211.9
MW-SRC-2	213.2	212.4	212.6	212.6	212.8	212.0	211.4	210.2	209.5	210.5	212.0	212.7
MW-BM-1	218.0	217.0	216.5	217.3	217.2	216.6	216.1	213.0	213.3	214.1	216.8	217.3
MW-HM-1	214.2	213.4	213.3	213.8	213.6	212.7	211.8	211.2	210.5	211.1	213.0	213.6
MW-PL-1	200.4	199.7	200.1	199.8	199.8	199.1	198.2	198.4	197.7	197.4	199.2	199.8
CHMW-1	187.0	185.7	186.3	185.5	185.6	184.9	184.0	184.0	183.3	183.4	185.8	186.4
CHMW-2S	143.8	141.4	142.2	141.0	141.0	140.1	139.1	138.9	138.3	138.6	141.8	142.9
CHMW-2D	142.5	141.0	141.6	140.7	140.7	140.0	139.1	138.9	138.3	138.5	141.2	141.9
CHMW-3S	190.6	189.0	189.8	188.8	189.0	188.1	187.0	187.0	186.2	186.2	189.0	189.8
CHMW-3D	190.2	188.6	189.4	188.3	188.5	187.5	186.3	186.3	185.4	185.3	188.4	189.3
CHMW-4S	193.7	192.3	193.0	192.1	192.3	191.4	190.4	190.4	189.6	189.6	192.2	193.0
CHMW-4D	191.8	190.5	191.2	190.3	190.5	189.6	188.6	188.6	187.8	187.8	190.4	191.1
MW-D-3	193.7	192.5	193.0	192.3	192.3	191.9	191.2	191.1	190.7	190.9	192.9	193.4
MW-93-MFS-C5-3	190.8	189.8	190.3	189.6	189.6	189.1	188.7	188.5	188.2	188.5	190.2	190.5

Table 8 - Performance Thresholds for Step 3 - Active Dewatering during Mining

Project No. 040001-014-02, South Parcel, DuPont, Washington

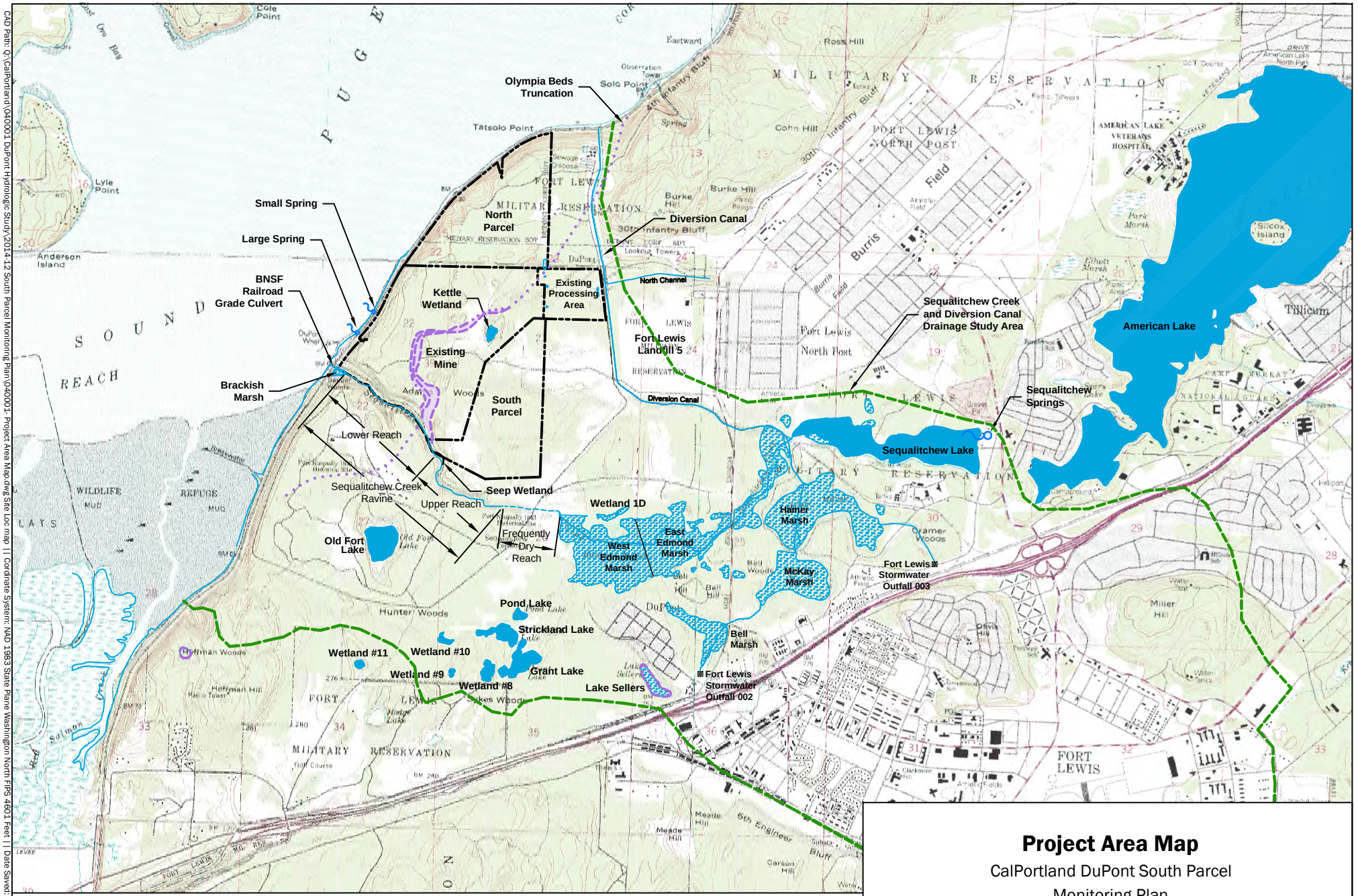
Well	Performance Threshold = Groundwater Elevation in Feet (NGVD 29)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MW-EM-1S	197.5	196.4	196.9	196.4	196.5	195.6	194.7	194.8	194.1	194.1	196.1	196.8
MW-EM-1D	199.4	198.4	198.9	198.3	198.4	197.6	196.8	196.9	196.2	196.2	198.1	198.7
MW-EM-2S	210.3	210.0	210.1	209.9	209.9	209.7	209.4	209.3	209.0	209.2	209.9	210.0
MW-EM-2D	210.5	210.1	210.3	210.1	210.0	209.8	209.5	209.4	209.1	209.3	210.0	210.2
MW-EM-3	212.1	211.9	211.8	211.9	212.0	211.6	211.4	210.8	210.2	210.3	211.5	211.8
MW-SRC-2	213.2	212.4	212.7	212.6	212.8	212.0	211.4	210.2	209.5	210.5	212.0	212.7
MW-BM-1	217.8	216.8	216.4	217.2	217.1	216.4	215.9	212.8	213.1	213.9	216.7	217.2
MW-HM-1	214.2	213.4	213.3	213.8	213.6	212.7	211.8	211.2	210.4	211.1	213.0	213.6
MW-PL-1	199.4	198.7	199.0	198.8	198.7	198.0	197.1	197.3	196.6	196.2	198.1	198.8
CHMW-1	129.8	129.1	129.4	128.9	128.9	128.5	127.8	127.8	127.3	127.4	129.2	129.5
CHMW-2S	136.0	134.5	135.0	134.1	134.1	133.5	132.9	132.8	132.3	132.5	134.9	135.5
CHMW-2D	135.9	134.7	135.1	134.3	134.2	133.7	133.1	132.9	132.4	132.6	134.9	135.5
CHMW-3S	131.1	128.4	130.3	128.9	129.2	127.9	126.6	127.0	126.2	126.3	129.0	130.2
CHMW-3D	128.3	127.4	127.9	127.6	127.6	126.8	125.8	126.1	125.4	125.1	127.0	127.6
CHMW-4S	181.0	179.7	180.4	179.6	179.7	178.8	177.7	177.8	176.9	176.9	179.5	180.3
CHMW-4D	178.5	177.3	178.0	177.1	177.3	176.4	175.3	175.4	174.5	174.4	177.1	177.8
MW-D-3	189.9	188.6	189.1	188.4	188.4	187.9	187.4	187.3	186.9	187.3	189.1	189.6
MW-93-MFS-C5-3	189.5	188.5	189.0	188.4	188.3	187.9	187.5	187.4	187.2	187.5	189.0	189.3

Table 10 - Performance Thresholds for Step 4 - Cessation of Active Dewatering

Project No. 040001-014-02, South Parcel, DuPont, Washington

Well	Performance Threshold = Groundwater Elevation in Feet (NGVD 29)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MW-EM-1S	198.1	197.0	197.6	197.0	197.1	196.2	195.4	195.3	194.8	194.7	196.8	197.4
MW-EM-1D	199.9	198.9	199.4	198.8	199.0	198.2	197.3	197.3	196.7	196.7	198.7	199.3
MW-EM-2S	210.3	210.0	210.1	210.0	209.9	209.7	209.4	209.3	209.0	209.2	209.9	210.1
MW-EM-2D	210.5	210.2	210.3	210.1	210.1	209.9	209.5	209.4	209.1	209.3	210.1	210.2
MW-EM-3	212.1	211.9	211.8	211.9	212.0	211.6	211.4	210.8	210.2	210.3	211.5	211.8
MW-SRC-2	213.2	212.4	212.7	212.6	212.8	212.0	211.4	209.9	209.4	210.4	212.0	212.7
MW-BM-1	217.9	216.9	216.4	217.2	217.1	216.5	216.0	212.3	213.0	213.8	216.7	217.2
MW-HM-1	214.2	213.4	213.3	213.8	213.6	212.7	211.8	211.0	210.3	211.1	213.0	213.6
MW-PL-1	199.5	198.8	199.2	198.9	198.9	198.2	197.3	197.5	196.8	196.4	198.2	198.9
CHMW-1	163.2	162.7	162.9	162.7	162.6	162.4	162.1	162.1	161.8	162.0	162.9	163.1
CHMW-2S	169.3	165.0	168.1	163.2	162.8	158.9	157.1	157.2	156.2	156.9	167.9	168.8
CHMW-2D	160.3	158.5	159.2	158.1	157.9	156.9	155.4	155.5	154.6	155.2	159.1	159.8
CHMW-3S	140.4	140.2	140.3	140.2	140.2	140.0	139.7	139.7	139.5	139.7	140.3	140.3
CHMW-3D	141.9	141.6	141.8	141.6	141.6	141.4	141.1	141.1	140.9	141.0	141.6	141.8
CHMW-4S	183.0	181.9	182.5	181.8	181.9	181.3	180.5	180.5	179.9	180.0	181.9	182.4
CHMW-4D	181.0	180.0	180.6	179.9	180.0	179.4	178.7	178.7	178.2	178.2	180.0	180.5
MW-D-3	191.4	190.2	190.7	190.0	189.9	189.5	188.9	188.8	188.5	188.9	190.7	191.1
MW-93-MFS-C5-3	190.1	189.1	189.5	188.9	188.8	188.4	187.9	187.9	187.6	188.0	189.6	189.9

FIGURES



Project Area Map

CalPortland DuPont South Parcel
Monitoring Plan
DuPont, Washington

Aspect CONSULTING	DEC-2014	BY: OGR/SCC	FIGURE NO. 1
	PROJECT NO. 040001-014	REVISED BY: -	

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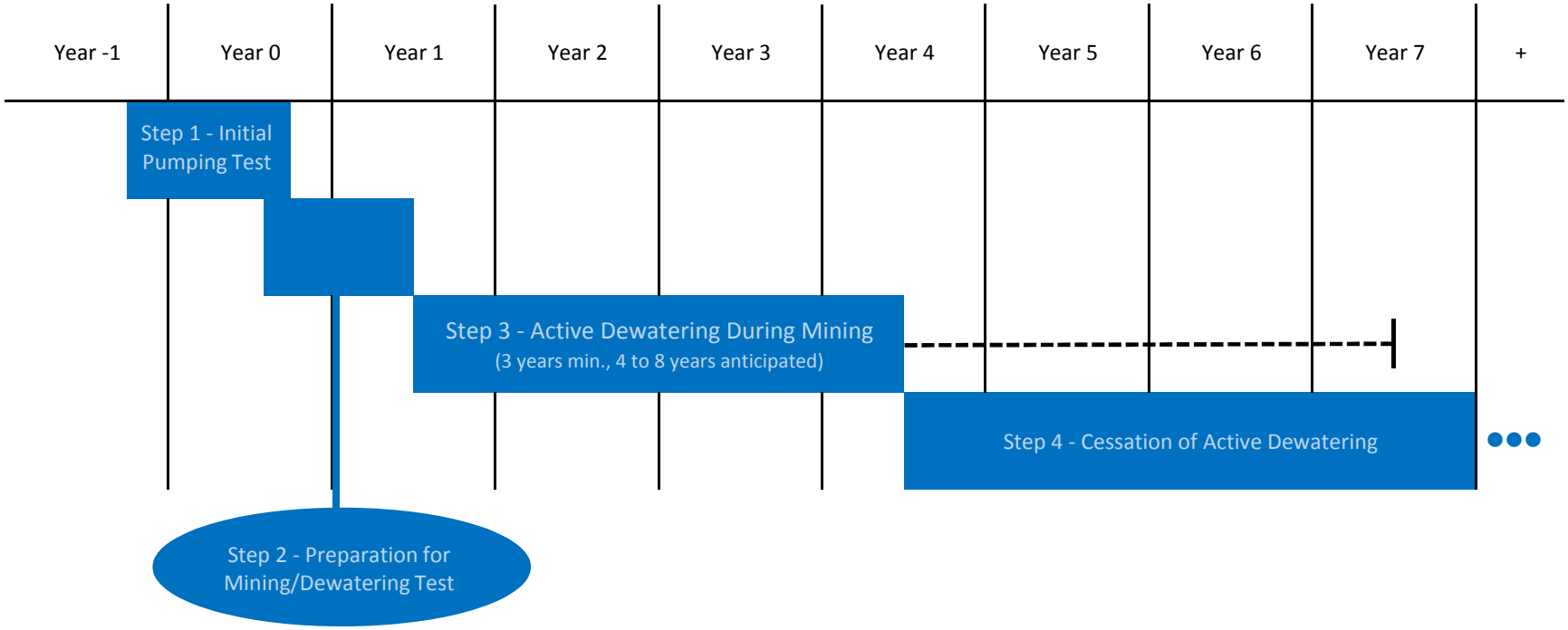
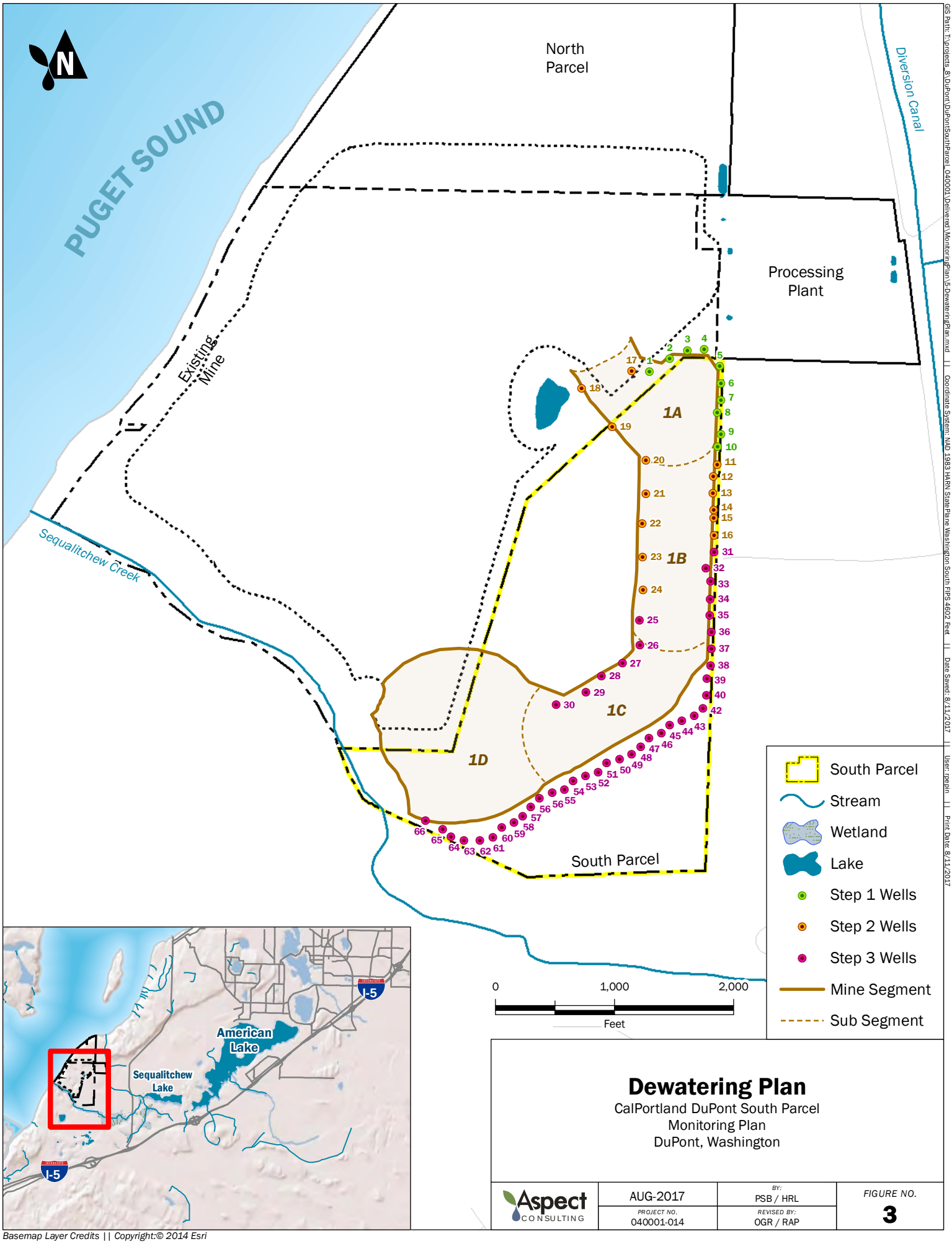


Notes:

1) Year 1 begins with the start of pumping in Step 2.

2) Timeline for Step 3 is based on CalPortland's commitment to a minimum duration of 3 years. The dashed line indicates the anticipated duration (6 years).

Figure 2
Timeline of Dewatering Steps
South Parcel Monitoring Plan
DuPont, Washington



Dewatering Plan

CalPortland DuPont South Parcel
Monitoring Plan
DuPont, Washington

Aspect CONSULTING	AUG-2017	BY: PSB / HRL	FIGURE NO. 3
	PROJECT NO. 040001-014	REVISED BY: OGR / RAP	

Basemap Layer Credits || Copyright:© 2014 Esri

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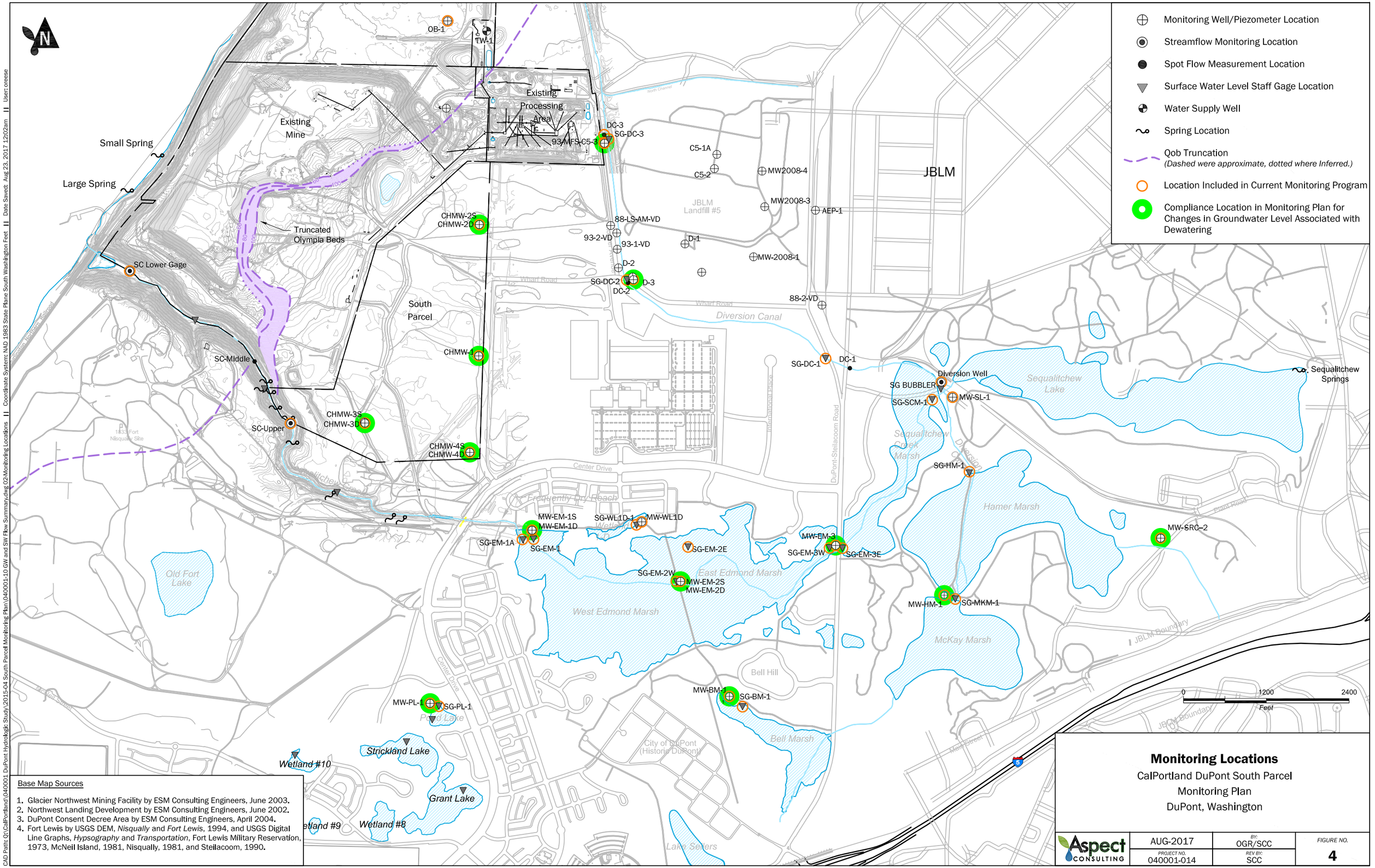

Base Map Sources

1. Glacier Northwest Mining Facility by ESM Consulting Engineers, June 2003.
2. Northwest Landing Development by ESM Consulting Engineers, June 2002.
3. DuPont Consent Decree Area by ESM Consulting Engineers, April 2004.
4. Fort Lewis by USGS DEM, *Nisqually* and *Fort Lewis*, 1994, and USGS Digital Line Graphs, *Hypsography* and *Transportation*, Fort Lewis Military Reservation, 1973, McNeil Island, 1981, Nisqually, 1981, and Steilacoom, 1990.

Monitoring Locations

CalPortland DuPont South Parcel
Monitoring Plan
DuPont, Washington

Aspect Consulting	AUG-2017	BY: OGR/SCC	FIGURE NO. 4
	PROJECT NO. 040001-014	REV BY: SCC	

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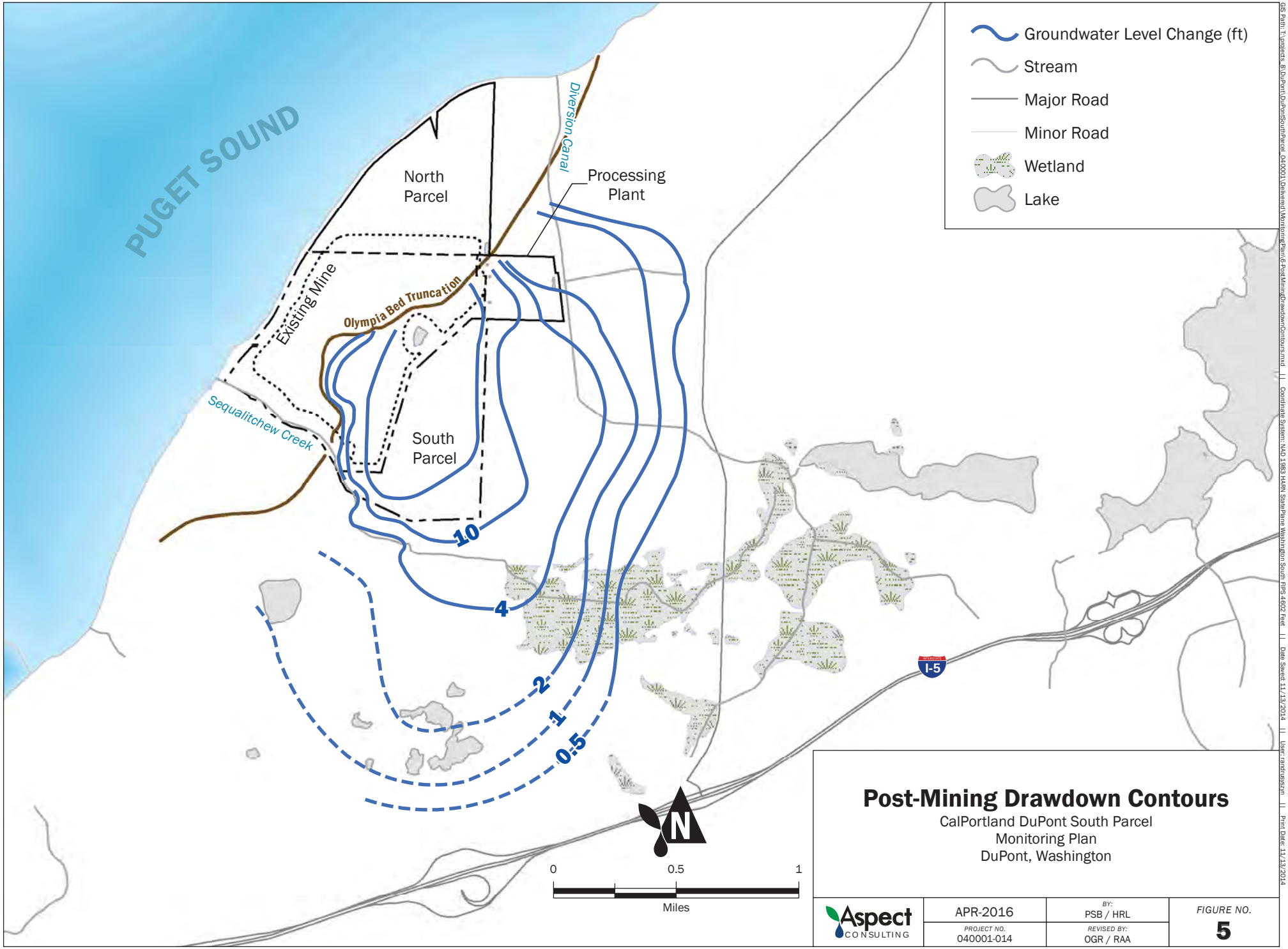

Post-Mining Drawdown Contours

CalPortland DuPont South Parcel
Monitoring Plan
DuPont, Washington

Aspect CONSULTING	APR-2016	BY: PSB / HRL	FIGURE NO. 5
	PROJECT NO. 040001-014	REVISED BY: OGR / RAA	

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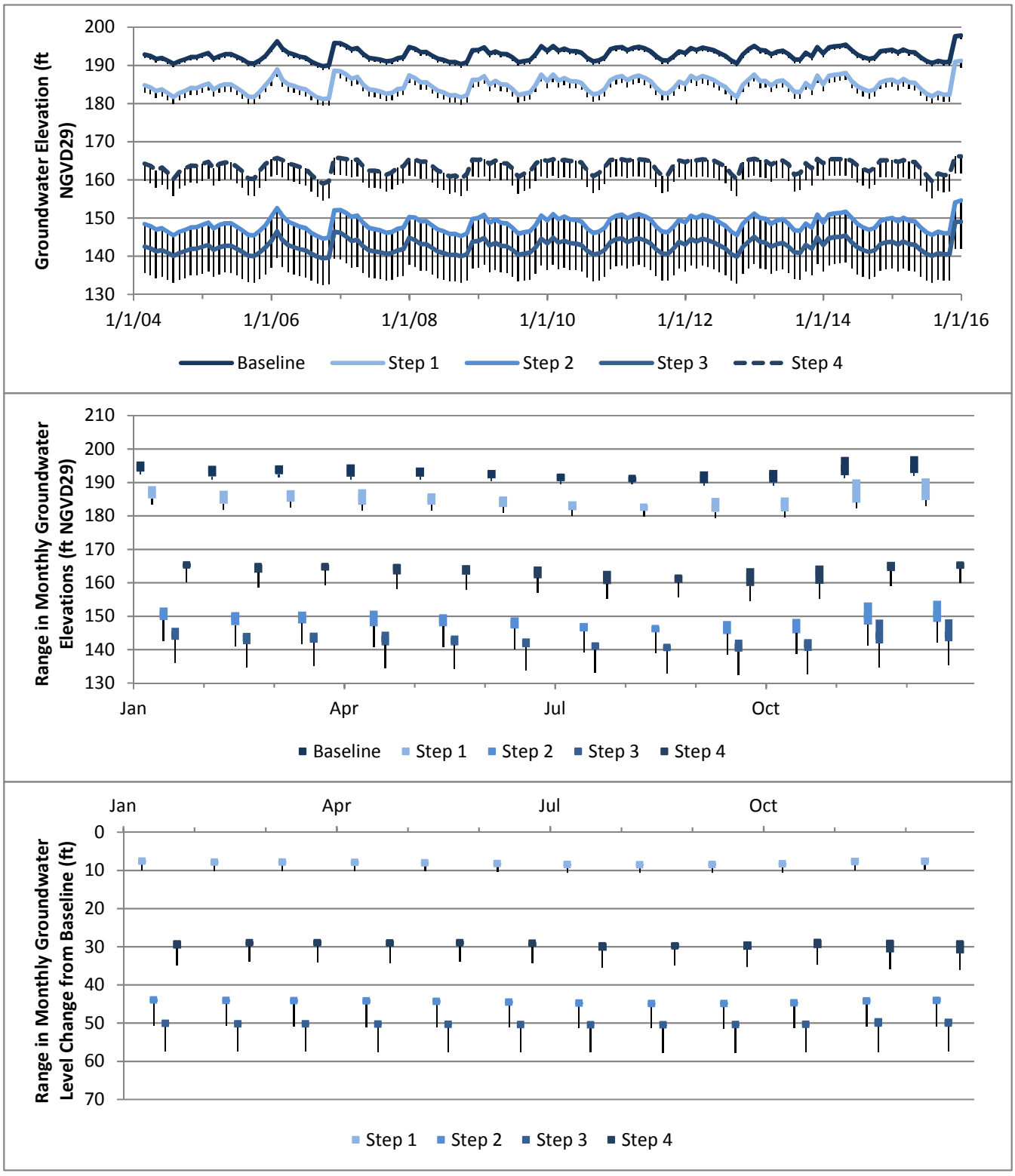
CHMW-2D



Aspect Consulting, LLC
03/20/2017
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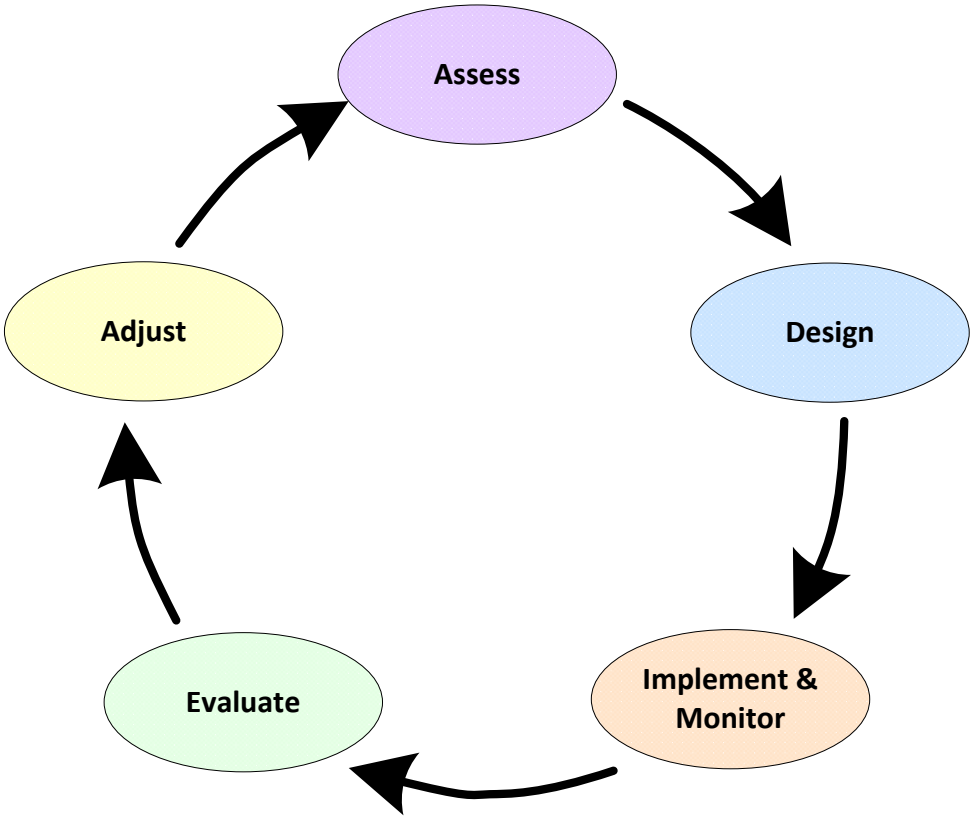
Figure 6
Predicted Changes and Ranges in Groundwater Levels



Adaptive Management Process

CalPortland DuPont South Parcel
Monitoring Plan
DuPont, WA

Aspect CONSULTING	APR-2016	BY: OGR	FIGURE NO. 7
	PROJECT NO. 040001-014	REV BY: ---	

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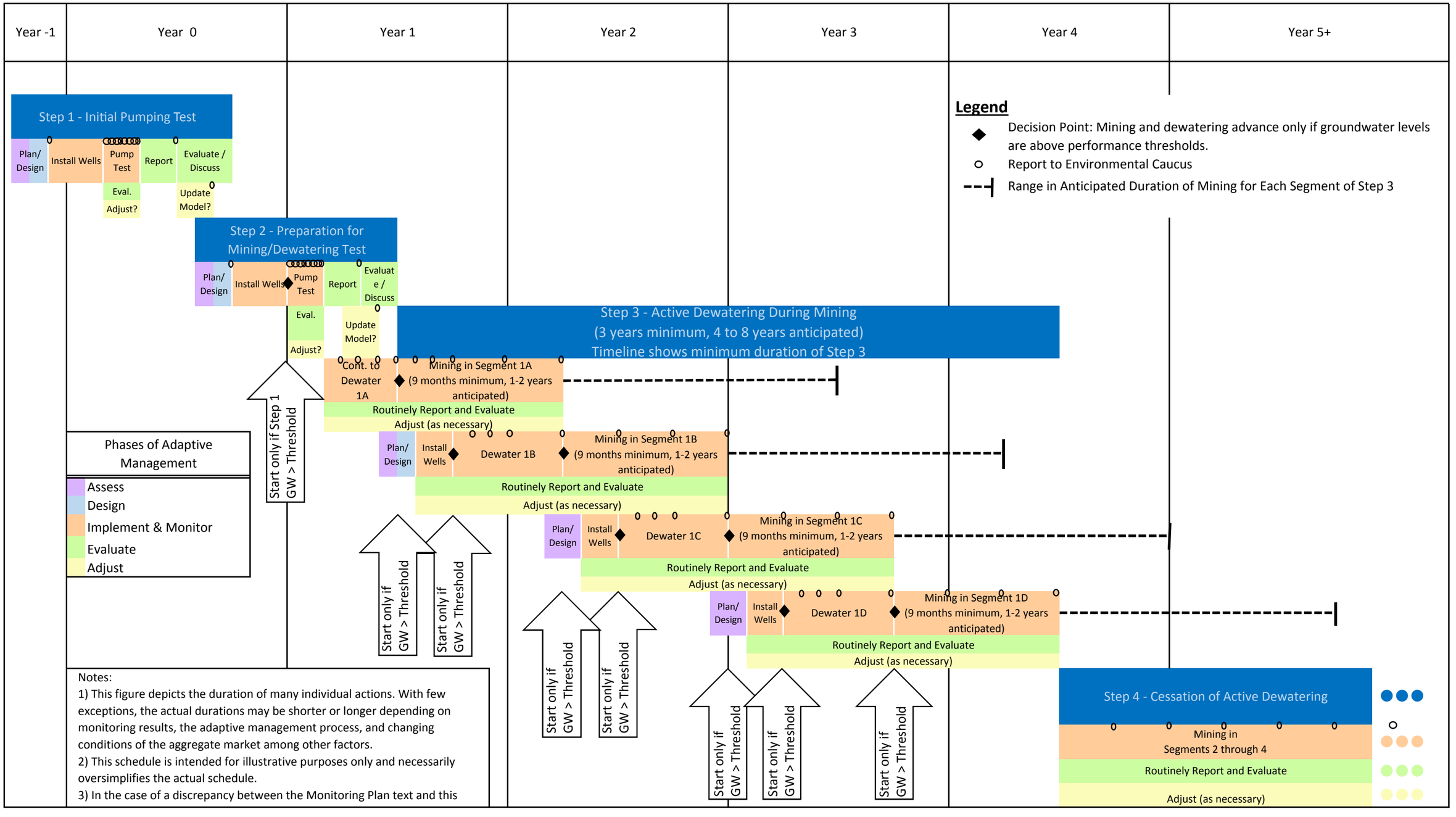
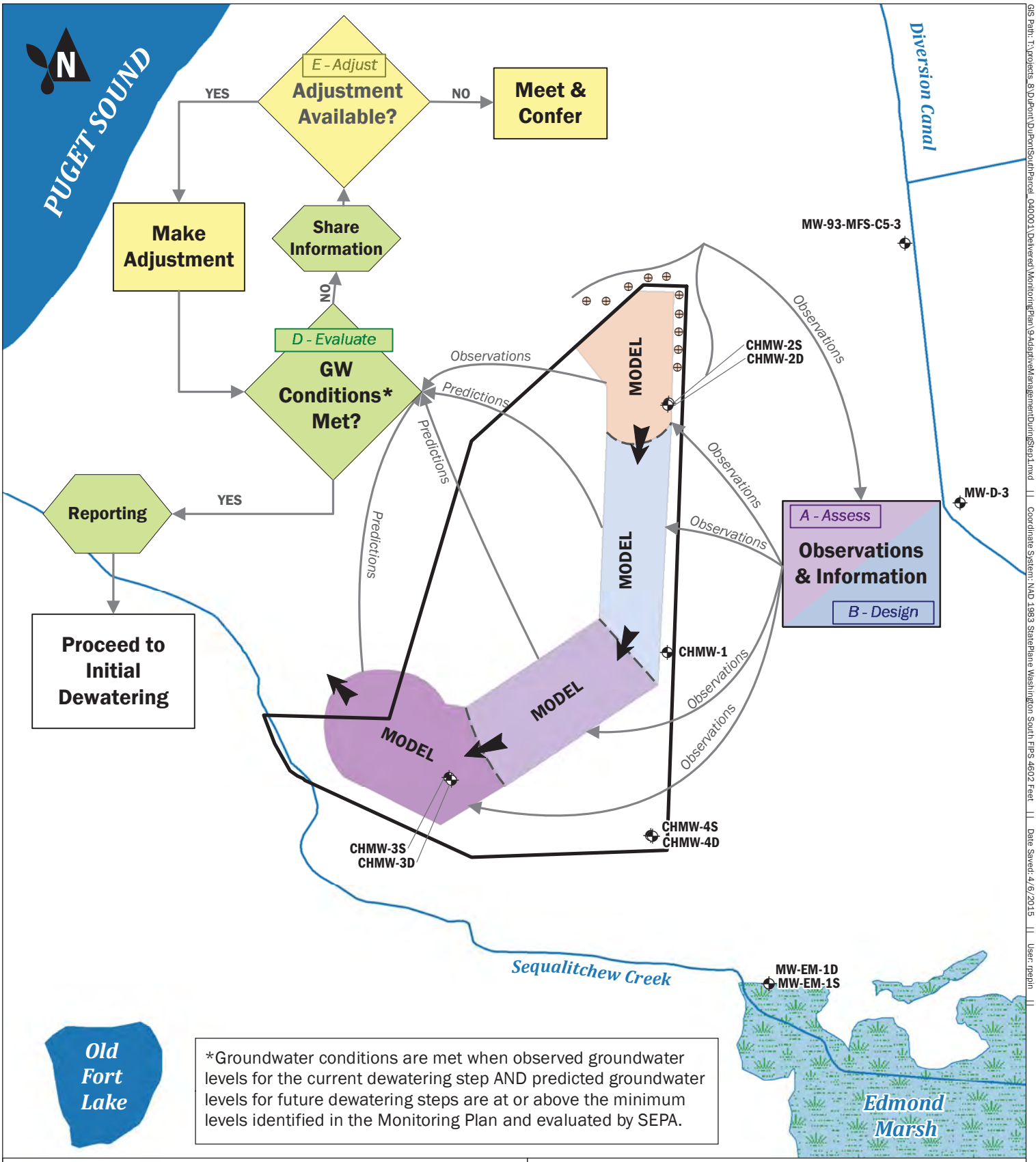


Figure 8
Timeline of Adaptive Management for South Parcel Mining



Adaptive Management Process During Step 1 - Initial Dewatering Test

CalPortland DuPont South Parcel
Monitoring Plan
DuPont, Washington

Aspect CONSULTING	APR-2016	BY: OGR / RAP	FIGURE NO. 9
	PROJECT NO. 040001-014	REVISED BY: ---	

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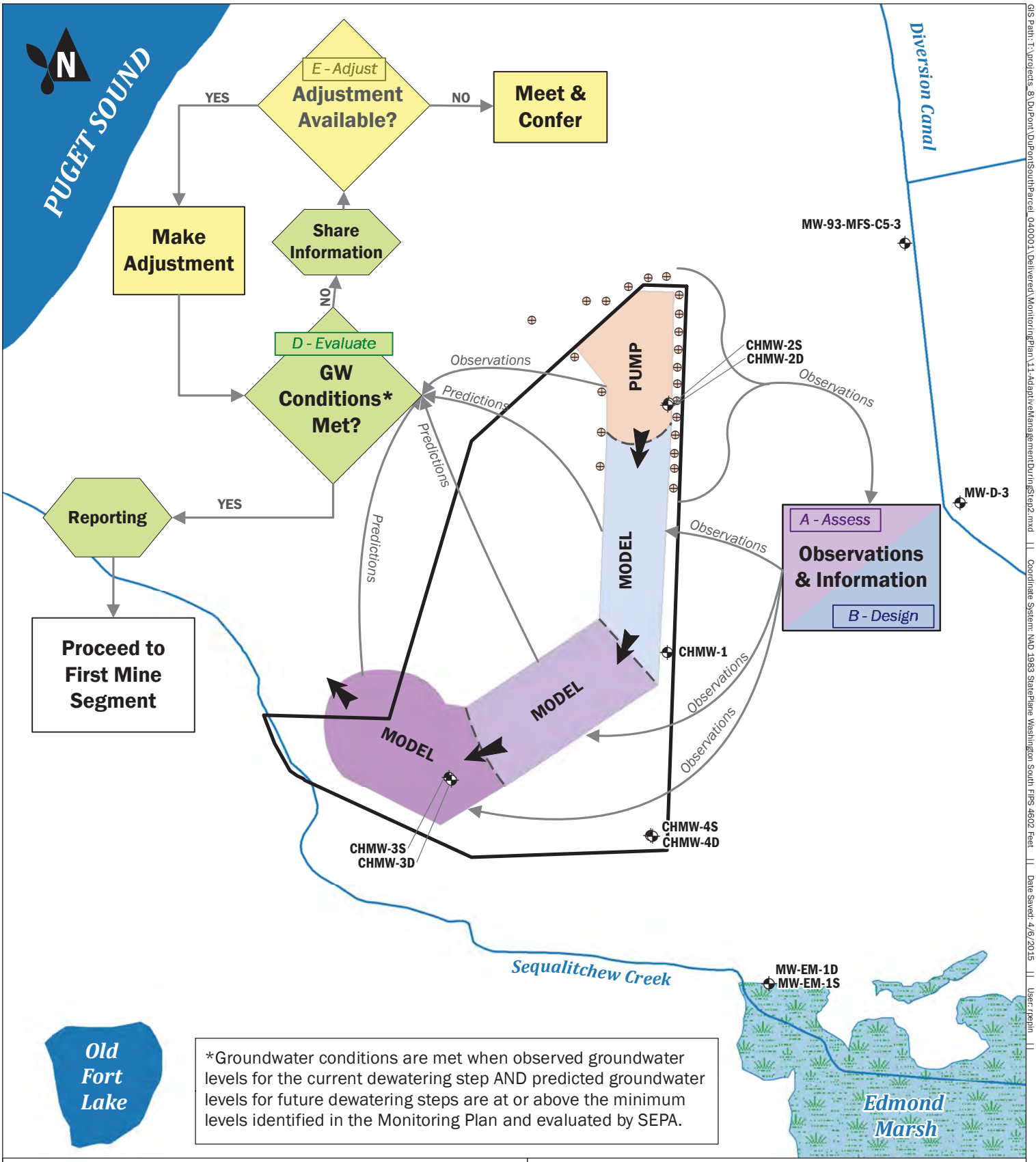
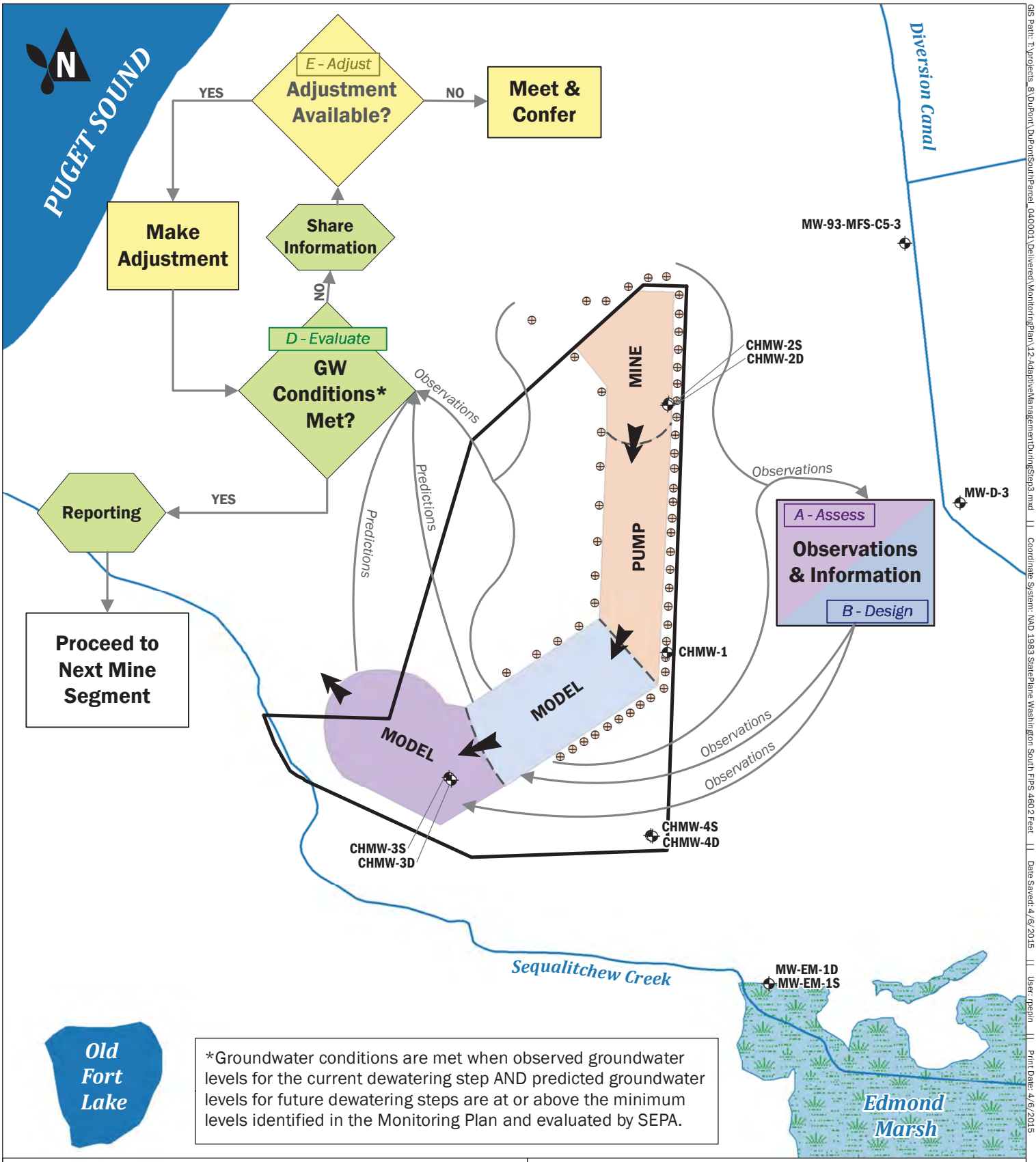


Adaptive Management Process During Step 2 - Preparation for Mining/ Dewatering Test

CalPortland DuPont South Parcel
Monitoring Plan
DuPont, Washington

Aspect CONSULTING	APR-2016	BY: OGR / RAP	FIGURE NO. 10
	PROJECT NO. 040001-014	REVISED BY: ---	

GIS Path: T:\projects_8\DuPont\DuPontSouthParcel_040001\Delivered\MonitoringPlan\11-AdaptiveManagementDuringStep2.mxd || Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet || Date Saved: 4/6/2015 || User: rpepin ||

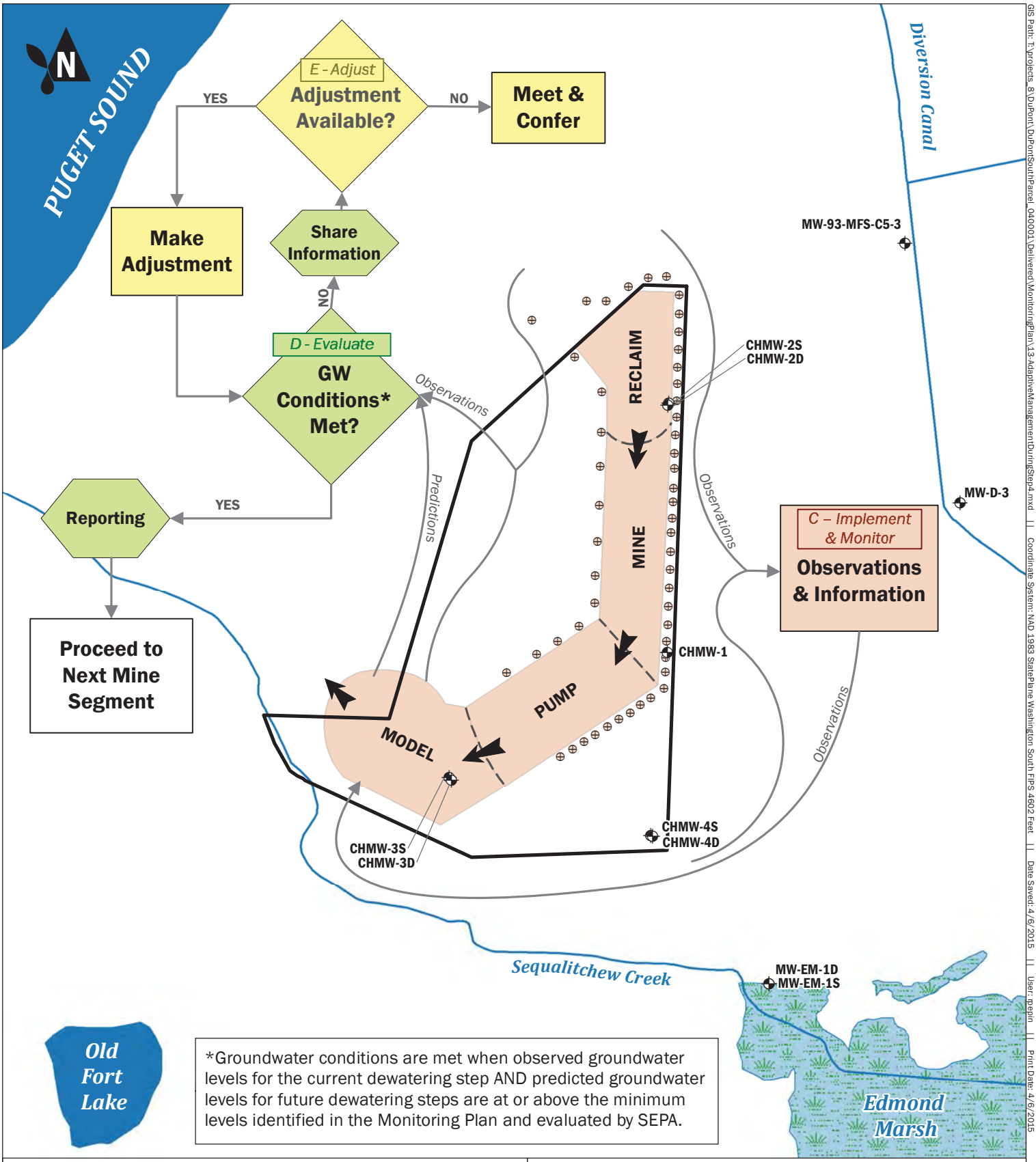


Adaptive Management Process During Step 3 - Active Dewatering and Mining

CalPortland DuPont South Parcel
Monitoring Plan
DuPont, Washington

Aspect CONSULTING	APR-2016	BY: OGR / RAP	FIGURE NO. 11
	PROJECT NO. 040001-014	REVISED BY: ---	

GIS Path: T:\projects_8\DuPont\DuPontSouthParcel_040001\Delivered\MonitoringPlan\12-AdaptiveManagementDuringStep3.mxd || Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet || Date Saved: 4/6/2015 || User: rpeplin || Print Date: 4/6/2015



*Groundwater conditions are met when observed groundwater levels for the current dewatering step AND predicted groundwater levels for future dewatering steps are at or above the minimum levels identified in the Monitoring Plan and evaluated by SEPA.

Monitoring Well
Dewatering Well
Wetland
Lake

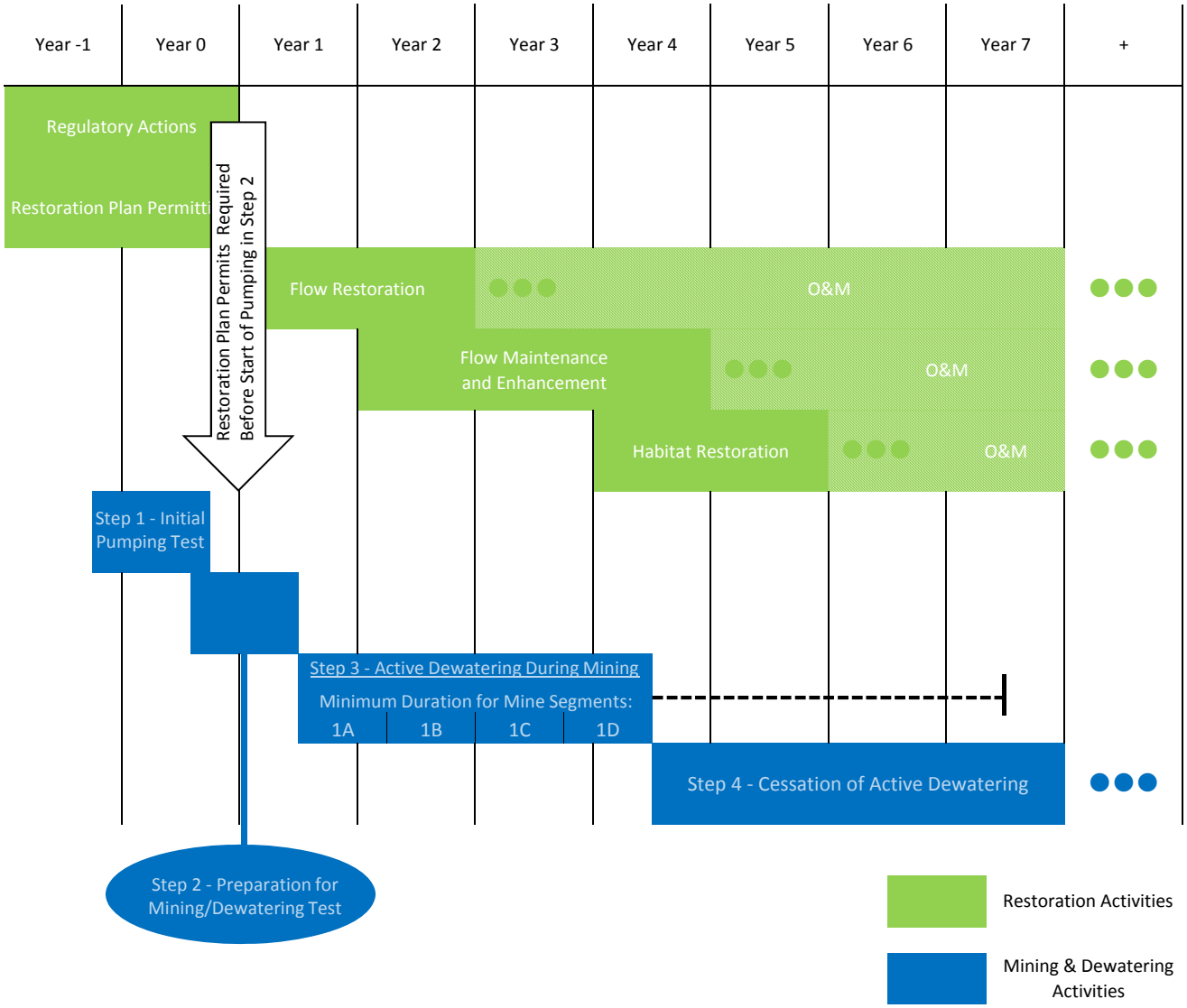
0 1,000 2,000
Feet

Adaptive Management Process During Step 4 - Cessation of Active Dewatering

CalPortland DuPont South Parcel
Monitoring Plan
DuPont, Washington

Aspect CONSULTING	APR-2016	BY: OGR / RAP	FIGURE NO. 12
	PROJECT NO. 040001-014	REVISED BY: ---	

GIS Path: T:\projects_8\DuPont\DuPontSouthParcel_040001\Delivered\MonitoringPlan\13-AdaptiveManagementDuringStep4.mxd || Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet || Date Saved: 4/6/2015 || User: rpeplin || Print Date: 4/6/2015

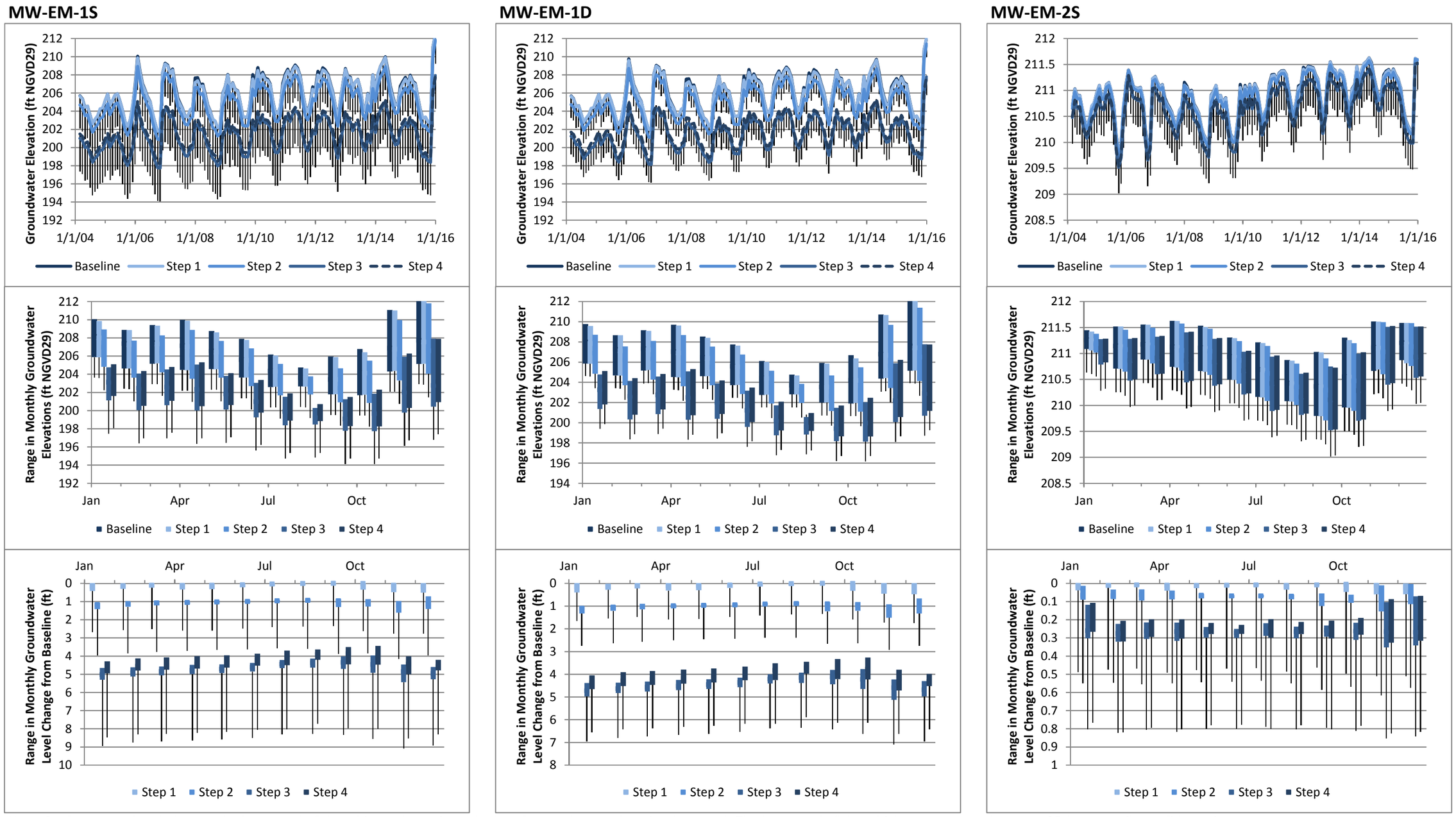


Notes:
1) Year 1 begins with the start of pumping in Step 2.
2) Mining timeline shown is based on the minimum duration of each mine segment in Step 3.
3) This figure depicts the duration of many individual actions. With few exceptions, the actual durations may be shorter or longer

Figure 13
Anticipated Timeline of Mining and Restoration Activities

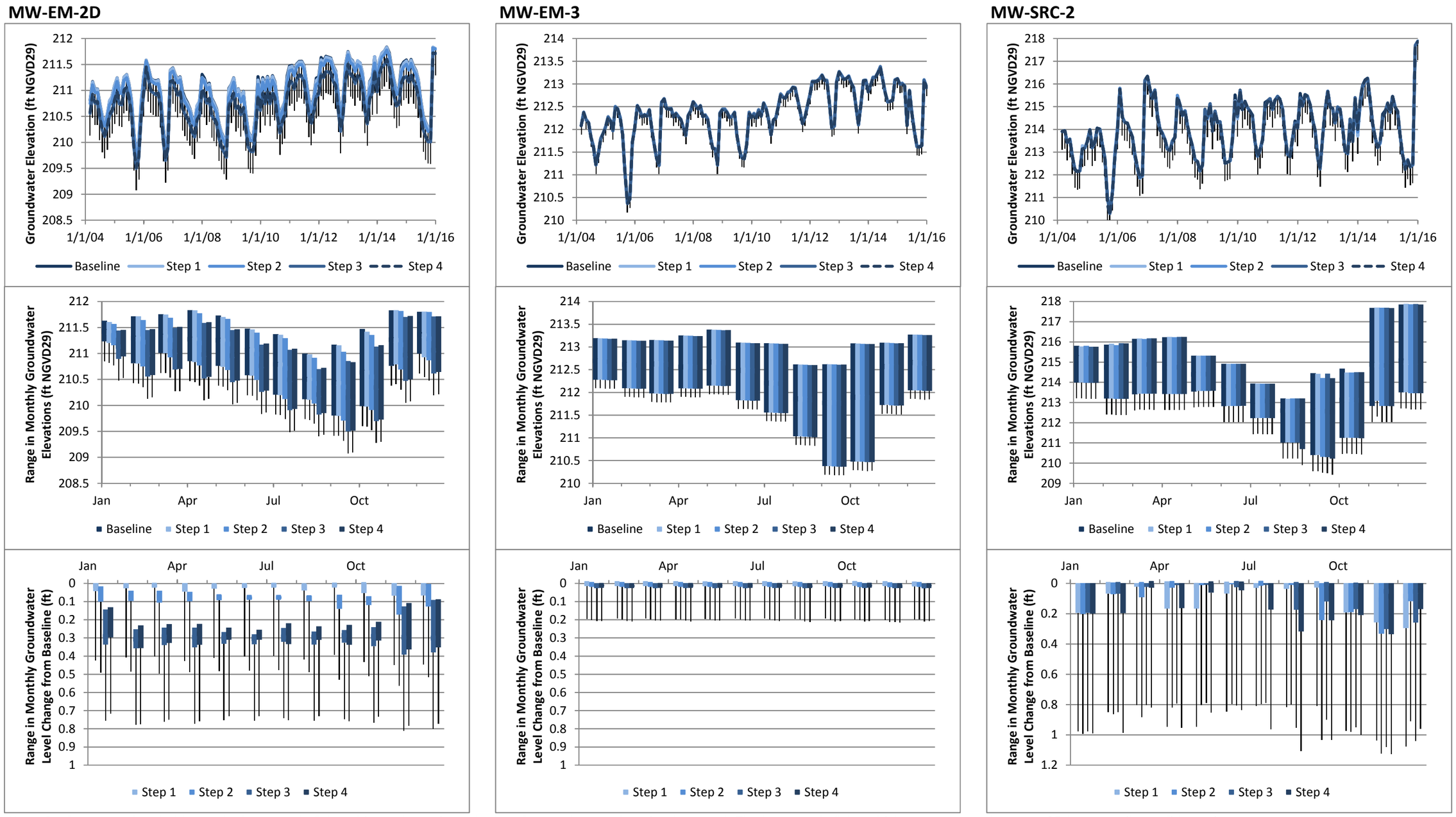
APPENDIX A

Performance Thresholds: Predicted Changes and Ranges in Groundwater Levels



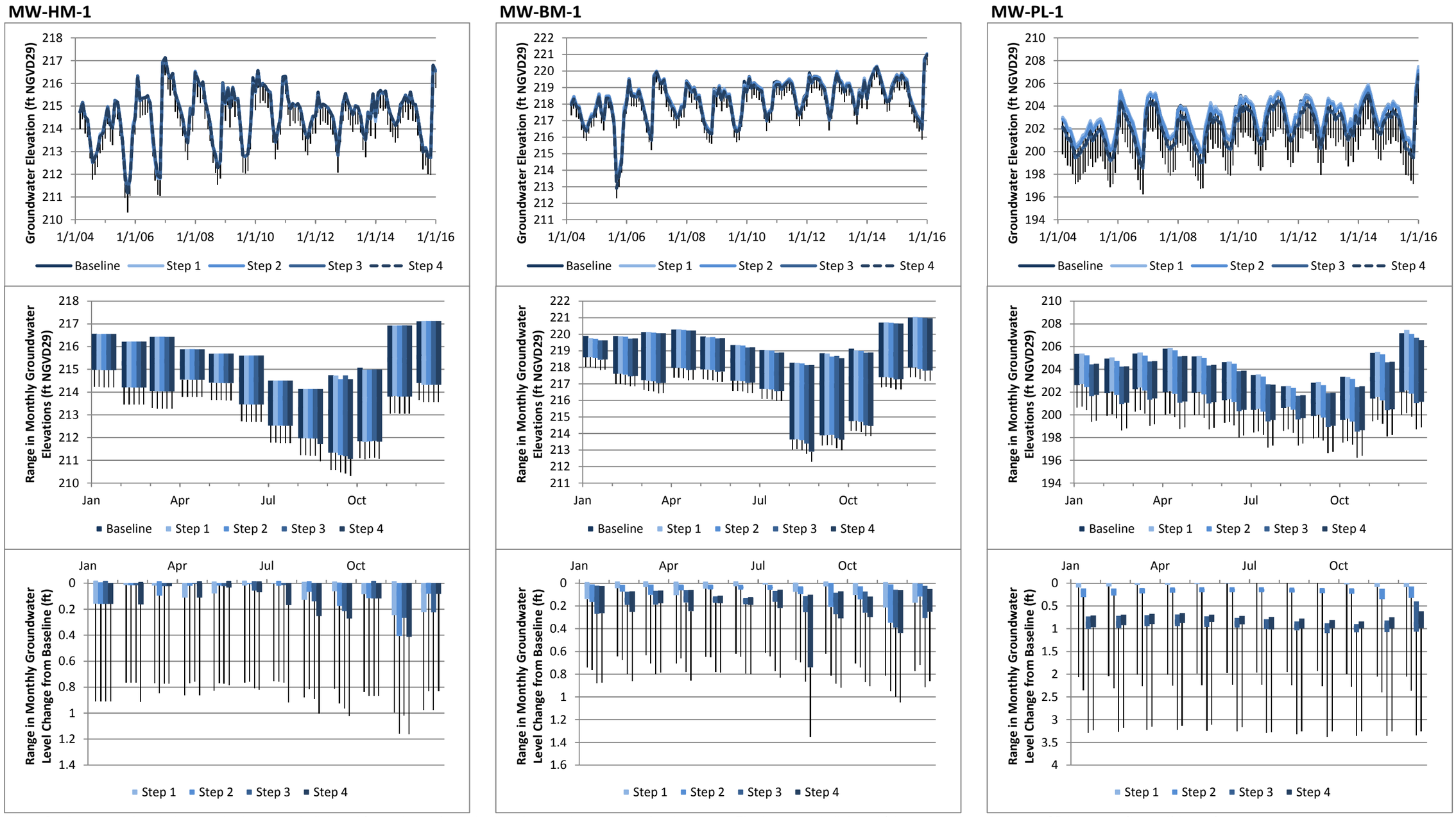
Note: Performance thresholds are the lower end of the whisker shown in each plot of groundwater elevation (top row). The lower end of the whisker represents the lower 95th-percentile confidence interval.

Figure A-1
Predicted Changes and Ranges in Groundwater Levels
Monitoring Plan



Note: Performance thresholds are the lower end of the whisker shown in each plot of groundwater elevation (top row). The lower end of the whisker represents the lower 95th-percentile confidence interval.

Figure A-1
Predicted Changes and Ranges in Groundwater Levels
Monitoring Plan



Note: Performance thresholds are the lower end of the whisker shown in each plot of groundwater elevation (top row). The lower end of the whisker represents the lower 95th-percentile confidence interval.

Figure A-1
Predicted Changes and Ranges in Groundwater Levels
Monitoring Plan

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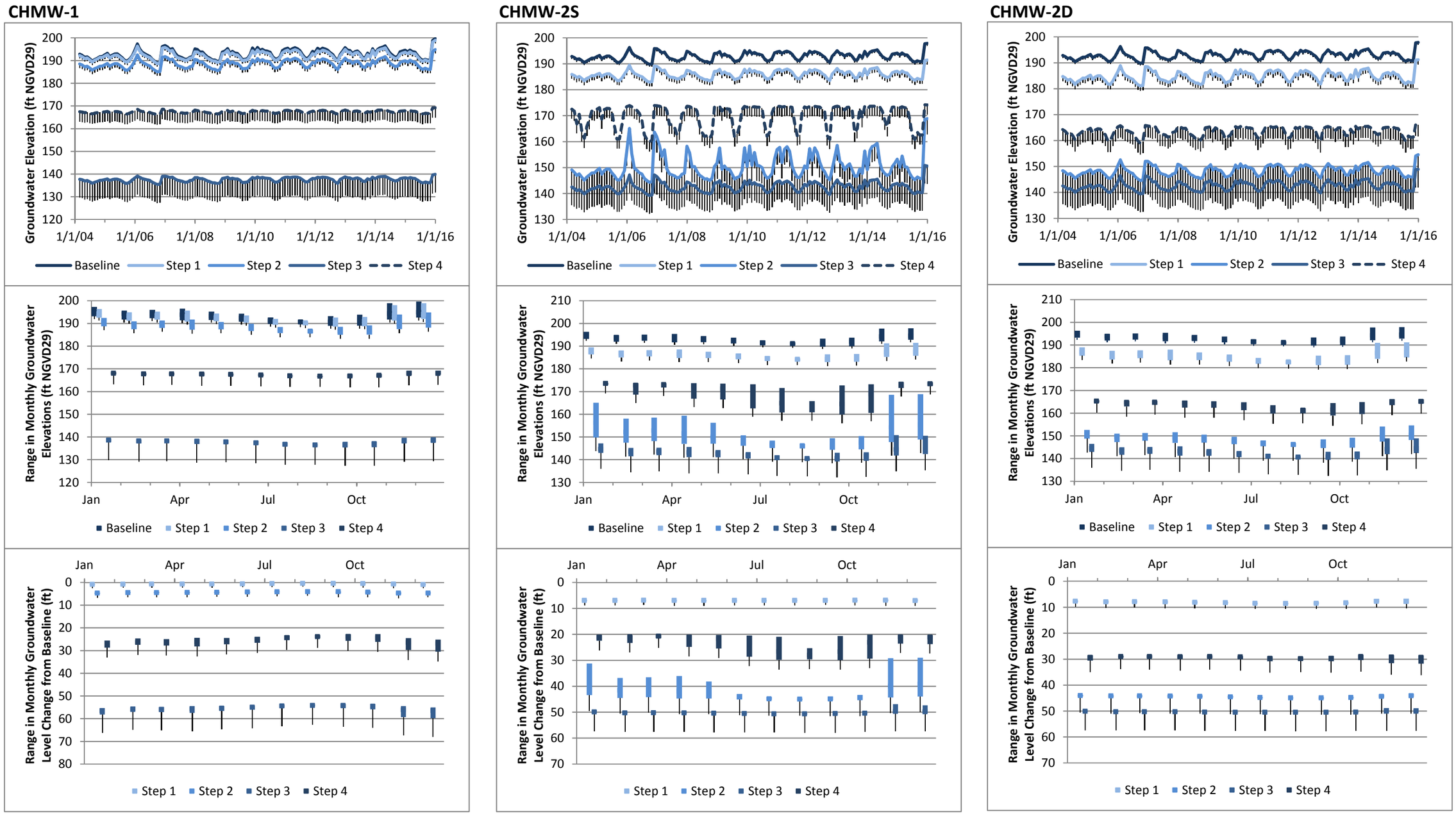
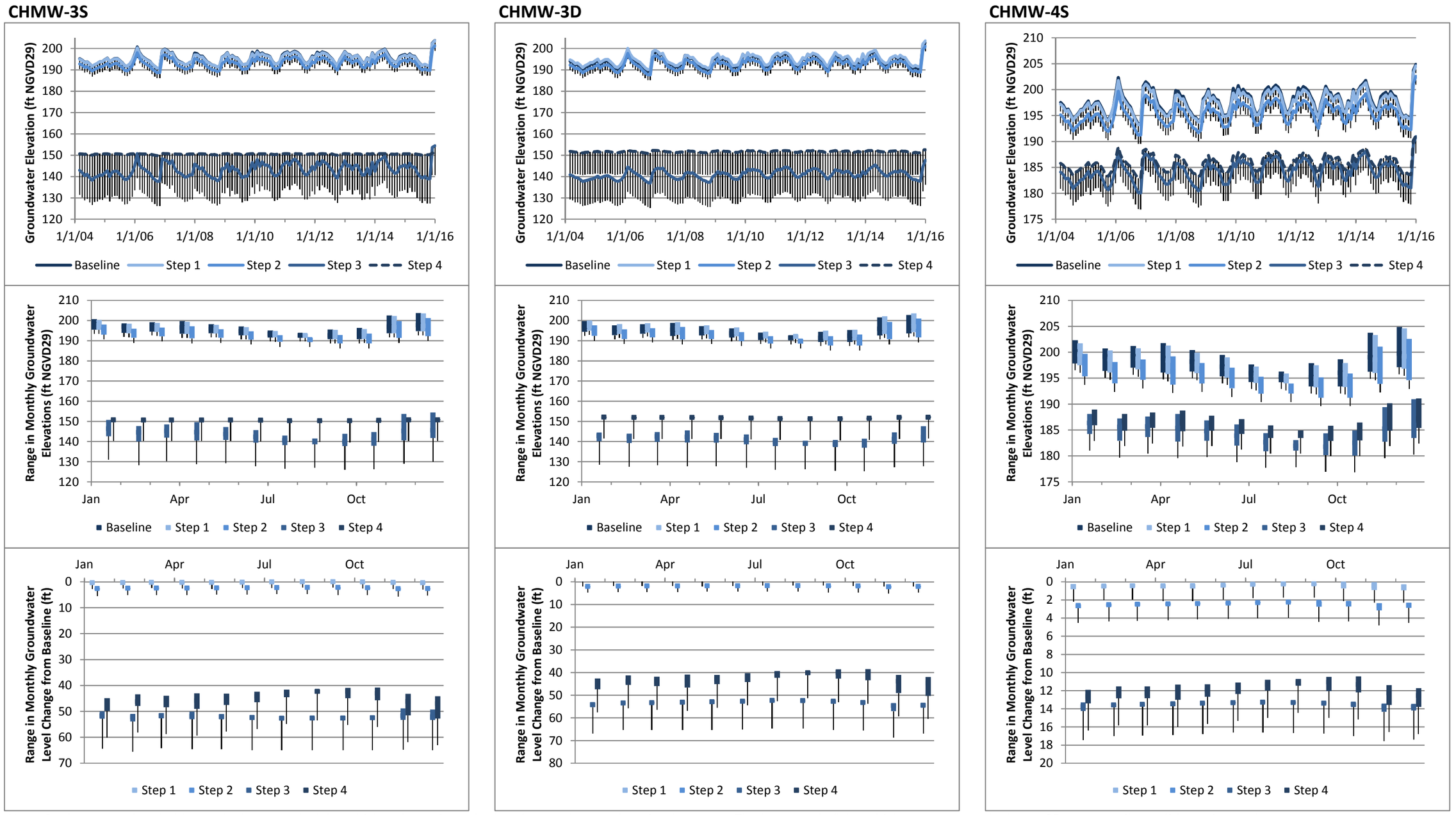
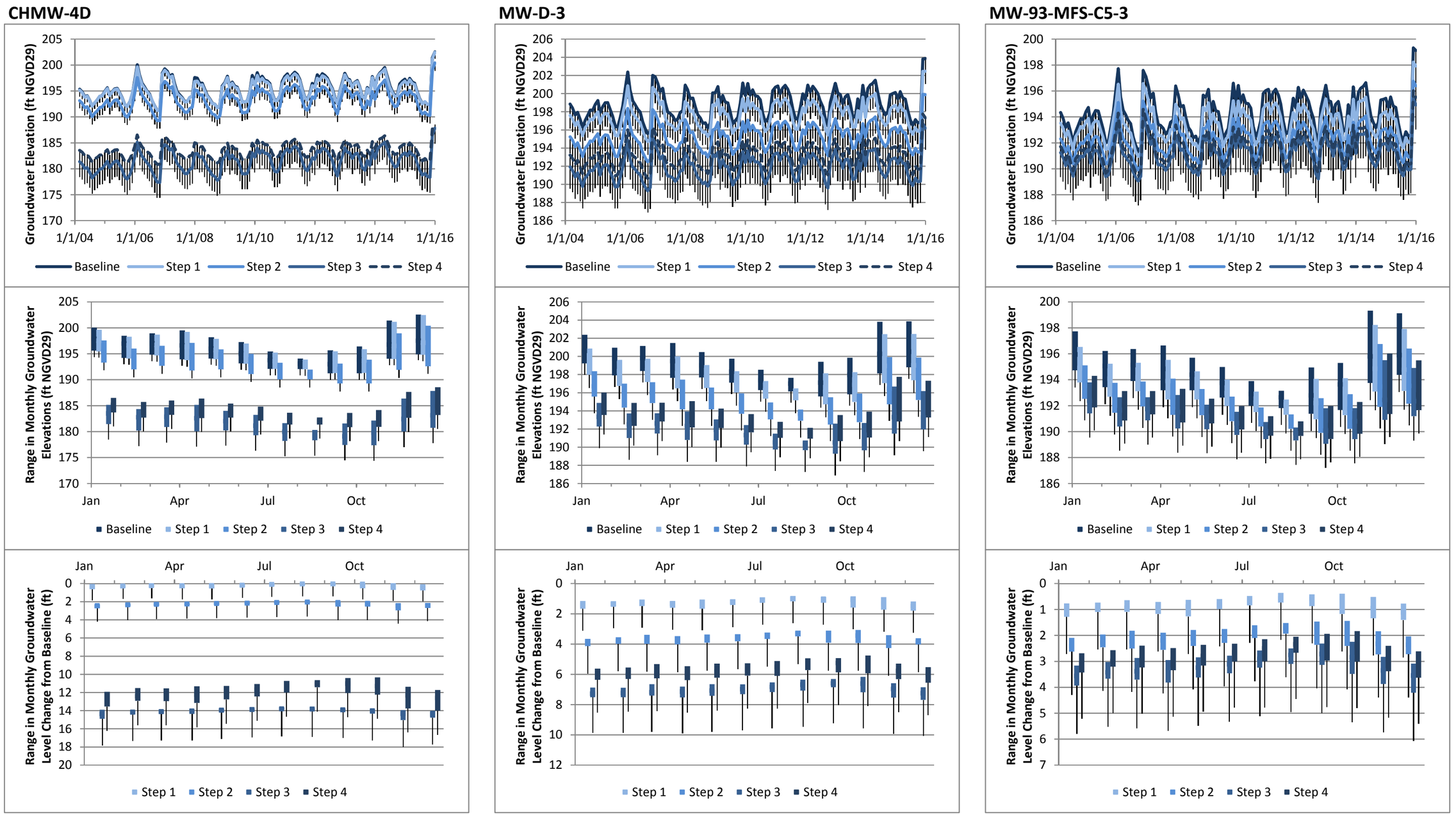


Note: Performance thresholds are the lower end of the whisker shown in each plot of groundwater elevation (top row). The lower end of the whisker represents the lower 95th-percentile confidence interval.



Note: Performance thresholds are the lower end of the whisker shown in each plot of groundwater elevation (top row). The lower end of the whisker represents the lower 95th-percentile confidence interval.

Figure A-1
Predicted Changes and Ranges in Groundwater Levels
Monitoring Plan



Note: Performance thresholds are the lower end of the whisker shown in each plot of groundwater elevation (top row). The lower end of the whisker represents the lower 95th-percentile confidence interval.

Figure A-1
Predicted Changes and Ranges in Groundwater Levels
Monitoring Plan

APPENDIX B

Sampling and Analysis Plan

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Sampling and Analysis Plan

A.1. Introduction

This document presents the Sampling and Analysis Plan (SAP) to collect the information necessary to support the adaptive management processes of the South Parcel Monitoring Plan and the Restoration Plan for the Sequalitchew Creek Watershed. This SAP is intended to direct collection, processing, and reporting of data by a single, reliable, and consistent source that will be used to inform both adaptive management plans.

A.2. Background

A.2.1. Baseline Monitoring Program

A baseline monitoring program of surface water and groundwater within the Sequalitchew Creek basin is currently conducted by CalPortland as a component of mine planning. The monitoring program generally consists of measuring water levels and flows on a monthly basis at multiple locations in Sequalitchew Creek and its related marshes. The hydrologic monitoring program has four basic elements:

- Groundwater elevation monitoring;
- Surface water elevation monitoring;
- Surface water streamflow monitoring; and
- Surface water quality monitoring (e.g., temperature, dissolved oxygen, and turbidity).

The monitoring program is summarized in Table 1, and monitoring locations are shown on Figure 1.

The baseline monitoring program began in 1999, then expanded significantly in 2003. Monitoring data has previously been presented in four reports (Aspect, 2004a, 2004b; Aspect and Anchor, 2007; and Appendix B of Anchor QEA and Aspect, 2010). The 2004 reports describe the surface water and groundwater systems of the Sequalitchew Creek basin and summarize the monitoring data collected through 2004. The 2007 report presents monitoring data collected in 2005 and 2006. The 2010 report provides summary hydrographs of streamflow and marsh levels, illustrating the data available at that time.

A.2.1.1. Groundwater Level Monitoring

In the baseline monitoring program, groundwater levels are monitored monthly at a network of 20 wells located throughout the watershed, including within the mine area, marshes, and upland areas:

- North Parcel mine area: OB-1
- South Parcel mine area: CHMW-1, CHMW-2S and -2D, CHMW-3S and -3D, and CHMW-4S and -4D
- Marshes and Lakes:
    - Edmond Marsh: MW-EM-1S and -1D, MW-EM-2S and -2D, and EM-3
    - Hamer and McKay Marshes: MW-HM-1
    - Sequalitchew Lake: MW-SL-1
    - Pond Lake: MW-PL-1
- Upland areas: D-3 (near Landfill #5) and SRC-MW-2 (east of Hamer Marsh)

Water levels are measured manually by measuring the depth to water from the top of the well casing. The top-of-casing elevation of each well has been surveyed relative to the National Geodetic Vertical Datum of 1929 (NGVD 29) to allow for calculation of groundwater elevations. Well logs for the existing monitoring wells are provided in Attachment A.

A.2.2. Surface Water Monitoring

A.2.2.1. Water Levels

The baseline monitoring program includes monthly measurement of surface water elevations at 15 locations in the Sequalitchew Creek watershed (Figure 1).

In many locations, staff gages are located close to monitoring wells to allow for coupled observations of surface water and groundwater levels. The following staff gages are included in the baseline monitoring program:

- Bell Marsh: SG-BM-1
- McKay Marsh: SG-MKM-1
- Hamer Marsh: SG-HM-1
- Sequalitchew Creek Marsh: SG-SCM-1 and SG-EM-3E
- East Edmond Marsh: SG-EM-3W and SG-EM-2E
- West Edmond Marsh: SG-EM-1/1A and SG-EM-2W
- Wetland 1D: SG-WL1D-1
- Pond Lake: SG-PL-1

- Diversion Canal: SG-DC-1, SG-DC-2, and SG-DC-3

The typical staff gage installed on this project is an enamel plate capable of measuring water levels in 0.01-foot increments over a 3.33-foot range. The staff gages at the west end of West Edmond Marsh (SG-EM-1/1A) are paired, with SG-EM-1 located near well MW- EM-1 and used to measure higher water levels in winter and SG-EM-1A located in a low spot behind the beaver dam at the outlet and used for measuring lower water levels in summer.

In addition, surface water levels are measured as a component of the three continuous flow monitoring stations described in Section A.2.2.3.

A.2.2.2. Water Quality

Beginning in 2009, surface water quality has been monitored monthly at three locations: the Diversion Weir, the outlet of Hamer Marsh, and the mid-ravine gage on Sequalitchew Creek. Monthly monitoring consists of field measurements of temperature, dissolved oxygen, specific conductance, oxidation reduction potential, and turbidity with a YSI Pro Plus and a Hach Turbidimeter. Several samples have been collected for laboratory analysis for select metals (iron, copper, and zinc) and total petroleum hydrocarbons.

A.2.2.3. Streamflow

The baseline streamflow monitoring program consists of continuous measurements at three stations, periodic measurements at three stations, and visual observations at five locations. The specific locations monitored are:

- Continuous streamflow monitoring at the Diversion Weir, and mid-ravine[1] and lower-ravine stations in Sequalitchew Creek.
- Periodic streamflow measurements at three locations in the Diversion Canal (SG-DC-1, SG-DC-2, SG-DC-3); and
- Visual estimates of flow at five locations:
    - Culvert from Hamer Marsh to Edmond Marsh,
    - Culvert from Sequalitchew Creek Marsh to Diversion Canal
    - Ditch at Plant Road flowing to Hamer Marsh,
    - Sequalitchew Creek at footbridge downstream of W. Edmond Marsh, and
    - Sequalitchew Creek under Center Drive.

Measurements of streamflow are made using the conventional current-meter method as described by the U.S. Geological Survey (USGS, 1982). Stream velocities are measured and discharges are calculated using a SonTek Flowtracker.

Discharge measurements are initially made at various stream stages to determine a relationship between stage and discharge. Discharge measurements are then made at

[1] The mid-ravine station was formerly known as the Upper gage or SC-Upper.

periodic intervals to verify the stage-discharge relationship or to define any change in the relationship caused by changes in channel geometry and/or channel roughness.

Rating curves, which relate water depth to flow in the channel, have been developed for each flow monitoring location based on a number of manual flow measurements collected over a range of different flows. These rating curves are used to convert observed water depths (stage) to flows.

Stream stage at each station is measured using a 4230 Bubble Flow Meter manufactured by Teledyne ISCO and powered by a 12-volt deep-cycle lead-acid battery. The meter uses an internal air compressor to force a metered amount of air through a bubble line submerged in the flow channel. The water level above the bubble line orifice is determined by measuring the pressure needed to force air bubbles out of the line. An internal data logger records the water level as bubbler pressure at 15-minute intervals. The water level is converted to a stage height by correlating the meter readings to manual measurements taken during monthly site visits from a staff gage that is installed at each station. The equipment for the stations is serviced once a month by replacing the batteries and downloading the data to a portable computer.

Flow over the Diversion Weir is monitored by continuously monitoring stage using an ISCO 4230 and calculating discharge with a standard weir equation for a fully contracted rectangular weir from the United States Bureau of Reclamation's (USBR) Water Measurement Manual (USBR, 2001). The weir equation is presented in Section A.5.4.1.

A.2.2.4. Habitat Monitoring

Wetland Habitat

Wetland monitoring conducted to date has been focused on documenting baseline (pre-project) conditions of three key variables in habitats: topography, hydrology, and vegetation. Major changes to the boundary of Edmond Marsh have been analyzed from high-resolution aerial photos, and compared to field-collected data. Twelve vegetation monitoring transects are located throughout the Sequalitchew Creek basin: in Edmond Marsh, Sequalitchew Creek Ravine, Wetland 1D, Pond Lake, and Brackish Marsh. Overall, patterns in species presence detected during the monitoring in the period from 2004–2015 have been documented by Anchor QEA (2016).

Stream Habitat

Anchor Environmental (Anchor; now Anchor QEA) has previously evaluated stream habitat in Sequalitchew Creek using toe-width and stage-discharge analysis methods as a component of the Fish Habitat Benefit Evaluation for Sequalitchew Creek (Anchor, 2004). Additional information on the methodology and background can be found in that document.

The **Toe-Width Method** applies information on active channel width to estimate the optimal flows (maximum habitat) for salmon spawning and rearing. Within Reach 2 and 3, transects were established in areas with fairly uniform depth over a gravel/cobble substrate (5 transects and 4 transects, respectively). Since Reach 1 was located in the estuary, no toe-width transects were established. Additional transects were established to represent riffle habitat in all three reaches.

The **Stage-Discharge Analysis** provides a more detailed evaluation of how habitat availability changes with incremental increases in flow by linking data on the physical relationship between water surface elevation (stage), velocity, and discharge with the biological habitat preferences of spawning and rearing salmon. Stage-discharge relationships in lower Sequalitchew Creek were developed at numerous transects that were selected to be representative of habitat conditions in the study area.

A.3. Roles and Responsibilities

The roles and responsibilities of all key members of the monitoring team are shown in Table 2 below. The monitoring team may be comprised of one or more qualified consulting firms, governmental agencies (e.g., USGS or Ecology), or nongovernmental organizations.

Table 2. Monitoring Team Roles and Responsibilities

Position	Roles and Responsibilities
Project Manager—Monitoring Team	Responsible for oversight of monitoring personnel, coordinating project tasks defined in the Consultant scope of work, tracking project progress and schedule relative to budget, and manage staff to complete project activities.
Principal-in-Charge—Monitoring Team	Responsible for oversight to project team to ensure that QC procedures are followed and project data quality objectives (DQOs) are being met. Oversight of development of project SAP, field audits, and project reports.
Data QC/Reporting Lead—Monitoring Team	Responsible for developing SAP, standard operating procedures (SOPs), and data QA/QC procedures for project. Responsible for managing project database, completing data QC on all project data, and reporting for individual events and the overall project.
Technology Lead—Hydrology/Water Quality	Responsible for the design of each monitoring station. Provide oversight for installation of each station's monitoring system. Provide oversight for monitoring station maintenance and lead equipment troubleshooting activities.
Data Collection Lead—Hydrology/Water Quality	Manages and oversees monitoring and maintenance activities that are completed in the field for hydrology and water quality data collection.
Data Collection Lead—Habitat	Manages and oversees habitat monitoring activities.

A.4. Monitoring Approach

The monitoring conducted under this SAP will collect data necessary to assess whether activities associated with the South Parcel expansion and restoration of Sequalitchew Creek are achieving the objectives of the South Parcel Monitoring Plan and the Restoration Plan for the Sequalitchew Creek Watershed. The monitoring approach is targeted at the specific performance and aspirational thresholds identified in those plans.

The monitoring program includes six components that will be implemented at key locations within the watershed: groundwater level, surface water level, stream flow, surface water quality, habitat, and precipitation monitoring. Each of these components are described below. A cross walk between specific SAP elements and the objectives of the Monitoring Plan and Restoration Plan is provided in Table 3.

In addition to the main monitoring activities, stand-alone special studies will be implemented to address specific concerns of the mine expansion and watershed restoration. These special studies will be developed further as mining and restoration planning progresses, but are described generally in Section A.8.

A.4.1. Groundwater levels

Groundwater levels will be monitored primarily for comparison with the performance thresholds of the South Parcel Monitoring Plan.

Groundwater level monitoring will use the existing network of monitoring wells (described in Section A.2.1 and shown in Figure 1) and new dewatering wells and monitoring wells that will be installed specifically for this project. Water level monitoring will include a combination of spot measurements in active dewatering wells and adjacent temporary monitoring wells, continuous monitoring at key monitoring wells adjacent to the active dewatering area and beneath West Edmond Marsh, and routine monthly or semimonthly monitoring at other wells in the network.

As described in the Monitoring Plan, active dewatering of the South Parcel will occur in three sequential steps, involving progressively more dewatering wells, from 10 wells during Step 1, up to 66 wells during Step 3. Water levels will be measured periodically in the active dewatering wells, in new observation wells located adjacent to the active dewatering wells, and in several long-term monitoring wells installed in the interior of the South Parcel. Water level monitoring at these wells will be used to assess performance of the dewatering operation and, once mining operations commence in the South Parcel, will indicate if the moisture content of the mined aggregate is at appropriately low levels for safe, efficient mining and processing.

Outside of the South Parcel, groundwater level monitoring will consist of a combination of continuous monitoring and monthly or semimonthly manual measurements. During all Dewatering Steps, water levels will be monitored continuously in key wells located along the eastern boundary of the South parcel and in the western portion of Edmond Marsh. Specifically, the following key wells will be monitored continuously: CHMW-1, CHMW-2S and -2D, CHMW-3S and -3D, CHMW-4S and -4D. MW-EM-1S and -1D and MW-EM-2S and -2D. Water levels at all other groundwater monitoring wells will be measured monthly, except during Dewatering Step 2, when twice monthly measurements will occur, and Dewatering Step 3 when twice monthly measurements will occur for 3 months once new dewatering wells start pumping.

Monitoring wells are generally one- or two-inch-diameter PVC casings protected with a locking steel surface monument. Well depths vary from 5 feet for shallow piezometers to 85 feet for wells penetrating the Vashon Outwash gravels. Monitoring well logs are provided in Attachment A.

Continuous groundwater level monitoring will be conducted using a submersible pressure transducer connected to an aboveground data logger housed in a weather-resistant enclosure. Instruments will measure and record water level at 15-minute intervals. Data loggers will be downloaded by field staff at least weekly during Dewatering Steps 1 through 3 and once each month during Step 4.

A.4.2. Surface water levels

Surface water level monitoring data will primarily be used to compare the effects of restoration efforts with the performance and aspirational thresholds specified in the Restoration Plan. Surface water monitoring will occur at 12 stations as shown on Figure 1 and listed in Table 3 (station IDs have a "SG" prefix).

Continuous surface water monitoring will occur at SG-EM-1/1A and SG-EM-2E. Continuous water level data will be useful for assessing the water level response to precipitation. Water level will be measured manually once per month at the other stations; except during Dewatering Step 2, when twice-monthly measurements will occur. More frequent spot measurements will be made during specific restoration activities, such as the installation and adjustment of flexible levelers at beaver dams. New staff gage locations may be installed and added to the monitoring program as necessary to support adaptive management of the flexible levelers.

Surface water level monitoring at the seven locations in Sequalitchew Marsh, East Edmond Marsh, and West Edmond Marsh will provide feedback for efforts to increase westward flows in Sequalitchew Creek. Surface water level monitoring at SG-HM-1 in Hamer Marsh, in concert with groundwater level measurements at MW-HM-1 and MW-EM-3, will assess the increase in subsurface flow from Hamer Marsh to East Edmond Marsh following installation of the weir at Hamer Marsh outlet.

All surface water level monitoring stations are currently equipped with staff gages; either Stevens Style A or C porcelain-enameled iron plate. Style A gages are 3.33 feet long and 4 inches wide with graduated marks every 0.02 feet. Style C gages are also 3.33 feet long and are 2.5 inches wide with graduated marks every 0.01 foot. Water levels are measured to the nearest 0.01 foot. Water level is converted to surface water elevation by subtracting the staff gage height from the surveyed top-of-staff gage elevation and then adding the measured staff gage water level. At SG-EM-1 and SG-EM-2W, continuous water level monitoring will be conducted using a pressure transducer housed in a PVC stilling well that is mounted adjacent to the staff gage. The pressure transducer will be connected to the data logger used for continuous groundwater monitoring at the adjacent groundwater monitoring wells (MW-EM-1D for SG-EM-1/1A and MW-EM-2D for SG-EM-2W).

A.4.3. Streamflow

Streamflow monitoring will include:

- Continuous streamflow monitoring at five locations: the three existing streamflow monitoring stations (i.e., the Diversion Weir, and mid-ravine and lower stations in Sequalitchew Creek) and two new gaging stations on Sequalitchew Creek at the Lake Outlet and at Center Drive.

- Visual observations at the culvert from Hamer Marsh to Edmond Marsh.

At each continuous gaging station, water level will be measured and recorded every 15 minutes using a pressure transducer housed in a PVC stilling well and connected to a data logger that is housed in a weatherproof enclosure. Each continuous stream flow gaging station will include a Stevens Style A or C porcelain-enameled iron-plate staff gage, as described previous for the water level monitoring sites. Water level measured by the pressure transducer will be calibrated to the staff gage at the site. Field staff will service and download the data loggers at least monthly.

At the Diversion Weir, flow will be calculated using a standard discharge equation for a fully contracted rectangular weir as described above in Section A.5.4.1. At the other four gaging stations, stage-discharge or rating curves will need to be developed and maintained to calculate flow. Rating curves will be developed and maintained consistent with industry standard practices, as is currently done.

Flow through the culvert from Hamer Marsh to Edmond Marsh will be visually estimated monthly. Additional locations for visual flow estimates may be added at any time to respond to conditions observed in the field or adaptive management needs.

Following installation of the weir at the outlet of Hamer Marsh, outflow from Hamer Marsh to the Diversion Canal will be determined using the appropriate weir equation, based on water level observations at SG-HM-1, whose staff gage elevation relative the top of the weir will be established.

Continuous flow data from the Diversion Weir will be used to assess achievement of the Restoration Plan performance threshold to reduce flow to the Diversion Canal.

Continuous flow data from the Sequalitchew Lake Outlet and Center Drive gages will be used to assess achievement of the performance standard to match flows at those two locations.

Flow data at Center Drive, Upper Sequalitchew Creek, and Lower Sequalitchew Creek gages will be used to assess achievement of the performance standard to eliminate flow losses in the ravine.

Spot flow measurements at the Hamer Marsh Weir, at the culvert between Hamer Marsh and East Edmond Marsh, and in the ditch under Plant Road to Hamer Marsh, in concert with surface and shallow groundwater monitoring in and around Hamer Marsh, will be used to assess efforts to increase surface and groundwater flow from Hamer Marsh into East Edmond Marsh.

Going forward, the sampling program will no longer collect spot flow measurements in the Diversion Canal, since those data are not relevant to the objectives of the South Parcel Monitoring Plan or the Restoration Plan.

A.4.4. Surface Water Quality

The evaluation of habitat suitability will include monitoring water quality conditions in the watershed restoration area. In particular, stream temperature is predicted to increase in summer as a result of the restoration and mining projects for two reasons: 1) water

temperatures in Sequalitchew Lake are warmer than the groundwater discharge that currently provides the flow in Sequalitchew Creek during summer, and 2) dewatering for mining will reduce the groundwater discharge. Prior monitoring indicates that Sequalitchew Lake temperatures can reach up to 21°C in summer, whereas Sequalitchew Creek is currently 12 to 13°C. This condition is largely natural resulting from solar radiation on the lake surface. However, it also represents the primary tradeoff of restoration—greatly increased flow and reconnection to the natural water source in exchange for higher temperatures in summer.

The water quality monitoring program has been designed to monitor for unintended consequences, primarily focused on temperature, resulting from the restoration and mining projects. Stream temperatures will be monitored continuously at the five locations in the Sequalitchew Creek watershed where flow is measured (Sequalitchew Lake Outlet, Diversion Weir, Center Drive, and mid-ravine and lower ravine Sequalitchew Creek stations), as well as at the continuous water level monitoring stations in East Edmond Marsh (SG-EM-1 and SG-EM-2). The pressure transducers used to monitor water levels will be equipped with temperature sensors and will record water temperature every 15 minutes. The monitoring data will allow for developing temperature profiles along Sequalitchew Creek from headwaters to near the mouth.

These monitoring data will inform the adaptive management components of the Restoration Plan. The Restoration Plan includes several restoration elements that either include specific components that would reduce temperatures, or include flexible elements that could be implemented adaptively in response to monitoring data that indicate unanticipated effects on stream temperature. Specifically, the following elements of the Restoration Plan have components related to temperature, beyond those aimed at increasing flow through the system:

> G – Losing Reach—restoration of riparian vegetation in the losing reach will benefit stream temperature through shading.
>
> J – Ravine Habitat—this element is intended to adapt to habitat conditions that emerge once flow is restored in the ravine. Envisioned as being used to enhance stream structure through large woody debris placement, it could also be used to address temperature issues by creating pools as refugia or shading through riparian plantings.

In addition to temperature, water quality monitoring will include periodic *in-situ* monitoring of temperature, dissolved oxygen, and turbidity at select surface water level monitoring locations.

Periodic *in-situ* water quality measurements of temperature, dissolved oxygen, and turbidity will be collected using portable water quality meters. Measurements will occur monthly, except during Dewatering Step 2, when measurements will be taken twice each month. These water quality data, used in conjunction with measurements of physical habitat characteristics, will inform the assessment of habitat conditions relative to performance thresholds in the Restoration Plan.

A special study of Hamer Marsh water quality will be developed and implemented separately as described in Section A.8.

A.4.5. Habitat

A.4.5.1. Wetland Habitat

The most important effect of the combined mining and restoration projects would be the restoration of a surface water and wetland community connection between the ravine and Edmond Marsh. Data collection discussed in this section is focused on detecting changes to vegetation and habitat structure. This will be used in conjunction with the collection of hydrology data (see section A.5.2) and topography to understand the effects of the project. Hydrology (water surface elevation) data will be used to further understand habitat changes:

- Changes in water surface elevations, particularly in East Edmond Marsh;
- Changes in the magnitude of seasonal fluctuation in water surface elevations;
- Changes in the location and amount of open-water habitat, specifically any loss of open-water habitat in East Edmond Marsh, or greater persistence (later in the growing season) of open water habitats in West Edmond Marsh; and
- The establishment of a surface water and wetland community connection between the ravine and Edmond Marsh.

The baseline wetland habitat monitoring approach (see Section A.2.2.4) will continue to be used to identify patterns in plant species presence, hydrology, and topography under changing conditions along these established transects for comparison and analysis with post-project conditions. New transects will be established between Edmond Marsh and Lower Sequalitchew Creek. Baseline data was not collected in this reach due to the lack of flow and wetland or riparian vegetation during the baseline period.

A.4.5.2. Stream Habitat

Stream habitat will be monitored by measuring physical habitat characteristics at consistent locations over time. Habitat monitoring stations will be established as cross sections of Sequalitchew Creek spaced 100 feet apart for 1,500 feet upstream of the BNSF culvert, then 200 feet apart upstream to the east end of Edmond Marsh. This will provide additional resolution in the area likely to be used for spawning by Chum.

At each section, the following physical parameters will be monitored: flow depth, velocity, substrate size and cover. Cross sections will be monitored in years 0, 1, 2, 3, 5, and 10 commencing prior to construction of the first Restoration Plan element.

Observations of fish presence and active erosion will be noted during the cross-section surveys. Surveys of large woody material will be conducted in years 5 and 10.

A.4.6. Precipitation

Precipitation will be continuously monitored with a tipping bucket rain gage to be located on or near the South Parcel (e.g., City Hall, Pioneer Middle School, or Chloe Clark Elementary). An on-site, program-operated rain gage will likely provide a more complete data set that is of known quality and will better represent precipitation occurring within the watershed than would data from the McMillin Reservoir rain gage, which has been used for prior monitoring efforts.

A continuous precipitation record will provide a context for evaluating short-term changes in surface water and shallow groundwater levels, stream flows, and water quality conditions monitored within the watershed in response to storm events. Observed seasonal precipitation patterns will be used in the analysis of seasonal groundwater and surface water levels, stream flows, and water quality conditions.

The rain gage will be installed at the top of a 1.5-inch-diameter steel pole, approximately 10 feet above the ground surface. The rain gage will be wired to a data logger that will record and totalize rainfall on a 15-minute interval. The data logger will be housed in a durable, weatherproof steel enclosure.

The rain gage will be maintained per manufacturer's recommendations (see Section A.5.7 for methods). The rain gage will be capable of measuring only liquid precipitation (i.e., rainfall or melted snow); it will not be a heated rain gage capable of melting snow. Alternate rain data from the McMillin Reservoir rain gage or PRISM estimates of gridded precipitation for the project area will be used should the project rain gage malfunction.

A.5. Monitoring Procedures

This section provides specific procedural guidelines regarding routine field measurement and maintenance activities pursuant to the monitoring objectives detailed in the previous section.

Campbell Scientific (CSI) pressure transducers and data loggers will be employed at groundwater, surface water, streamflow monitoring stations, which continually measure level and water temperature. A project rain gage will be installed at one of the central monitoring stations, and be recorded by the station data logger. Equipment specifications and installation guidelines for continual monitoring stations includes the following:

- Parameter data (e.g., level, temperature, precipitation) will be recorded at a minimum of 15-minute intervals.
- Transducers selected for each station will be designed with a PSI range and cable length that is appropriate for the range of water levels expected in the observation well or surface water environment.
- Transducer sensor diaphragms will be vented to the atmosphere; eliminating corrections regarding barometric pressure compensation.
- Groundwater pressure transducers will be suspended from a fixed reference point in each monitoring well, at a point below the lowest expected water level. Suspending

the transducer prevents corrosion/interference of benthic sediment, or level discrepancies/drift due to settling.

- Surface water pressure transducers will be installed at a fixed point within a PVC stilling well, adjacent to the station staff plate.
- All level and flow rate measurements will be reported in decimal-feet and cubic feet per second (cfs), respectively.

Water levels measurements at stations recording continuous data will be maintained within a 0.02-foot tolerance. If the difference between the level measured during site inspections and the data logger recorded level is greater than ± 0.02 feet, field personnel will calibrate the data logger recorded level during routine site inspections. Differences in level, as well as calibration points, will be recorded on field sheets. Level drift observed from either the pressure transducer, or movement of the suspension cable, will be corrected by linear interpolation within the project dataset.

A.5.1. Routine Station Inspections

Routine site inspections will occur at least monthly while the project is actively collecting water quality, level, and/or flow data. Field staff will complete a field data collection form, or electronic equivalent, when conducting station inspections (see example in Attachment B). During monthly inspections, all equipment will be maintained per manufacturer recommendation, and include the following tasks:

- Download data logger module records;
- Maintain station grounds for clear and safe access;
- Clean and maintain enclosures, sensors, and monitoring equipment;
- Change/charge station batteries; and
- Calibrate/verify the accuracy, precision, and operation of sampling and monitoring equipment.

All observed and recorded field measurements, as detailed below, will be updated within the project database following routine inspection activities.

A.5.2. Groundwater levels

Groundwater levels are measured in monitoring well stations using a 150- or 300-foot electronic water level indicator. Depth to water is measured from a black mark on the top of the well casing and recorded to the nearest 0.01 foot. The depth to water is converted to a groundwater elevation by subtracting the depth to water from the surveyed top of casing elevations. Groundwater level measurements will be conducted and recorded on field sheets, or electronic equivalents, during each routine site inspection.

The well casings are accessed by unlocking and removing the lids on the steel stick-up-style monuments protecting each well. MW-C5-3 is maintained by JBLM. A key to unlock MW-C5-3 is obtained from JBLM during each site visit.

A.5.3. Surface water levels

Surface water levels are visually observed/measured during routine site inspections from staff plate gages; measured to the nearest 0.01 foot. Water levels will be converted to surface water elevation by subtracting the staff gage height from the surveyed top-of-staff gage elevation and then adding the measured staff gage water level.

A.5.4. Streamflow

Streamflow monitoring for this project will be performed by continuously observing the water level in the stream and calculating flow using one of two methods: a standardized weir-discharge equation or a stage-discharge rating curve.

Stream water levels will be visually observed/measured during routine site inspections from staff plate gages. CSI pressure transducers at continuous-record streamflow stations will be calibrated to the correspond station staff-gage level. Spot level measurements and observations at all other stations will be recorded during routine inspections. All level measurements will be used to calculate and update discharge flow volumes from each station.

A.5.4.1. Weir-Discharge Equations

Streamflow at the Diversion Weir is calculated using a standard discharge equation for a fully contracted rectangular weir from the USBR's Water Measurement Manual (USBR, 2001). The equation relates discharge (Q) to the length of the weir (l) and depth (d) of water over the weir as follows:

$$Q = 3.33*(l - 0.2*d)*d^{(3/2)}$$

It is imperative to maintain flow through weirs free from debris and obstructions, to ensure accurate level/flow measurements. Weir discharge equations will be incorporated into the project database, to ensure precision when field personnel transcribe field observations and measurements.

A.5.4.2. Stage-Discharge Rating Curve

Open-channel streamflow monitoring stations require the development of flow rating curves, which relate observed water depths (i.e., stage) to flow volumes. Rating curves will be developed for each flow monitoring location based on manual flow measurements collected over a range of different flows.

Measurements of streamflow (in cubic feet per second [cfs]) will be made using the conventional current-meter method as described by the USGS (1982). Stream velocities will be measured and discharges are calculated using a SonTek Flowtracker, or other similar velocity meter.

In accordance with the USGS current-meter method, observations of width, depth, and velocity will be made at approximately 10 to 15 intervals in a cross section by wading the stream. The average velocity of each subsection will be taken at 0.6 of the depth below the water surface. That velocity represents the average velocity for that stream subsection, whose cross-section area will be calculated from the corresponding width and

depth measurements. A streamflow measurement is the sum of the flow in each subsection.

The recorded discharge measurements are plotted against corresponding stage heights. The stage-discharge rating (i.e., regression equation) is determined by plotting a best-fit line through a series of stage-discharge points.

Rating curves will be developed at streamflow monitoring stations during a minimum of three (3) different flow event regimes, including flows covering the low-, mid-, and high ranges of the depths expected in each channel. To measure flows at these ranges, field personnel will collect flow measurements during various intensity storm events, as well as baseflow conditions. For existing stations, the rating curves developed during baseline monitoring will be used initially.

Rating curves are evaluated by comparing sets of flow event measurements to determine if the average rating curve for each event graphs similarly on a stage-discharge plot. A change in curve shape or shift in location indicates a change in channel geomorphology and a new rating curve is developed and updated, as necessary. Manual streamflow measurements are made at periodic intervals to verify the rating curve and evaluate if there has been any change in the stage-discharge relationship caused by changes in channel geometry and/or channel roughness. Rating curves were previously developed and reported for the mid-ravine and lower Sequalitchew Creek stations (Aspect and Anchor, 2007), and have continued to evolve since. The rating curves from these stations will be evaluated against new flow-discharge measurements, to ensure updated and accurate rating curves are used.

A.5.5. Surface water quality

Surface water quality parameters, including temperature, dissolved oxygen, pH, and turbidity will be monitored at all surface water stations. Water quality parameters are measured with a YSI Pro Plus multiparameter meter and a Hach Turbidimeter or equivalent instruments.

Surface water temperature will be continually logged by integrated CSI pressure transducer temperature sensors or equivalent equipment (e.g., Onset Hobo/Tidbit© temperature loggers). Temperature sensors will have a minimum accuracy/precision range of +/- 0.2°C. Temperature sensors will be calibrated and maintained in accordance with Ecology's (2015) Standard Operating Procedure (SOP) for Continuous Temperature Monitoring of Fresh Water Rivers and Streams (EAP080). Deployment techniques for temperature sensors/loggers will follow guidance and from Ecology's SOP; however, may vary slightly based on alternative equipment specifications.

Table 4 summarizes the water quality parameters and standard methods that will be employed for the surface water quality monitoring objectives of this project.

Table 4. Water Quality Grab Sample Parameters and Methods

Sample Type	Field Collection Containers	Parameter	Holding Time	Method	Lab Sample Container	Preservative
Continuous	*In-situ* stream or surface water station	Temperature	N/A	Continually logged via CSI pressure transducer, or equivalent	*In situ* (n/a)	*In situ* (n/a)
Grab	1-liter poly	pH	15 minutes	EPA 150.1 via YSI	*In situ* (n/a)	*In situ* (n/a)
		Dissolved Oxygen	15 minutes	EPA 150.2 via YSI	*In situ* (n/a)	*In situ* (n/a)
		Turbidity	15 minutes	EPA 180.1 via YSI	*In situ* (n/a)	*In situ* (n/a)

Manual grab samples will be collected by directly filling sample bottles from the monitoring discharge point, using a “clean hands” approach. The principle of the “clean hands” technique is that field personnel wear appropriate noncontaminating, disposable, powderless gloves during the entire grab sample collection procedure; changing gloves frequently with each change in task.

In-situ measurements with the YSI multiparameter meter may be conducted by directly submerging the sensors into surface waters, so long as there is no interference from bottom sediments or debris.

A.5.5.1. Equipment maintenance

Monitoring equipment will be inspected and serviced as recommended by the manufacturer, or at least once preceding the deployment of temporary monitoring station setups. Generally, equipment maintenance includes: inspection, testing, calibration, and replacement of worn or missing components. Table 5 summarizes the water quality field equipment specifications for this project, including: parameters, decontamination, and calibration procedures.

Table 5. Field Monitoring Equipment Decontamination and Calibration Procedures

Equipment	Parameters	Decontamination Procedure	Calibration Procedures
YSI water quality multimeter, or equivalent	pH; dissolved oxygen	Rinse sensors thoroughly with DI water as needed Store sensors in KCl solution between uses.	Perform the following prior to each site inspection: • Three-point calibration of pH (4,7,10) • Dissolved oxygen using barometric pressure and/or saturation method
HACH Turbidimeter, or equivalent	Turbidity	Rinse sample vials thoroughly with DI water as needed.	Perform reference calibration before every sample period, in accordance with manufacturer specifications.
Continually logged via CSI pressure transducer, or equivalent	Temperature	Gently clean temperature loggers with a soft cloth or soft-bristled brush to remove any biofouling or sediment.	Record ten reference *in-situ* measurements using NIST field thermometer. Compare the mean absolute value of the NIST thermometer measurements against the continuous temperature logger for the same time period; ensure the mean difference isn't greater than 0.2°C.

A.5.5.2. Qualitative Observations

In addition to the quantitative observations of water quality described above, surface water stations will be qualitatively inspected for the following, where applicable:

- Channel conditions, including the presence/absence of beaver dams, downed trees, streambed composition, vegetation, and particularly fast or slow flow velocities.
- Water color, floating oil and grease, floating debris/scum, and materials that may be toxic or harmful to human or other life.

A.5.6. Habitat

Habitat data are collected for two purposes: 1) stream cross sections are measured for comparison with the performance and aspirational thresholds of Goal 2 of the Restoration Plan, and 2) wetland and additional stream habitat measurements are collected to understand the linkages between stream restoration activities and effects on habitat. The wetland and additional stream habitat measurements could inform decisions to employ additional adaptive management strategies or modify existing strategies to limit impacts and/or increase benefits. The supplemental data would not be applicable to the evaluation of performance or aspirational thresholds.

A.5.6.1. Wetland Habitat

Wetland habitat will be measured using established transects with surveyed topography that has been related to surface water monitoring stations. The protocols for point intercept methods for determination of the vegetation community will generally follow Heady et al., 1959. Vegetation data will be collected annually at the end of the growing season (September or October, typically). A tape measure will be strung between fixed points (T-stakes or rebar, typically) and all vegetation species present at each given interval (1-foot or 2-foot, depending on transect length) will be recorded along with the distance from the start of the transect for correlation to surveyed ground surface elevation and surface water elevation data collected throughout the growing season.

A.5.6.2. Stream Habitat

Habitat monitoring stations will be established as cross sections and marked with driven rebar, or similar, in the field. Stations will be spaced 100 feet apart for 1,500 feet upstream of the BNSF culvert, and will be spaced 200 feet apart upstream to the east end of Edmond Marsh. At each section, the following data will be collected, at the frequency indicated in Table 6.

Table 6. Stream Habitat Monitoring Parameters and Methods

Parameter	Method	Precision/ units	Frequency
Depth	Measured every 2 feet within the wetted width of the section using a stadia rod.	0.1 foot	Years 0,1,2,3,5,10
Velocity	Measured at least every 2 feet within the wetted width of the section with a minimum of five measurements using a current velocity meter (Swoffer 2100 or similar).	0.1 feet per second (fps) for velocities between 0.5 and 25 fps	Years 0,1,2,3,5,10
Substrate size	D50 of randomly chosen substrate at least every 2 feet within the wetted width of the section with a minimum of 10 measurements.	1 mm	Years 0,1,2,3,5,10
Cover	Densiometer	Intersects	Years 0,1,2,3,5,10

Additional observations will be collected along the creek and referenced by distance upstream from the BNSF culvert (by station), as shown in Table 7.

Table 7. Additional Habitat Observations

Parameter	Method	Precision/ units	Frequency
Large Woody Material	Repeat existing survey based on methodology by Fox and Boulton (2007).	Count	Years 5, 10
Fish Presence	Visual identification	Species/ size (approx.)/ behavior	0,1,2,3,5,10
Active erosion	Visual identification	Photo documentation with scale	0,1,2,3,5,10

All data, except large woody material, will be collected once per indicated year in November or December when flows are between 100 and 200 percent of mean monthly average flow (or as predicted during years 1 and 2). Data on large woody material can be collected at any time of year.

All data will be presented in an annual monitoring report, including summarization and analysis of the data in terms of the quantity of usable and optimal habitat for Chum spawning and salmonid rearing. Trends over monitoring years will be included along with adaptive management considerations regarding the project performance or this sampling methodology.

A.5.7. Precipitation

For this project, a Hydrological Services Model TB3, or similar, tipping bucket rain gage will be installed at the designated site on the South Parcel. This instrument measures rainfall at 0.01-inch increments. The rain gauge will be connected to a CSI data logger, recording rainfall data at 15-minute intervals. The rain gage will be downloaded at least once each month. Field staff will inspect the rain gage monthly and service as needed. Rain gage calibration checks will occur using the method and at the frequency recommended by the manufacturer.

A.6. Quality Control

This section presents the quality control (QC) requirements for field and laboratory activities associated with this project.

A.6.1. Field

Field measurement equipment, dataloggers, and pressure transducers will be maintained and calibrated every month, at a minimum, to help ensure proper monitoring station operation. Preventative maintenance of the pressure transducers and water quality multimeters will be performed as specified by the manufacturer. The pressure transducers and sensors will be calibrated to the manufacturer's recommendations.

Original field records will be maintained in designated binders for all monitoring and field-related activities using project-specific forms, and guided by the procedures outlined in this SAP. Field documentation will include monthly inspection field sheets, maintenance/calibration logs, COC forms, and other required documentation. All entries in field notebooks will be written in pencil or waterproof ink. When errors are made,

project staff cross-out the error and enter the correct information. All corrections will be initialed and dated. Electronic equivalents of field forms may be used.

Field personnel will employ the following additional field-sample collection QC procedures, as needed:

- Collect grab water quality samples in certified contaminant-free or properly decontaminated containers.
- Use "clean hands/dirty hands" sampling techniques (that is, one team member performs "dirty tasks," while the other member performs "clean tasks," such as handling sample collection bottles).
- Hold samples on ice in coolers during retrieval and delivery to analytical laboratory.
- Deliver samples to analytical laboratory with proper chain of custody, and within holding times.

A.6.2. Laboratory

An accredited laboratory will be contracted to complete additional analyses, as needed, by the inclusion of special studies. Analytical test methods will be standardized and in accordance with procedures approved under 40 Code of Federal Regulations (CFR) §136. The minimum laboratory QA/QC requirements shall also include, but may not necessarily be limited to the following:

- Calibration of analytical laboratory instruments within acceptable limits.
- Periodic inspection, maintenance/servicing, and analysis of quality indicator samples, as necessary, to determine the accuracy and precision of procedures, instruments, and operators.
- Statistical procedures, such as control charts to monitor the precision and accuracy of the analytical data and to establish acceptance ranges and control limits. These data shall be maintained with project records and available upon request or during an audit.
- A continuous review of results to identify and correct problems originating with the instrument, the methodology or the analyst.
- Thorough documentation of the performance of systems, procedures, and operators.
- Certify that electronic data deliverables will exactly match all hard copy data.
- Provide notification of all nonconforming events and conditions, including missed holding times and delays in turnaround time, potentially impacting sample analysis.

A summary of laboratory QA/QC procedures will be requested in the final analytical report deliverables.

A.7. Data Management

This section describes the data management procedures to be used for ensuring access to consistently reliable data. The data management procedure includes 1) recording measurements in the field, 2) downloading data from storage devices in the field, and 3) transferring these data into project databases. There are two separate databases, one for hydrologic data and managed by the hydrology/water quality consultant, and a second for storing vegetation information from the wetland transects and quadrats in the marshes and creek, managed by the habitat consultant. This section defines the structure, inputs, outputs, and quality assurance(QA) and quality control (QC) procedures for the hydrologic database. These data management procedures closely follow those used for current and prior monitoring activities.

A.7.1. Hydrologic Data Collection

Field measurements/observations will be recorded in the field notebook. The field notebook will include the following data sheets: field visit data sheets, field equipment calibration sheets, and the equipment maintenance activity log. Custom field data sheets will be developed for the actual equipment installed. Examples of field data sheets are in Attachment B. Electronic equivalents of field forms may be developed and used.

The Data Collection Lead is responsible for updating and storing the field notebook. The field notebook will be photocopied monthly, and the copy stored at the Consultant's offices. Data loggers will be downloaded onto a project-designated field computer using applicable software and returned to the Consultant's office for transfer to the project database, as described below. Information from field notebook is transcribed into the project database manually. The project data files and database are stored on the Consultant's server, which is to be backed up for disaster recovery purposes at least once per week.

A.7.2. Hydrologic Database Structure

Hydrologic data are stored in an existing central Microsoft Access database created for the ongoing monitoring activities, and a set of specially formatted spreadsheets for ISCO datalogger data. The database will be used to assist with the analysis of groundwater and surface water conditions, and both consolidation and dissemination of information to other parties. The database provides a central storage area for ongoing data collected by Aspect Consulting, LLC and previous data sources, and allows data to be viewed in a uniform manner.

This database is structured such that, whenever possible, user input is validated using predefined formats and common terms making data input fast and simple, while ensuring that data can be accessed reliably through predefined queries. The data management tools in the database include:

- Task/field event setup for verifying completeness of data;
- Manual data entry;
- Querying and reporting tools; and

- Output of graphs and tabulated data.

Additional features designed to protect the integrity of the data and ensure smooth operation of the database include compact on close, tag data additions and modifications with date/time stamp and user id, and "*edit guard*" function that avoids inadvertent editing errors.

Due to the volume of ISCO bubbler data collected since 2004, it is currently managed as a set of Excel spreadsheets that combine to allow storage, correction, and graphing of the raw 15-minute stage data into final analysis and figures.

A.7.3. Database Inputs

Existing hydrologic data currently reside in the database. Data from planned monitoring described in this SAP will be routinely entered into the database as described below.

A.7.3.1. Existing Data

The following types of data were previously input for existing monitoring points:

- Survey coordinates and elevation data for staff gages and well top-of-casing elevations;
- Staff gage and well water level data;
- 15-minute continuous-record stream stage data;
- Stream stage-discharge rating equations for SC-Upper and SC-Lower;
- Standard weir equation for the Diversion Weir; and
- Spot flow measurements.

Existing water quality data is stored in an EQUIS database.

A.7.3.2. New Data

Data inputs from planned data collection include:

- Survey coordinates and elevation data for new staff gages (e.g., at SC-Center Drive gaging station and Sequalitchew Lake Outlet gaging station);
- New surface water staff gage measurements;
- Depth to groundwater measurements from wells;
- Monthly 15-minute stage-height data files for continuous flow and surface water monitoring stations;
- Monthly 15-minute groundwater level data files for continuous groundwater level monitoring stations;
- Monthly 15-minute precipitation data files from on-site rain gage;
- Water quality data;
- New manual streamflow flow measurements; and

- New stream stage-discharge rating equations, as necessary.

Staff gage, depth-to-groundwater, and spot water quality measurements are manually entered directly into the database using the manual data entry form following each field visit. The form includes fields for all monitoring data to help verify completeness.

Continuous stage height, groundwater level, temperature, and precipitation data files are loaded into the database and verified against manual measurements. Manual streamflow measurements and staff gage readings for the Sequalitchew Lake Outlet, SC-Center Drive, SC-Upper, and SC-Lower gaging stations are also entered into MS Excel to evaluate the appropriateness of the current rating curves for each station. When a new rating equation is necessary, it is entered manually into the database and applied to a specific date range for the station.

A.7.3.3. Back-up Precipitation Data

In the event the project rain gage malfunctions, precipitation data from the McMillin Reservoir weather station will be used to fill data gaps, as available. The McMillin Reservoir weather station is located about 20 miles northeast of the project area. This gage was selected as the most appropriate source of back-up precipitation data because it is the closest station with a lengthy period of record, and it receives similar monthly and annual precipitation amounts (Aspect, 2004a).

The precipitation data from McMillin Reservoir are collected as a part of the National Weather Service's (NWC) Cooperative Observer Program (COOP). Electronic files of daily precipitation can be downloaded from the COOP website and imported directly into the database using automated data import routines.

A.7.4. Database Outputs

Figures and tabulated data outputs are generated by an either automated output from the database, or generated via spreadsheet through Tableau. When new figures or tables are desired, water levels and flows are recalculated and printed from their appropriate software.

Water level elevations are calculated in the database, based on the supplied reference elevations for each point. The surveyed elevation of staff gages and monitoring wells is input in the database with a timestamp of when it was measured. Old water levels can be recalculated, based on resurveyed reference elevations when new ones become available.

Raw stage data from the continuous record stream gages is processed with the supplied stage-discharge ratings. Each station has a list of correlations that are applied over a specified time frame—typically for a given year or set of years. From the processed stage data, streamflow in either hourly or 15-minute data intervals is then averaged to mean daily flow for use in graphs and tables.

Precipitation data from the site rain gage is processed to calculate daily, monthly, and annual precipitation totals. Precipitation data at the appropriate time scale is exported to Excel for display on graphs and tables. The data export includes qualifiers indicating the quantity of missing data, if any.

Water quality data are stored and processed in the database. Continuous temperature data will be aggregated to calculate daily and monthly minimum and maximum temperatures as well as the 7-day average of daily maximum temperatures (7-DADMax), which has regulatory significance. Periodic water quality observations will also be output from the database.

A standard monthly report will be developed to assist with routine sharing of information during the mining and restoration projects. The report format will present a summary of observations for the prior month, and compare the observations with relevant performance and aspirational thresholds to determine if the adaptive management processes have been triggered.

A.7.5. QA/QC Protocol

QA/QC protocol for this project fall into three categories, based on which step of data collection and entry is taking place. Data QA/QC occurs during data collection in the field, data entry, and data reporting.

Key components of each QA/QC procedure are summarized below.

A.7.5.1. Data Collection

- The task/field event setup feature identifies all current monitoring points, and organizes them in the order that the data is typically collected on preprinted field forms. This feature helps ensure the completeness of data, especially in the event of field staff turnover.
- While measurements are being collected, the field staff quickly references the previous event's field form to verify the current measurement seems reasonable, and remeasures if necessary.

A.7.5.2. Data Entry

Manual data entry utilizes real-time data verification against defined valid values, acceptable data ranges, expected parameters, and standard data formats. Entries that fall outside these defined parameters will return an error message and reject the data.

A.7.5.3. Data Reporting

After each data entry event, data is reviewed in tabulated and graphical formats. This allows the user to readily identify data outliers and missing values. Data tables and figures will be inspected each month as a final step to verify the completeness and quality of monitoring data.

A.7.6. Data Archival (EIM)

To provide long-term data preservation by a neutral party, data collected under this SAP will be uploaded annually to Ecology's Environmental Information Management (EIM) database: http://www.ecy.wa.gov/eim/. Alternately, data collected by a governmental party with a similar, publicly accessible database (e.g., USGS's Nationwide Water Information System) may be stored in that database.

A.8. Special Studies

This SAP describes the routine monitoring approaches and methods for use in implementing the mining and restoration plans. Those plans also identify several special studies—notably the 60-day pumping test proposed as Step 1 of dewatering, and a study of water quality in Hamer Marsh to determine if it is adequate for improving the connection to Sequalitchew Creek. Specific plans will be developed for these studies, and others that may arise during implementation and adaptive management of the projects.

A.9. References

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TABLES

Table 1 - Summary of Baseline Monitoirng Program

Project No.: 040001-014-03, DuPont, Washington

Station ID	Summary of Monitoring					Description
	Surface Water	Streamflow	Water Quality	Groundwater Elevation		
				Shallow	Deep	
MW-BM-1				X		Bell Marsh - Monitoring Well
SG-BM-1	X					Bell Marsh - Stage Gage
SG-MKM-1	X					McKay Marsh - Stage Gage
MW-HM-1				X		Hamer Marsh - Monitoring Well
MW-SRC-2				X		Hamer Marsh - Monitoring Well
SG-HM-1	X		X			Hamer Marsh - Stage Gage
G-Diversion Weir	X	X	X			Diversion Canal - Continuous Stage Gage and Discharge Transect
SG-DC-1	X	X				Diversion Canal - Stage Gage and Discharge Transect
SG-DC-2	X	X				Diversion Canal - Stage Gage and Discharge Transect
SG-DC-3	X	X				Diversion Canal - Stage Gage and Discharge Transect
MW-D-3				X		Diversion Canal - Monitoring Well
IW-93-MFS-C5-3				X		Diversion Canal - Monitoring Well
MW-SL-1				X		Sequalitchew Lake Outlet - Monitoring Well
SG-SCM-1	X					Sequalitchew Creek Marsh - Stage Gage
SG-EM-3E	X					Edmond Marsh - Stage Gage
SG-EM-3W	X					Edmond Marsh - Stage Gage
MW-EM-3				X		Edmond Marsh - Monitoring Well
SG-EM-2E Island	X					Edmond Marsh - Stage Gage
G-EM-2W Culvert	X					Edmond Marsh - Stage Gage
MW-EM-2(D)					X	Edmond Marsh - Monitoring Well
MW-EM-2(S)				X		Edmond Marsh - Monitoring Well
SG-WL1D-1	X					Edmond Marsh - Stage Gage
MW-WL1D-1				X		Edmond Marsh - Monitoring Well
SG-EM-1	X					Edmond Marsh - Stage Gage
SG-EM-1A	X					Edmond Marsh - Stage Gage
MW-EM-1(D)					X	Edmond Marsh - Monitoring Well
MW-EM-1(S)				X		Edmond Marsh - Monitoring Well
MW-PL-1				X		Pond Lake - Monitoring Well
SG-PL-1	X					Pond Lake - Stage Gage
CHMW-1				X		Mine Area - Monitoring Well
CHMW-2-D					X	Mine Area - Monitoring Well
CHMW-2-S				X		Mine Area - Monitoring Well
CHMW-3-D					X	Mine Area - Monitoring Well
CHMW-3-S				X		Mine Area - Monitoring Well
CHMW-4-D					X	Mine Area - Monitoring Well
CHMW-4-S				X		Mine Area - Monitoring Well
OB-1				X		Mine Area - Monitoring Well
SG-SC-Lower		X				Sequalitchew Creek - Continous Stage Gage and Discharge Transect
SG-SC-Upper		X	X			Sequalitchew Creek - Continous Stage Gage and Discharge Transect

Table 3 - Relationship of Proposed Monitoring to Adaptive Management Thresholds

DRAFT

Project No. 040001-014-03, DuPont, Washington

Plan Objectives			Sampling and Analysis Plan Elements[1]				
			Precipitation	Groundwater Level			
			on-site rain gage	Dewatering Wells	Key Wells: CHMW-1, CHMW-2S&D, CHMW-3S&D, CHMW-4S&D, MW-EM-1S&D, MW-EM-2S&D	MW-BM-1, MW-HM-1, MW-D-3, MW-93-MFS-C5-3, MW-SRC-2, MW-SL-1, MW-EM-3, MW-WLD-1, MW-PL-1	Two new monitoring wells in mine interior
South Parcel Monitoring Plan Objectives	Step 1 - Initial Pumping Test	Groundwater levels at monitoring wells near Edmond Marsh and Sequalitchew Creek are at or above predicted, approved-upon levels.	continuous		continuous	monthly	
		Moisture content of mined aggregate is at appropriately low levels for safe and efficient mining and processing.	continuous	continuous			
	Step 2 - Prep for Mining/ Dewatering Test	Groundwater levels at monitoring wells near Edmond Marsh and Sequalitchew Creek are at or above predicted, approved-upon levels.	continuous		continuous	twice monthly	
		Moisture content of mined aggregate is at appropriately low levels for safe and efficient mining and processing.	continuous	continuous			as needed
	Step 3 - Active Dewatering During Mining	Groundwater levels at monitoring wells near Edmond Marsh and Sequalitchew Creek are at or above predicted, approved-upon levels.	continuous		continuous	twice monthly for 3 months after new dewatering wells are brought on line, then monthly	
		Moisture content of mined aggregate is at appropriately low levels for safe and efficient mining and processing.	continuous	as needed			as needed
	Step 4 - Cessation of Active Dewatering	Groundwater levels at monitoring wells near Edmond Marsh and Sequalitchew Creek are at or above predicted, approved-upon levels.	continuous		continuous	monthly	
		Moisture content of mined aggregate is at appropriately low levels for safe and efficient mining and processing.	continuous	as needed			as needed
Sequalitchew Creek Restoration Plan Objectives	After Elements B, C, and D,	Achieve year-round surface water flow in Sequalitchew Creek from Sequalitchew Lake to the mouth, as climate conditions allow.	continuous				
		Minimize the flow lost to the Diversion Canal.	continuous				
	After B, C, D, and G	Increase access to suitable spawning and rearing habitat in Sequalitchew Creek	continuous				

Notes:

1) additional monitoring locations may be added through adaptive management

* Continue routine monitoring of flow and surface water stations to aid in interpretation of groundwater measurements. Flow and surface water stations do not have Monitoring Plan performance thresholds.

Table 3 - Relationship of Proposed Monitoring to Adaptive Management Thresholds

Project No. 040001-014-03, DuPont, Washington

Plan Objectives			Sampling and Analysis Plan Elements*					
			Flow			Surface Water Level		
			Sequalitchew Lake Outlet	Diversion Weir	Sequalitchew Creek gages (Center Drive, mid-ravine, and SC-Lower)	West Edmond (SG-EM-1/1A and SG-EM-2W)	East Edmond and Sequalitchew Creek Marshes (SG-SCM-1, SG-EM-3E, SG-EM-3W, SG-EM-2E)	Hamer, McKay, and Bell Marshes (SG-HM-1, SG-MKM-1, SG-BM-1)
South Parcel Monitoring Plan Objectives	Step 1 - Initial Pumping Test	Groundwater levels at monitoring wells near Edmond Marsh and Sequalitchew Creek are at or above predicted, approved-upon levels.	* continue routine monitoring			* continue routine monitoring		
		Moisture content of mined aggregate is at appropriately low levels for safe and efficient mining and processing.						
	Step 2 - Prep for Mining/ Dewatering Test	Groundwater levels at monitoring wells near Edmond Marsh and Sequalitchew Creek are at or above predicted, approved-upon levels.	* continue routine monitoring			* continue routine monitoring, but at twice monthly frequency		
		Moisture content of mined aggregate is at appropriately low levels for safe and efficient mining and processing.						
	Step 3 - Active Dewatering During Mining	Groundwater levels at monitoring wells near Edmond Marsh and Sequalitchew Creek are at or above predicted, approved-upon levels.	* continue routine monitoring			* continue routine monitoring, but at twice monthly for first three months after new dewatering wells are brought on line, then monthly		
		Moisture content of mined aggregate is at appropriately low levels for safe and efficient mining and processing.						
	Step 4 - Cessation of Active Dewatering	Groundwater levels at monitoring wells near Edmond Marsh and Sequalitchew Creek are at or above predicted, approved-upon levels.	* continue routine monitoring			* continue routine monitoring		
		Moisture content of mined aggregate is at appropriately low levels for safe and efficient mining and processing.						
Sequalitchew Creek Restoration Plan Objectives	After Elements B, C, and D,	Achieve year-round surface water flow in Sequalitchew Creek from Sequalitchew Lake to the mouth, as climate conditions allow.	continuous		continuous	continuous	monthly	monthly
		Minimize the flow lost to the Diversion Canal.		continuous				
	After B, C, D, and G	Increase access to suitable spawning and rearing habitat in Sequalitchew Creek			continuous	continuous	monthly	

Notes:

1) additional monitoring locations may be added through adaptive management

* Continue routine monitoring of flow and surface water stations to aid in interpretation of groundwater measurements. Flow and surface water stations do not have Monitoring Plan performance thresholds.

Table 3 - Relationship of Proposed Monitoring to Adaptive Management Thresholds

Project No. 040001-014-03, DuPont, Washington

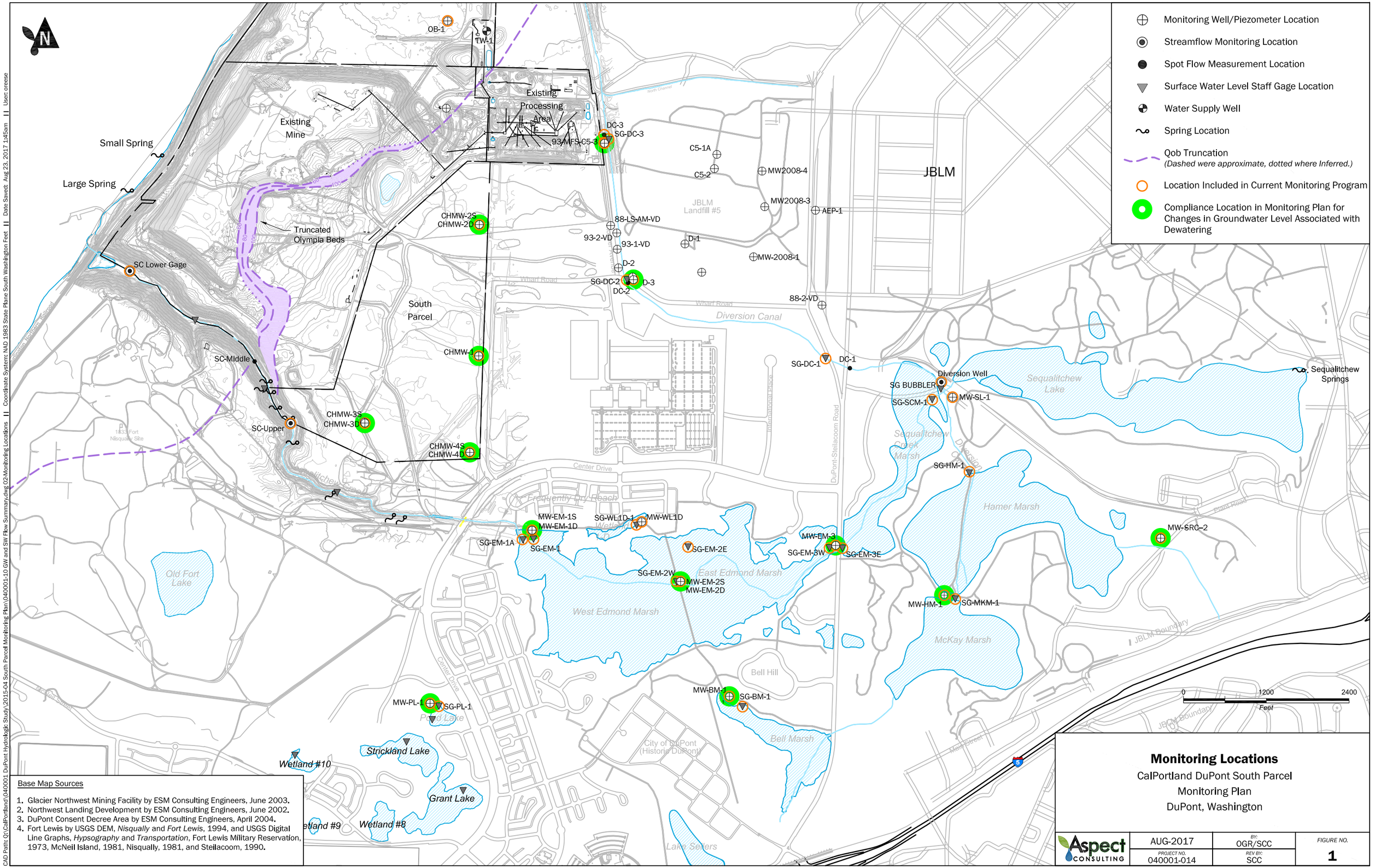
Plan Objectives			Sampling and Analysis Plan Elements*				
			Water Quality		Habitat		
			Temperature at SG-EM-1, SG-EM-2W, Diversion Weir, Sequalitchew Lake Outlet, SC-Center Drive, mid-ravine, SC-Lower	Water quality sampling for DO, turbidity, pH, Temperature at select surface water stations	Cross-section physical characteristics (depth, velocity, substrate,and cover)	Visual Observations (fish presence, active erosion)	Large Woody Material
South Parcel Monitoring Plan Objectives	Step 1 - Initial Pumping Test	Groundwater levels at monitoring wells near Edmond Marsh and Sequalitchew Creek are at or above predicted, approved-upon levels.					
		Moisture content of mined aggregate is at appropriately low levels for safe and efficient mining and processing.					
	Step 2 - Prep for Mining/ Dewatering Test	Groundwater levels at monitoring wells near Edmond Marsh and Sequalitchew Creek are at or above predicted, approved-upon levels.					
		Moisture content of mined aggregate is at appropriately low levels for safe and efficient mining and processing.					
	Step 3 - Active Dewatering During Mining	Groundwater levels at monitoring wells near Edmond Marsh and Sequalitchew Creek are at or above predicted, approved-upon levels.					
		Moisture content of mined aggregate is at appropriately low levels for safe and efficient mining and processing.					
	Step 4 - Cessation of Active Dewatering	Groundwater levels at monitoring wells near Edmond Marsh and Sequalitchew Creek are at or above predicted, approved-upon levels.					
		Moisture content of mined aggregate is at appropriately low levels for safe and efficient mining and processing.					
Sequalitchew Creek Restoration Plan Objectives	After Elements B, C, and D,	Achieve year-round surface water flow in Sequalitchew Creek from Sequalitchew Lake to the mouth, as climate conditions allow.					
		Minimize the flow lost to the Diversion Canal.					
	After B, C, D, and G	Increase access to suitable spawning and rearing habitat in Sequalitchew Creek	continuous	monthly	Years 0, 1, 2, 3, 5 and 10		Years 5 and 10

Notes:

1) additional monitoring locations may be added through adaptive management

* Continue routine monitoring of flow and surface water stations to aid in interpretation of groundwater measurements. Flow and surface water stations do not have Monitoring Plan performance thresholds.

FIGURE



Base Map Sources

1. Glacier Northwest Mining Facility by ESM Consulting Engineers, June 2003.
2. Northwest Landing Development by ESM Consulting Engineers, June 2002.
3. DuPont Consent Decree Area by ESM Consulting Engineers, April 2004.
4. Fort Lewis by USGS DEM, *Nisqually* and *Fort Lewis*, 1994, and USGS Digital Line Graphs, *Hypsography* and *Transportation*, Fort Lewis Military Reservation, 1973, McNeil Island, 1981, Nisqually, 1981, and Steilacoom, 1990.

Monitoring Locations

CalPortland DuPont South Parcel
Monitoring Plan
DuPont, Washington

Aspect Consulting	AUG-2017	BY: OGR/SCC	FIGURE NO. 1
	PROJECT NO. 040001-014	REV BY: SCC	

CAD Path: Q:\CalPortland\040001 DuPont Hydrologic Study\2015-04 South Parcel Monitoring Plan\040001-10 GW and SW Flow Summary.dwg 02-Monitoring Locations || Coordinate System: NAD 1983 State Plane South Washington Feet || Date Saved: Aug 23, 2017 1:45am || User: oreese

APPENDIX A

Boring Logs

14P1

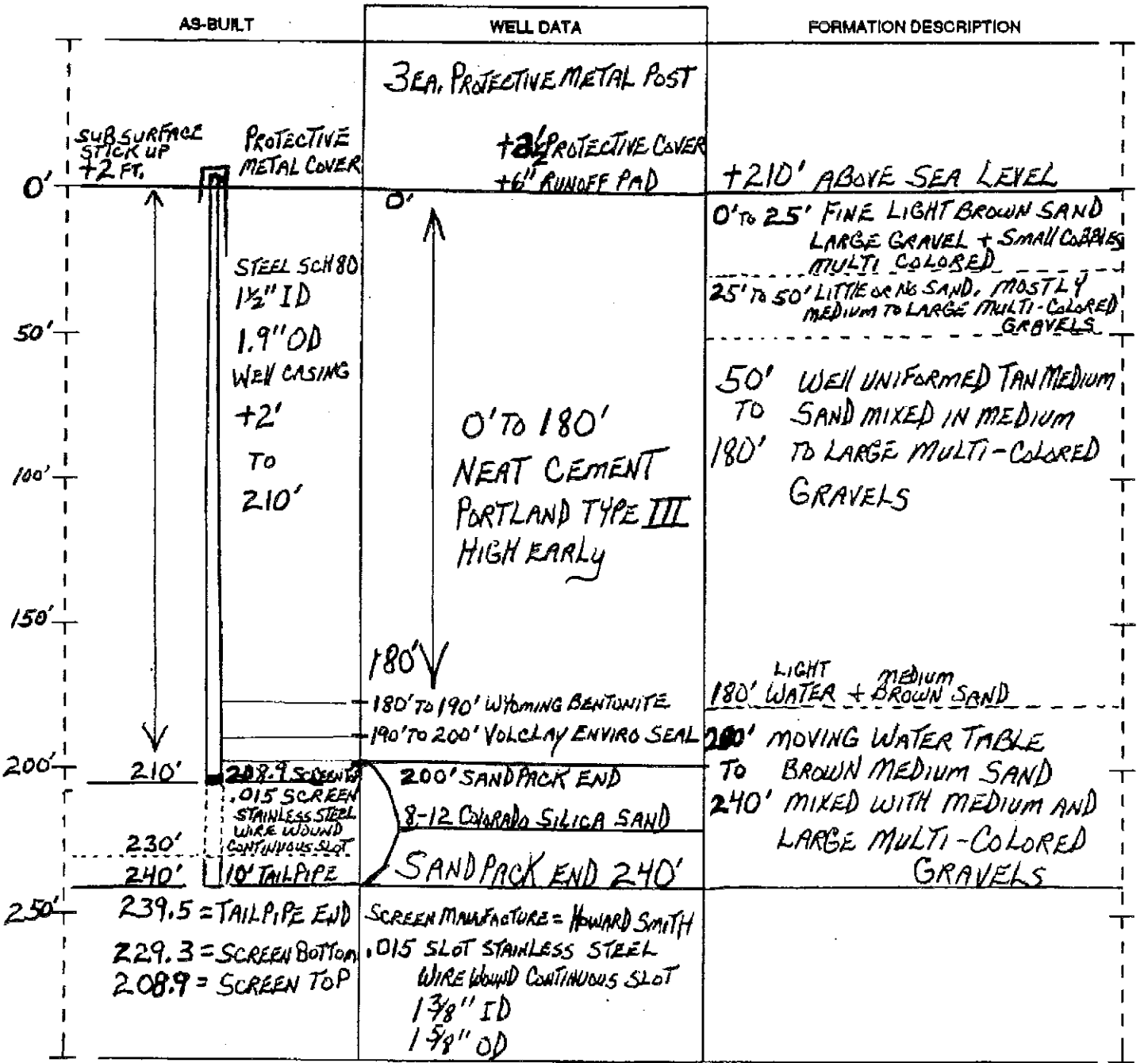
21 FEB 9

RESOURCE PROTECTION WELL REPORT

START CARD NO. 063977

PROJECT NAME: LONESTAR NW OBSERVATION WELL
WELL IDENTIFICATION NO. LONE STAR OB-1
DRILLING METHOD: REVERSE CIRCULATION ROTARY
DRILLER: DOUGLAS GRABOWSKI
FIRM: BECKER DRILLS INC.
SIGNATURE: William J. Flickey
CONSULTING FIRM: HART CROWSER
REPRESENTATIVE: TOM NOYES

COUNTY: PIERCE
LOCATION: SE¼ SW¼ Sec 14 Twn 19N R 1E
STREET ADDRESS OF WELL: NORTHWEST LANDING ANNEX DUPONT STEILACOOM ROAD DUPONT WASHINGTON
WATER LEVEL ELEVATION: 200 FT. STATIC
GROUND SURFACE ELEVATION: +210
INSTALLED: FEBRUARY 15, 1991
DEVELOPED:



SCALE: 1" = 50 FEET

PAGE 1 OF 1

ECY 050-12 (Rev. 11/89)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report

CH2MHILL

Well Number: CHMW-1

Sheet: 1 of 1

Client: Glacier NW
Project: N Sequalitchew Creek Aquifer Tests
Location: DuPont, Washington
Project Number: 151973.A2.AT

Driller: Hokkaido Drilling (Bill & Steve)
Drilling Method: Speedstar 15 Truck-Mounted Air Rotary
Sampling Method: Sand pump (water added)
Logged by: driller
Start/Finish Date: 9/23/99 - 9/24/99

Depth (ft)	Sample Info: Sample #	Sample Info: STP (6"-6"-6")	Soil Log	Soil Description	Depth / Elev	Well Drawing	Well Construction Notes
-5					5		
					217		Monument (not shown)-- Lockable 6" steel protective casing in concrete.
0				Ground Surface			
				Topsoil	2		
5				Sand and gravel with silt, dry, brown	210		
10							Casing - 2" sch 40 PVC pipe
15							
20					22		
				Brown silty gravel	190		
25					26		
				Brown gravel, like till	186		
30					33		
				Brown silt	179		
35				Light brown gravel, productive water-bearing zone			
40							
45							
50							
55					57		
				Dark brown gravel and sand. Note no "soupy sand" like in CHTW-1.	155		
60							Casing Seal - Hydrated medium bent
65							
70							
75					76		Filter pack - 10-20 CSSI sand
				Dark brown sand and gravel	136		Screen - 2" sch 40 PVC, 0.020-in slot
80					82		
				Gray-blue silty sand, sand and gravel.	130		
85					85		6" end cap
					127		

CH2MHILL

Well Number: CHMW-2(S)

Sheet: 1 of 1

Client: Glacier NW
Project: N Sequalitchew Creek Aquifer Tests
Location: DuPont, Washington
Project Number: 151973.A2.AT

Driller: Hokkaido Drilling (Daryl & Tom)
Drilling Method: Star 71 cable tool, 8" steel casing
Sampling Method: Sand pump (water added)
Logged by: driller
Start/Finish Date: 11/17/99 - 11/19/99

Depth (ft)	Sample Info: Sample #	Sample Info: STP (6"-6"-6")	Soil Log	Soil Description	Depth / Elev	Well Drawing	Well Construction Notes
-5					5 212		Monument (not shown)-- Lockable 6" steel protection casing in concrete.
0				Ground Surface Topsoil and gravel	3		
5				Brown silty sand and gravel	204		
10							Casing - 2" sch. 40 PVC pipe
15							Casing seal - Hydrated medium bentc
20					21		
25				Larger gravel and sand, slightly silty, very hard	186 26		
30				Brown silty sand, gravel Sandier with gravel	181		Sandy filterpack - 10-20 CSSI sand
35					36		
40				Clean sand and gravel, water	171		Screen - 2 centralizers, 2" sch 40 PV(0.020-inch slot width
45					43		6" end cap
50				End of Log	164		

CH2MHILL

Well Number: CHMW-2(D)

Sheet: 1 of 1

Client: Glacier NW
Project: N Sequalitchew Creek Aquifer Tests
Location: DuPont, Washington
Project Number: 151973.A2.AT

Driller: Hokkaido Drilling (Steve & Tom)
Drilling Method: Speedstar 15 & Star 71 Cable Tool
Sampling Method: Sand pump (water added)
Logged by: Driller
Start/Finish Date: 11/12/99 - 11/18/99

Depth (ft)	Sample Info: Sample #	Sample Info: STP (6"-6"-6")	Soil Log	Soil Description	Depth / Elev	Well Drawing	Well Construction Notes
-5					5 212		Monument (not shown): Lockable 6' steel protection casing in concrete
0				Ground Surface			
				Topsoil	4		
5				Brown silty gravel	203 9		
10				Brown gravel	198		Casing--2" sch 40 PVC pipe
15				Brown silty gravel, moist	15 192		
20					24		
25				Hard till, brown	[illegible]		
				Loose sand and gravel, water	181		
30							Casing Seal--Hydrated medium bentc
35				Brown till	35 172		
40							
45					48		
50				Loose sand and gravel, water	159		
55					58		
60				Brown silt bound sand and gravel, tight	149		
65					66		Screen - 2" sch 40 PVC, 0.020-in slot with centralizer
				no record	141		
70					73		6" end cap
75				End of Log	134		

CH2MHILL

Well Number: CHMW-3(D)

Sheet: 1 of 1

Client: Glacier NW
Project: N Sequalitchew Creek Aquifer Tests
Location: DuPont, Washington
Project Number: 151973.A2.AT

Driller: Hokkaido Drilling (Steve)
Drilling Method: Speedstar 15 Air Rotary Drill Rig
Sampling Method: Sand pump (water added)
Logged by: driller
Start/Finish Date: 11/4/99 - 11/5/99

Depth (ft)	Sample Info: Sample #	Sample Info: STP (6"-6"-6")	Soil Log	Soil Description	Depth / Elev	Well Drawing	Well Construction Notes
-5					5		Monument (not shown): Lockable 6" steel protective casing in concrete
					221		
0				Ground Surface			
				Brown topsoil	2		
5				Loose brown gravel	214		
10							Casing - 2" sch 40 PVC pipe
15					16		
				Brown silty sand and gravel	200		
20							
25					26		
				Brown silty sand and gravel (moist)	190		Casing seal - hydrated medium bento
30					31		
				Brown sand and gravel, dirty, water	185		
35							
40					41		
				Brown till	175		
45							
					48		
50				Sand and gravel, water	168		
					54		
55				Brown till	162		
				Silt, sand and gravel, brown, wet			
60							
					64		
65				Clean sand and gravel	152		
70							
							Filter pack - 10-20 CSSI sand
75							Screen - 2" sch 40 PVC, 0.020-in slot
80							
					85		6" end cap
85				End of Log	131		
90							

CH2MHILL

Well Number: CHMW-3(S)

Sheet: 1 of 1

Client: Glacier NW
Project: N Sequalitchew Creek Aquifer Tests
Location: DuPont, Washington
Project Number: 151973.A2.AT

Driller: Hokkaido Drilling (Steve)
Drilling Method: Speedstar 15 Air Rotary Drill Rig
Sampling Method: Sand pump (water added)
Logged by: driller
Start/Finish Date: 11/5/99

Depth (ft)	Sample Info: Sample #	Sample Info: STP (6"-6"-6")	Soil Log	Soil Description	Depth / Elev	Well Drawing	Well Construction Notes
-5					5 221		Monument (not shown): Lockable 6" steel protection casing in concrete
0				Ground Surface Brown topsoil	2		
				Loose gravel	214		
5							Casing - 2" sch 40 PVC pipe
10							
15					16		Casing seal - Hydrated medium bentc
				Silty brown sand and gravel	200		
20							
25					26		
				Moist silty brown sand and gravel	190		Filter pack - 10-30 CSSI sand
30					31		Screen - 2" sch 40 PVC, 0.020-in slot
				Clean sand and gravel, water	185		
35							
40					40		6" end cap
				End of Log	176		
45							

CH2MHILL

Well Number: CHMW-4(S)

Sheet: 1 of 1

Client: Glacier NW
Project: N Sequalitchew Creek Aquifer Tests
Location: DuPont, Washington
Project Number: 151973.A2.AT

Driller: Hokkaido Drilling (Steve)
Drilling Method: air rotary
Sampling Method: Sand pump (water added)
Logged by: driller
Start/Finish Date: 11/23/99

Depth (ft)	Sample Info: Sample #	Sample Info: STP (6"-6"-6")	Soil Log	Soil Description	Depth / Elev	Well Drawing	Well Construction Notes
-5					5 219		Monument (not shown): Lockable 6" steel protective casing
0				Ground Surface Topsoil with large gravel	3		
5				Brown silty sand and gravel	211		
10					11		Casing - 2" sch 40 pvc pipe w/ j-plug
				Brown silty sand and large boulders	203		
15					15		Casing seal - hydrated medium bento
				Sand and gravel with water	199 17		
				Brown silt with gravel	197		
20							
25							Filterpack - 10-20 CSSI sand
							Screen - 2" sch 40 pvc, 0.020-in slot v
30							
35							
					37		6" end cap
				End of Log	177		
40							

CH2MHILL

Well Number: CHMW-4(D)

Sheet: 1 of 1

Client: Glacier NW
Project: N Sequalitchew Creek Aquifer Tests
Location: DuPont, Washington
Project Number: 151973.A2.AT

Driller: Hokkaido Drilling (Steve)
Drilling Method: air rotary
Sampling Method: Sand pump (water added)
Logged by: diller
Start/Finish Date: 11/11/99

Depth (ft)	Sample info: Sample #	Sample info: STP (6"-6"-6")	Soil Log	Soil Description	Depth / Elev	Well Drawing	Well Construction Notes
-5					5 / 219		
0				Ground Surface			
				Topsoil	2		
5				Brown gravel	212		Monument: Lockable 6" steel protective casing in concrete
10							
15					15		
				Brown till	199		
20							
25							Casing - 2" sch 40 PVC pipe
30							
					34		
35				Sand, gravel, making water	180		Casing seal - hydrated medium bento
40							
45							
					48		
50				Brown till	166		
					53		
55				Sand, gravel, making water	161		
60							
65					66		
				Brownish orange silty gravel	148		
70				Sand, gravel, water			
75							Filter pack - 10-20 CSSI sand
							Screen - 2" sch 40 PVC, 0.020-in slot
80							
					85		6" end cap
85					129		

CH2MHILL

PROJECT NUMBER : 151973.A1.AT

WELL NUMBER : CHMW-1

WELL CONSTRUCTION/BORING LOG

PROJECT : **LONE STAR, DUPONT** LOCATION : **50' S. OF CHTW-1**

WATER LEVELS : **21'6 3/4" ATD**

DRILLING METHOD/EQUIPMENT : **SPEEDSTAR 15 TRUCK-MOUNTED AIR ROTARY**

START : **9/23/99** END : **9/24/99** LOGGER: **HOKKAIDO(BILL&STEVE)**

DEPTH BELOW SURFACE (FT)	CORE DESCRIPTION/COMMENTS
0	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.
	0-2FT Topsoil
	2-22FT Sand/gravel w/silt (dry,brown)
5	
10	
15	
20	
	22-26FT Brown silty gravel
25	
	26-33FT Brown gravel (like till)
30	

CH2MHILL

PROJECT NUMBER : 151973.A1.AT	WELL NUMBER : CHMW-1 SHEET 2 OF 3

WELL CONSTRUCTION/BORING LOG

PROJECT : **LONE STAR, DUPONT** LOCATION : **50' S. OF CHTW-1**

WATER LEVELS : **21'6 3/4" ATD**

DRILLING METHOD/EQUIPMENT : **SPEEDSTAR 15 TRUCK-MOUNTED AIR ROTARY**

START : **9/23/99** END : **9/24/99** LOGGER: **HOKKAIDO(BILL&STEVE)**

DEPTH BELOW SURFACE (FT)	CORE DESCRIPTION/COMMENTS
	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.
	33-35FT Brown silt
35	35-57FT Lt.brown gravel, productive water-bearing zone
40	
45	
50	
55	
	57-59FT Dk.brown gravel & sand NOTE: No "soupy sand" at 50' like in CHTW
60	

CH2MHILL

PROJECT NUMBER : 151973.A1.AT

WELL NUMBER : CHMW-1

WELL CONSTRUCTION/BORING LOG

PROJECT : **LONE STAR, DUPONT** LOCATION : **50' S. OF CHTW-1**

WATER LEVELS : **21'6 3/4" ATD**

DRILLING METHOD/EQUIPMENT : **SPEEDSTAR 15 TRUCK-MOUNTED AIR ROTARY**

START : **9/23/99** END : **9/24/99** LOGGER: **HOKKAIDO(BILL&STEVE)**

DEPTH BELOW SURFACE (FT)	CORE DESCRIPTION/COMMENTS
	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.
65	
70	
75	76-82FT Dk.brown sand & gravel
80	82-83FT Gray silty sand & gravel
85	83-85FT Blue sand & gravel
	WELL: STICKUP=2' (2"sch 40 pvc) SCREEN=75'-84.5' (2"sch 40 pvc, 20-slot) 6" endcap 84.5 -85 fbgs ANNULUS=15 bags 10-20 cost sand (50lb. ea) 52 bags med. bentonite chips (50lbs ea) MONUMENT=6" steel protective casing in concrete
0	

CH2MHILL

PROJECT NUMBER : 151973.A1.AT	WELL NUMBER : CHMW-2(S)
	SHEET 1 OF 2

WELL CONSTRUCTION/BORING LOG

TOC elev = 209.39 Stickup = 1.45
grd = 207.94

PROJECT : **LONE STAR, DUPONT** LOCATION : **50' N. OF TW-2(~15FT E.OF MW-2(D)**

WATER LEVELS :

DRILLING METHOD/EQUIPMENT: **STAR 71 CABLE TOOL, 8" STEEL CASING**

START : **11/17/99** END : **11/19/99** LOGGER: **HOKKAIDO(DARYL & TOM)**

DEPTH BELOW SURFACE (FT)	CORE DESCRIPTION/COMMENTS
0	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.
	0-3FT Topsoil & gravels
	3-21FT Brown silty sand and gravels
5	
10	
15	
20	
	21-26FT Larger gravels & sand slightly silty, very hard
25	
	26-27FT Brown silty sand & gravel
	27-28FT Sandier w/gravel (gravel smaller)
30	

CH2MHILL

PROJECT NUMBER : 151973.A1.AT	WELL NUMBER : CHMW-2(S) SHEET 2 OF 2

WELL CONSTRUCTION/BORING LOG

PROJECT : **LONE STAR, DUPONT** LOCATION : **50' N. OF TW-2(~15FT E.OF MW-2(D)**

WATER LEVELS :

DRILLING METHOD/EQUIPMENT: **STAR 71 CABLE TOOL, 8" STEEL CASING**

START : **11/17/99** END : **11/19/99** LOGGER: **HOKKAIDO(DARYL & TOM)**

DEPTH BELOW SURFACE (FT)	CORE DESCRIPTION/COMMENTS
	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.
35	36-43FT Clean sand & gravel w/H20 Total casing=46'-81/2" Well: Stickup=2' (2" sch 40 pvc) w/j-plug Screen=33'-421/2' bgs w/2 centralizers & 6' end (2"sch 40 pvc, 20-slot) Annulus=13 50-lb bags 10-20 cgsi sand 18 50-lb bags medium bentonite chips Monument= 6"steel protecting casing in concrete (7 bags)
40	
45	
50	
55	
60	

CH2MHILL

PROJECT NUMBER : 151973.A1.AT	WELL NUMBER : CHMW-2(D) SHEET 1 OF 3

WELL CONSTRUCTION/BORING LOG

TOC elev = 209 Stickup = 1.8 grd = 207.2

PROJECT : **LONE STAR, DUPONT** LOCATION : **50' N. OF TW-2**

WATER LEVELS :

DRILLING METHOD/EQUIPMENT: **SPEEDSTAR 15, 8" STEEL CASING(TO58") &STAR 71 CABLE TOOL, 8" CASING**

START : **11/12/99** END : **11/18/99** LOGGER: **HOKKAIDO(STEVE & TOM)**

DEPTH BELOW SURFACE (FT)	CORE DESCRIPTION/COMMENTS
0	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.
	0-4FT Dark brown topsoil
	4-9FT Brown silty gravel
5	
10	9-15FT Brown gravel
15	15-24FT Brown, silty gravel, moist
20	
25	24-26FT Hard till, brown
	26-35FT Loose sand & gravel H20
30	

CH2MHILL

PROJECT NUMBER : 151973.A1.AT	WELL NUMBER : CHMW-2(D) SHEET 2 OF 3

WELL CONSTRUCTION/BORING LOG

PROJECT : **LONE STAR, DUPONT** LOCATION : **50' N. OF TW-2**

WATER LEVELS :

DRILLING METHOD/EQUIPMENT: **SPEEDSTAR 15, 8" STEEL CASING(TO58") &STAR 71 CABLE TOOL, 8" CASING**

START : **11/12/99** END : **11/18/99** LOGGER: **HOKKAIDO(STEVE & TOM)**

DEPTH BELOW SURFACE (FT)	CORE DESCRIPTION/COMMENTS
	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.
35	35-48FT Brown till
40	
45	
50	48-58FT Loose sand & gravel H20
55	
60	58-66FT Brown tight Silt Bound sand & gravel

CH2MHILL

PROJECT NUMBER : 151973.A1.AT	WELL NUMBER : CHMW-2(D) SHEET 3 OF 3

WELL CONSTRUCTION/BORING LOG

PROJECT : **LONE STAR, DUPONT** LOCATION : **50' N. OF TW-2**

WATER LEVELS :

DRILLING METHOD/EQUIPMENT: **SPEEDSTAR 15, 8" STEEL CASING(TO58") &STAR 71 CABLE TOOL, 8" CASING**

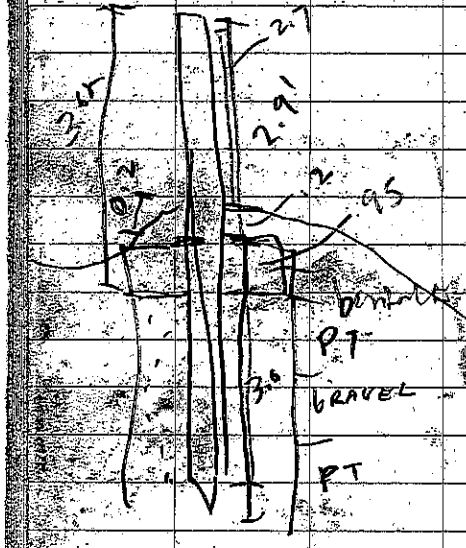
START : **11/12/99** END : **11/18/99** LOGGER: **HOKKAIDO(STEVE & TOM)**

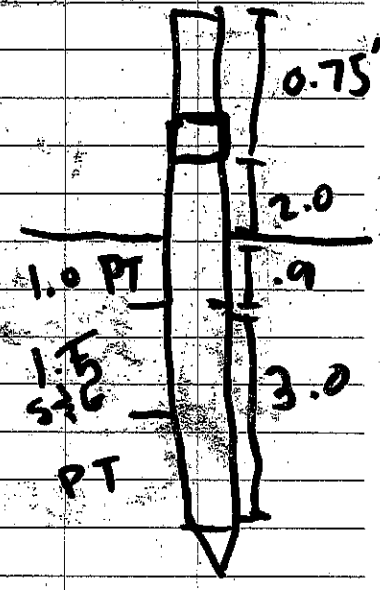
DEPTH BELOW SURFACE (FT)	CORE DESCRIPTION/COMMENTS
	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.
65	66-73FT NO RECORD
	Total Casing=72'-41/4"
	Well:
70	Stickup=2' (2"sch 40 pvc) w/j plug
	Screen= 63'-721/2' bgs (2" sch 40 pvc, 20-slot)
	w/centralizer 6"end cap 721/2-73 fbgs
	Annulus=13 50-lb bags 10-20 cssi sand
	34 50-lb bags medium bentonite chips
	Monument= 6" steel protectivecasing in concrete
75	
80	
85	
90	

CHMW- 4 (S) 18.42

4 (D) 20.81

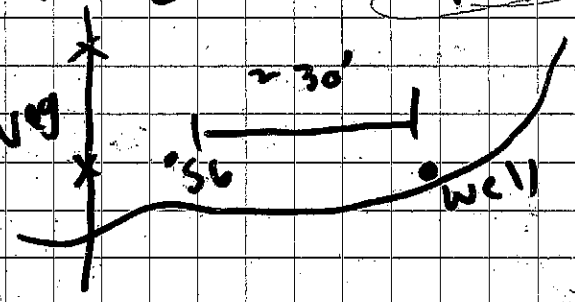
CHMW-1 19.40 14:21





Pond L. well 2.95

Pond L. SG 1.07



BM-MW-1 14.23' 12:30

BM-SG-1 2.53' 12:32

EM-1A 3.69' 12:40

Top 6.65'

SG EM1 dry Top 3.33

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
040001	SL-1	1 of 1

Project Name: North Sequalichew Creek
Location: Fort Lewis, WA
Drilling Method: Hollow stem auger, 4" ID ; Holt Drilling
Sampling Method: 3" diameter D&M
Ground Elevation 214.94

Top of PVC Casing Elev. (ft mllw) 217.74
Depth to Water (ft BTC) 6.25
Start Date March 11, 2004
Finish Date March 11, 2004

Depth feet	Well Construction	Tests\Remarks	Blows/ 6"	Sample ID	Mtl. Graphic	Description
	5" diameter steel monument, 3' stickup; Concrete seal 0'-2'					Grass, duff
						FILL
						Gravel up to 1-1/2" diameter, to a depth of 8" below ground surface
			4 3 3	S-1		Medium stiff, moist to very moist, dark brown, gravelly SILT with SAND
		3/26/04 ▼				
5			3 3 4	S-2		•Very gravelly drilling, no recovery
			9 8 11	S-3		Medium dense, wet, gray, sandy GRAVEL; sand medium to coarse, gravel fine to coarse
			4 6 6	S-4		•Low recovery, trace gravel in sampler
			7 7 7	S-5		RECESSIONAL OUTWASH Medium dense, wet, gray, very gravelly SAND; sand predominantly coarse
10	Bentonite chips 2'-13'		7 7 9	S-6		Medium dense, wet, gray-brown, sandy GRAVEL; sand predominantly coarse
			6 7 12	S-7		
			11 10 9	S-8		•Trace silt
15	10/20 silica sand filter pack 13'-20'		10 7 7	S-9		•Trace silt
	20-slot screen 15'-20'; slip cap with SS screw 20'-20.3'		4 6 7	S-10		
20						Bottom of boring at 20 feet.

Sampler Type (ST):
- 3.25" OD D & M Split-Spoon Ring Sampler
- No Recovery
- 2" OD Split-Spoon Sampler

PID - Photoionization Detector
▼ Water Level (ATD)
▽ Static Water Level

Logged by: RRH
Approved by: LJH
Figure No. B - 2

SEQUALICHEW CREEK.GPJ July 20, 2004
MW_GEOLG

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
040001	HM-MW-1	1 of 1

Project Name: North Sequalitchew Creek
Location: DuPont, Washington
Drilling Method: Hollow Stem Auger - 4" ID ; Holt Drilling
Sampling Method: 3" Diameter D&M

Top of Casing Elev. (ft mllw): 221.06
Ground Surfave Elev. (ft): 217.75
Depth to Water (ft bgs): 5
Start Date: August 2, 2004
Finish Date: August 2, 2004

Depth feet	Well Construction	Tests\Remarks	Blows/ 6"	Sample ID	Mtl. Graphic	Description
1						Brown, slightly silty GRAVEL; gravel, predominantly coarse and cobbles (observed from drill action and cuttings) (GP)
2	5" diameter steel monument, cement seal 0'-4'					
3		18"/5"	3 27 30	2.5-4		Brown, moist, slightly silty to trace silt, sandy GRAVEL; sand medium to coarse; gravel fine to coarse, abundant cobbles, subangular to rounded (GW)
4						
5		8/2/04 ▼ 18"/8"	11 23 23	5-6.5		Brown to olive gray, wet, very sandy GRAVEL, trace silt; sand medium to coarse, predominantly medium; gravel fine to coarse with cobbles, subangular to subround; no apparent organization.
6	Bentonite Chips 4'-7.5'					
7						
8		18"/11"	19 22 24	7.5-9		Color change to olive gray; grades to medium to coarse sand and predominantly fine gravel; increase in silt (still trace silt), less cobbles.
9						
10		18"/6"	22 28 32	10-11.5		Olive gray to gray-green, wet, SAND; trace gravel; sand medium to coarse, occasional zones of fine to medium; gravel fine (SP-SW)
11	10/20 silica sand filter pack 7.5'-20.3'					
12						
13		18"/12"	21 30 35	12.5-14		Olive gray, wet, slightly silty, very sandy GRAVEL; gravel fine to coarse; with cobbles; sand predominantly medium to coarse (GW-GM)
14						
15	20-slot screen 10'-20'; slip cap with SS screw 20'-20.3'	18"/10"	21 31 44	15-16.5		Gray-green to olive gray, wet, SAND, trace gravel; sand predominantly medium to coarse; gravel fine (SW)
16						Olive gray, wet, very sandy GRAVEL, trace silt, sand medium to coarse, occasional fine, predominantly coarse; gravel fine to coarse (GW)
17						
18		18"/10"	26 50/6"	17.5-19		Gray-green, wet SAND; trace gravel; sand predominantly medium to coarse (SW)
19						Olive-gray, wet, very sandy GRAVEL, trace silt; gravel fine to coarse; sand predominantly medium to coarse (GW)
20		18"/11"	26 50/6"	20-21.5		Gray to olive gray, wet SAND; sand medium; homogenous (SP)
21						
22						Olive gray to gray, wet, sandy GRAVEL, trace silt; gravel fine to coarse; subrounded to rounded; sand medium to coarse, predominantly medium (GW)
23						Total depth = 20' drilled, 22.5' driven.
24						
25						
26						
27						
28						
29						

Sampler Type (ST):
- 3.25" OD D & M Split-Spoon Ring Sampler
- No Recovery
- 2" OD Split-Spoon Sampler

PID - Photoionization Detector
▼ Water Level (ATD)
▽ Static Water Level

Logged by: ILE
Approved by: LJH
Figure No. A-2

APPENDIX B

MW_GEOL S CRK.GPJ November 23, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
040001	EM-3	1 of 1

Project Name: North Sequalichew Creek
Location: Fort Lewis, WA
Drilling Method: Hollow stem auger, 4" ID ; Holt Drilling
Sampling Method: 3" diameter D&M
Ground Elevation 214.63

Top of PVC Casing Elev. (ft mllw) 217.38
Depth to Water (ft BTC) 4.96
Start Date March 11, 2004
Finish Date March 11, 2004

Depth feet	Well Construction	Tests\Remarks	Blows/ 6"	Sample ID	Mtl. Graphic	Description
	5" diameter steel monument, 3' stickup; Concrete seal 0'-2'					Sod and dark brown organic soil
						FILL
		3/26/04 ▼				Gravel, some cobbles at 0.5'
			3 7 10	S-1		Medium dense, moist, dark brown, sandy GRAVEL with SILT and ORGANICS, trace wood
			3 6 8	S-2		Medium dense, wet, gray SAND and GRAVEL
5			6 2 1	S-3		MARSH DEPOSITS
		K Test K = 1x10^{-6} cm/s	1 1 9	S-4		Soft, wet, brown, slightly fibrous PEAT, trace gravel
			8 12 14	S-5		Medium dense, wet, brown, sandy GRAVEL to GRAVEL, trace silt
10	Bentonite chips 2'-13'		2 6 6	S-6		RECESSIONAL OUTWASH
			7 8 13	S-7		Medium dense, wet, gray SAND, trace gravel; sand fine to medium; 1/4" silt seam
			1 12 25	S-8		No recovery, coarse gravel in shoe of sampler
15			16 17 16	S-9		Dense, wet, brown, gravelly SAND to sandy GRAVEL
	10/20 silica sand filter pack 13'-20'		11 16 32	S-10		Dense, wet, sandy GRAVEL
	20-slot screen 15'-20'; slip cap with SS screw 20'-20.3'		15 25 35	S-11		
20						Bottom of boring at 20 feet.

Sampler Type (ST):
- 3.25" OD D & M Split-Spoon Ring Sampler
- No Recovery
- 2" OD Split-Spoon Sampler

PID - Photoionization Detector
▼ Water Level (ATD)
▽ Static Water Level

Logged by: RRH
Approved by: LJH

Figure No. B - 1

SEQUALICHEW CREEK.GPJ 7/29/04

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
040001	BM-MW-1	1 of 1

Project Name: North Sequalitchew Creek
Location: DuPont, Washington
Drilling Method: Hollow Stem Auger - 4" ID ; Holt Drilling
Sampling Method: 3" Diameter D&M

Top of Casing Elev. (ft mllw): 232.32
Ground Surfave Elev. (ft): 229.37
Depth to Water (ft bgs): 12.5
Start Date: August 3, 2004
Finish Date: August 3, 2004

Depth feet	Well Construction	Tests\Remarks	Blows/ 6"	Sample ID	Mtl. Graphic	Description
1	5" diameter steel monument, cement seal 0'-1.5'					Brown, dry, GRAVEL, trace silt; gravel fine to coarse, predominantly coarse; abundant cobbles, subrounded to rounded (GW)
2						
3						(Road fill)
4	Natural Fill 1.5'-5'					
5		18"/4"	11	5-6.5		Brown to tan, moist sandy GRAVEL, trace silt; gravel fine to coarse, subrounded to rounded; sand predominantly medium to coarse.
6			12			
7			10			
8		18"/12"	4	7.5-9		Brown to reddish brown, moist, slightly gravelly SAND, trace silt; sand fine to coarse, predominantly medium; gravel fine, subangular to rounded (SP)
9	Bentonite Chips 5'-12'		10			
10			16			
11		18"/5"	9	10-11.5		Occasional coarse gravel and grades medium to coarse sand.
12		8/3/04 ▼	15			
13		18"/6"	19			
	10/20 silica sand filter pack 12'-26.5'		8	12.5-14		Brown to red-brown, wet, gravelly SAND, trace silt; sand predominantly coarse; gravel fine to coarse, predominantly fine.
15		18"/10"	14			
16			15			
17			9	15-16.5		
18		18"/8"	10			Yellowish-green to brown, highly oxidized, wet, slightly to trace silt; sandy GRAVEL; gravel fine to coarse; sand predominantly coarse (GW-GM)
19			16			
20	20-slot screen 15'-25'; slip cap with SS screw 25'-25.3'	18"/12"	5	17.5-19		Yellow brown, highly oxidized, wet, slightly gravelly SAND, trace silt; sand medium to coarse, predominantly coarse; gravel predominantly fine (SP)
21			8			Grades to slightly silty and gravelly in shoe (SP-SM)
22			8			
23		18"/14"	9	20-21.5		Gray olive, wet, SAND; trace gravel; trace to no silt; sand predominantly medium to coarse (SP)
24			11			
25		18"/3"	13			Gray green, wet, slightly silty to trace silt, sandy GRAVEL; gravel fine to coarse, subrounded to rounded; sand medium to coarse. (GP-GM)
26			13	22.5-24		Gray green, wet, SAND; sand medium (SP)
27			25			
28			24			Gray olive, wet, sandy GRAVEL, trace silt; gravel fine to coarse, sand predominantly medium to coarse (GP)
29			28	25-26.5		Gray olive, wet, slightly silty sandy GRAVEL; gravel fine to coarse; sand medium to coarse (GP-GM)
			19			
			17			Total depth = 25' drilled; 26.5' driven.

Sampler Type (ST):
- 3.25" OD D & M Split-Spoon Ring Sampler
- No Recovery
- 2" OD Split-Spoon Sampler

PID - Photoionization Detector
▼ Water Level (ATD)
▽ Static Water Level

Logged by: ILE
Approved by: LJH
Figure No. A- 1

APPENDIX B

MW_GEOL S CRK_SEQ CRK.GPJ November 23, 2004

CH2MHILL

GS elev = 212.1'

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-2
Sheet: 1 of 3

SOIL BORING LOG

PROJECT: N. Sequalitchew Creek Wetland **LOCATION:** ~10' S. of Edmond Marsh Trail
ELEVATION: **DRILLING CONTRACTOR:** Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log **START:** 12/12/02 0934 **FINISH:** 12/12/02 1228 **LOGGER:** S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0					Ground Surface	
		DM	12	2-5-5 (10)	SILTY SAND WITH ORGANICS (SM) Dark brown, moist, loose, fine grained sand, trace fine to medium round to subround gravel, est. 30-40% fines, 20% organics (TOPSOIL)	Two piezometers installed in separate monuments. EM-2(S) is the shallow piezometer, and EM-2(D) is the deep piezometer
		DM	6	5-6-6 (12)	SANDY SILTY GRAVEL (GM) Dark brown, moist to wet, medium dense, well graded round to subround gravel, est. 20% fines, 30-40% sand, trace organics (FILL)	3': Driller states in gravel and a little water
		DM	18	3-1-1 (2)	SILTY SAND WITH GRAVEL (SM) Light brown, moist, medium dense, fine to medium grained sand, fine to medium round to subround gravel, est. 15-20% gravel, 20% fines, trace organics (FILL)	
5		DM	18	6-16-18 (34)		5': Driller states drilling in gravel
					PEAT (PT) Dark brown, wet, very soft, fiberous	
					SANDY SILTY GRAVEL (GM) Gray, moist, medium dense, well graded round to subround gravel, fine to medium grained sand, est. 20% fines, 30% sand	8': Sampled, then loaded hole with water
		DM	12	18-21-15 (36)	SILTY SAND WITH GRAVEL (SM) Gray, wet, medium dense, fine to medium grained sand, fine to coarse round to subround gravel, est. 20-30% fines, 20-30% gravel, not compacted, soupy	
10						
		DM	12	18-22-18 (40)	GRAVELLY WELL GRADED SAND (SW) Gray, wet, medium dense, round to subround sand and gravel, fine to medium gravel, trace coarse gravel, est. <5% fines, 30-40% gravel	13': Driller states from 8-13' pretty sandy, not much gravel 14': Sampler wet
15						
		DM	10	44-50/6" (50/6")	GRAVELLY WELL GRADED SAND (SW) Gray, moist to wet, very dense, fine to coarse grained sand, fine round to subround gravel, est. 30-35% gravel	18': Top of sample was heave
20						

CH2MHILL

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-2
Sheet: 2 of 3

SOIL BORING LOG

PROJECT: N. Sequalitchew Creek Wetland **LOCATION:** ~10' S. of Edmond Marsh Trail
ELEVATION: **DRILLING CONTRACTOR:** Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log **START:** 12/12/02 0934 **FINISH:** 12/12/02 1228 **LOGGER:** S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		DM	12	24-26-30 (56)	GRAVELLY WELL GRADED SAND (GW) Gray, moist to wet, medium dense, fine to coarse grained sand, fine to coarse round to subround gravel, est. 30-40% gravel	20.5': Heave in sampler
		DM	12	34-50/6" (50/6")	SANDY WELL GRADED GRAVEL (GW) Gray, moist to wet, very dense, well graded sand, round to subround gravel, est. 30-35% sand	
25		DM	12	23-36-50/6" (86/12")	SANDY WELL GRADED GRAVEL (GW) -Similar to above, gray, moist to wet, dense to very dense, well graded sand, est. 30-40% sand, becomes siltier toward bottom of sample, est. up to 10% silt toward bottom of sample	25.5': Driller drained water out of samples before opening split spoon. Driller loads hole with water, difficult to determine if samples are wet from drilling water or groundwater. All heave in sample from 25.5'. Resampled.
30		DM	12	32-40-50/6" (90/12")	GRAVELLY WELL GRADED SAND (SW) Gray, moist to wet, very dense, fine to coarse grained sand, fine round to subround gravel, "clean"-little to no fines	
		DM	12	36-44-50/6" (94/12")	GRAVELLY WELL GRADED SAND (SW) -Similar to above	
35		DM	2	44-50/3" (50/3")	WELL GRADED SAND (SW) Gray, moist to wet, very dense, fine to coarse round to subround sand	
		DM	6	36-50/6" (50/6")	SANDY WELL GRADED GRAVEL (GW) Gray, moist to wet, very dense, well graded sand, round to subround gravel, est. 30-40% sand, est. 5% silt	
40		DM	3	33-40-50/6" (90/12")	POORLY GRADED SAND WITH GRAVEL (SP) Gray, moist to wet, very dense, fine to medium grained sand, coarse round to subround gravel, est. 15-20% gravel	38': 3" of heave in sampler

CH2MHILL

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-2
Sheet: 3 of 3

SOIL BORING LOG

PROJECT: N. Sequalitchew Creek Wetland **LOCATION:** ~10' S. of Edmond Marsh Trail
ELEVATION: **DRILLING CONTRACTOR:** Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log **START:** 12/12/02 0934 **FINISH:** 12/12/02 1228 **LOGGER:** S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		DM	10	16-38-50/6" (88/12")	**WELL GRAED SAND WITH GRAVEL (SW)** Gray, moist to wet, very dense, fine round to subround gravel, "clean", grades to **WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM)** 42' Gray, moist to wet, very dense, fine round to subround gravel, est. 15% gravel, 10-15% silt	
		DM	12	18-28-30 (58)	**POORLY GRADED SAND (SP)** Gray, moist to wet, fine to medium grained sand, trace fine to coarse round to subround gravel, est. 5% or less gravel	
45		DM	12	29-36-42 (78)	**POORLY GRADED SAND (SP)** -Similar to above, some gravels have brown staining surrounding the gravel and within the fine grained sand, fine gravel	
Qvr		DM	12	36-50/6" (50/6")	**POORLY GRADED SAND WITH GRAVEL (SP)** Gray, moist, very dense, fine to medium grained sand, fine to coarse round to subround gravel, gravel was packed in "tight", trace dark organics?, pockets/lenses of fine sand at 48'	48': Driller states it felt more compacted Bottom of boring at 51.7' at 1228 on 12-12-02
50		DM	6	(100/6")	**SILTY WELL GRADED SAND WITH GRAVEL (SM)** Gray, moist to wet, very dense, some is compact where the sand is finer grained, est. 20-25% gravel	**Deep Piezometer Construction (EM-2(D))** +2.55-0' Steel riser, locking monument 0-2' Concrete 2-36' Quick grout 36-38' Bentonite chips 38-51.7' Lapis Lustre 2/12 silica sand 0-40' Blank pvc 40-50' 0.020 machine slot screen and cap
Qvt		SS	6	(100/8")	**SILTY SAND WITH GRAVEL (SM)** Gray, moist, very dense, fine grained sand, fine round to subround gravel, est. 20-25% gravel, compacted looking	
55					BOTTOM OF BORING	**Shallow Piezometer Construction (EM-2(S))** Drilled and installed in a separate monument about 3 feet east of deep well 0-1' Concrete and riser 1-2' Bentonite chips 2-5' Lapis Lustre 2/12 silica sand 0-2.5' Blank pvc 2.5-5' 0.020 machine slot screen and cap
60						

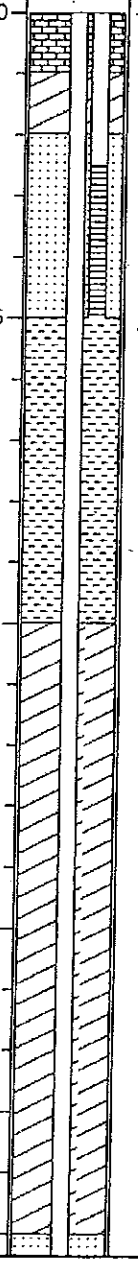
CH2MHILL

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-1
Sheet: 1 of 2

SOIL BORING LOG

GS elev = 207.3

PROJECT: N. Sequalitchew Creek Wetland **LOCATION:** ~100' S. of Edmond Marsh Trail
ELEVATION: **DRILLING CONTRACTOR:** Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log **START:** 12/11/02 1544 **FINISH:** 12/11/02 1620 **LOGGER:** S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0					Ground Surface	Drilled down to 24 feet bgs before first sample. Two piezometers installed in one monument. EM-1(S) is the shallow piezometer, and EM-1(D) is the deep piezometer 4': Driller states in gravel and a little water 12': Sounded gravelley to 14' while drilling, rig stopped in gravel 14': Loaded hole with water 14-16': Gravelly, smoother drilling below 16' 17': Driller states cobbles about 4" in diameter, then smaller sized gravels below 17' 17-24': Smooth drilling, loaded hole with water
5						
10						
15						
20						

CH2MHILL

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-1
Sheet: 2 of 2

SOIL BORING LOG

PROJECT: N. Sequalitchew Creek Wetland LOCATION: ~100' S. of Edmond Marsh Trail
ELEVATION: DRILLING CONTRACTOR: Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log START: 12/11/02 1544 FINISH: 12/11/02 1620 LOGGER: S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
25		DM	12	16-20-25 (45)	POORLY GRADED SAND WITH GRAVEL (SP) Gray, wet, medium dense, fine to medium grained sand, fine to coarse round to subround gravel, est. 15-20% gravel	
		DM	0	39-50/4" (50/4")	POORLY GRADED SAND WITH GRAVEL (SP) -similar to above but fine to medium gravel	Bottom of boring at 33.5' at 1620 on 12/11/02.
30		DM	12	34-35-35 (70)	No recovery -Slough	Measured groundwater at 6.10' (EM-1(S)) and 7.47' (EM-1 (D)) below top of steel on 12/11/02
		DM	6	50/6" (50/6")	POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM) Gray, wet, very dense, fine to medium grained sand, fine to coarse gravel, gets siltier toward bottom of sample, grades to SILTY SAND WITH GRAVEL (SM) at 32' Gray, wet, very dense, fine to medium grained sand, fine to medium round to subround gravel, est. 10-20% silt, 20-25% gravel	Piezometer Construction (EM-1(S) and EM-1(D)) +3.65-0' Steel riser, locking monument 3.xx-2.5' Blank PVC (EM-1(S)) 3.xx-22' Blank PVC (EM-1(D)) 0-1' Concrete 1-2' Bentonite chips 2-5' Lapis Lustre 2/12 silica sand 2.5-5' 0.020 machine slot screen and cap (EM-1(S)) 5-10' Cuttings 10-20' Bentonite chips 20-33.5' Lapis Lustre 2/12 silica sand 22-32' 0.020 machine slot screen and cap (EM-1(D)) Note: Both piezometers are in one steel, riser monument
35					BOTTOM OF BORING	
40						

CH2MHILL

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-1A
Sheet: 1 of 5

SOIL BORING LOG

PROJECT: N. Sequalitchew Creek Wetland **LOCATION:** ~100' S. of Edmond Marsh Trail
ELEVATION: **DRILLING CONTRACTOR:** Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log **START:** 12/11/02 **FINISH:** 12/11/02 **LOGGER:** S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0					Ground Surface	
		DM	18	1/12"-1/6" (2)	ORGANICS Dark brown, moist, very soft	
		DM	18	5-7-12 (19)	PEAT (PT) Dark brown, moist, very soft, fiberous	
		DM	8	43-40-40 (80)	SANDY SILTY GRAVEL (SM) Light brown, wet, loose, fine to coarse grained sand, coarse round to subround gravel	3': Driller states in gravel and a little water
5		DM	8	35-37-39 (76)	PEAT (PT) Dark brown, moist, very soft, fiberous, trace gravel mixed in	4.5': Sampler very wet, large gravel/small cobble jammed in shoe
					SANDY SILTY GRAVEL (GM) -Similar to above, light brown, wet, dense, fine to coarse grained sand, coarse round to subround gravel	6': Drilled in gravel from 4.5-6'.
					SILTY SAND WITH GRAVEL (SM) Gray, wet, dense, fine to coarse grained sand, fine to coarse round to subround gravel, trace round cobbles (TILL-LIKE)	
10		DM	10	28-35-39 (74)	SILTY GRAVEL WITH SAND (SM) Gray, wet, dense, fine to coarse gravel, fine to coarse grained sand, est. 30% silt, 20% sand (TILL-LIKE) In shoe: SANDY SILT (ML) Gray, moist, hard, fine to medium grained sand, est. 20-30% sand	
15		DM	12	42-35-38 (73) ?	SANDY WELL GRADED GRAVEL WITH SILT (GW-GM) Gray, wet, medium dense, fine to coarse round to subround gravel, fine to coarse sand, est. 30% sand, 10-15% fines	14': Sampler wet 17': Driller states not as much rock, large gravel 19': Water poured out of sampler 19.5': Measured groundwater through augers at 1406 on 12/11/02. Augers may be acting as a barrier.
20		DM	4	21-25-27 (52)		

CH2MHILL

PROJECT NUMBER: 151973.A4.WL **BORING NUMBER:** EM-1A
Sheet: 2 of 5

SOIL BORING LOG

PROJECT: N. Sequalitchew Creek Wetland **LOCATION:** ~100' S. of Edmond Marsh Trail
ELEVATION: **DRILLING CONTRACTOR:** Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log **START:** 12/11/02 **FINISH:** 12/11/02 **LOGGER:** S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
					GRAVELLY SAND (SW) Gray, wet, medium dense, fine to coarse grained sand, fine to coarse round to subround gravel, est. 30-40% gravel	
25		DM	10	42-33-30 (63)	**POORLY GRADED SAND WITH GRAVEL (SP** Gray, wet, medium dense, fine to medium grained sand, fine to coarse round to subround gravel, trace fine cobbles, est. 15-20% gravel	
30		DM	12	24-35-38 (73)	**WELL GRADED SAND WITH GRAVEL (SW)** Gray, wet, medium dense, fine to coarse grained sand, fine to medium round to subround gravel, trace fines, increased fines toward bottom of sampler, est. 20-30% gravel	
35		DM	6	50/6" (50/6")	**POORLY GRADED SAND WITH SILT AND GRAVEL TO SILTY SAND WITH GRAVEL (SP-SM/SM)** Gray, wet, very dense, fine to medium grained sand, fine to medium round to subround gravel, est. 10-20% fines, 20-25% gravel (TILL??)	34': Driller states back into a few cobbles
40		DM	4	50/4" (50/4")		

Qvt
Dof
d
Boring

CH2MHILL

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-1A
Sheet: 3 of 5

SOIL BORING LOG

PROJECT: N. Sequalitchew Creek Wetland **LOCATION:** ~100' S. of Edmond Marsh Trail
ELEVATION: **DRILLING CONTRACTOR:** Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log **START:** 12/11/02 **FINISH:** 12/11/02 **LOGGER:** S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
					POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM) Gray, wet, very dense, fine to medium grained sand, fine to coarse round to subround gravel, est. 10% fines, 10-15% gravel	
45		DM	4	50/5" (50/5")	POORLY GRADED SAND (SP) Gray, wet, very dense, fine to medium grained sand, trace fines	
50		DM	4	50/4" (50/4")	GRAVELLY WELL GRADED SAND WITH SILT (SW-SM) Gray, wet, very dense, fine to coarse round to subround gravel, est. 5-10% fines, 30-40% gravel	
55		DM	6	50/6" (50/6")	POORLY GRADED SAND (SP) Gray, wet, very dense, fine to medium grained sand	
60		DM	6	50/6" (50/6")		59': Driller states a little more gravel

CH2MHILL

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-1A
Sheet: 4 of 5

SOIL BORING LOG

PROJECT: N. Sequalitchew Creek Wetland **LOCATION:** ~100' S. of Edmond Marsh Trail
ELEVATION: **DRILLING CONTRACTOR:** Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log **START:** 12/11/02 **FINISH:** 12/11/02 **LOGGER:** S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
					POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM) Gray, wet, very dense, fine to medium grained sand, fine to medium round to subround gravel, est. 10-15% fines, 5-10% gravel	
65		DM	5	50/5" (50/5")	WELL GRADED SAND WITH GRAVEL TO WELL GRADED SAND WITH SILT AND GRAVEL (SW/SW-SM) Gray, wet, very dense, fine to coarse grained sand, fine to medium round to subround gravel, est. 5-10% fines, 20-30% gravel	
70		DM	5	50/5" (50/5")	POORLY GRADED SAND (SP) Gray, wet, very dense, medium to coarse grained round to subround sand, fine to medium round to subround gravel, est. <5% fines, 5-10% gravel	
75		DM	6	50/6" (50/6")	WELL GRADED SAND WITH GRAVEL TO WELL GRADED SAND WITH SILT AND GRAVEL (SW/SW-SM) Gray, wet, very dense, fine to coarse grained sand, fine round to subround gravel, est. 5-10% fines, 10-15% gravel	
80		DM	5	50/5" (50/5")		

CH2MHILL

PROJECT NUMBER: 151973.A4.WL BORING NUMBER: EM-1A
Sheet: 5 of 5

SOIL BORING LOG

PROJECT: N. Sequalitchew Creek Wetland LOCATION: ~100' S. of Edmond Marsh Trail
ELEVATION: DRILLING CONTRACTOR: Cascade Drilling
DRILLING METHOD AND EQUIPMENT: CME 75 nodwell track rig, HSA, Dames & Moore, 140lb hammer
WATER LEVELS: See log START: 12/11/02 FINISH: 12/11/02 LOGGER: S. McGinnis

DEPTH BELOW GROUND SURFACE	WELL INSTALLATION	SAMPLE TYPE	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
					POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM) Gray, wet, very dense, fine grained sand, fine to medium round to subround gravel, est. 10-15% fines, 20-30% gravel	
						83': Driller states into silts
85		DM	4	50/4" (50/4")	SILT (ML) Gray, moist to wet, hard	
90		DM	4	50/4" (50/4")	SILT (ML) -Similar to above, gray, moist to wet, hard, fine to medium sand seams	Bottom of boring at 89.3' at 1300 on 12/11/02.
					BOTTOM OF BORING	Driller states not much heave while drilling
						Backfilled boring with grout. Could not install piezometer in this boring. Had to move 3' north and redrill to the bottom of the piezometer installation.
95						
100						

RESOURCE PROTECTION WELL REPORT

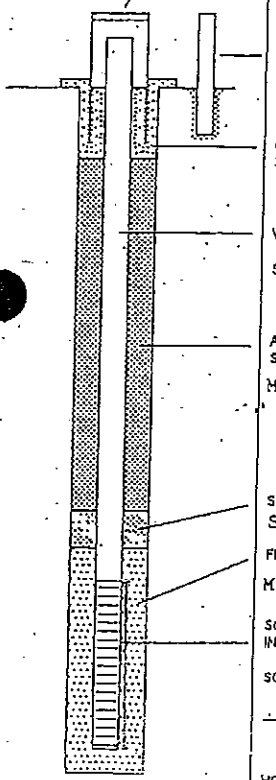
Close Demolition Waste Area - Ft. Lewis

START CARD NO. 17224

PROJECT NAME: Fort Lewis Public Works
WELL IDENTIFICATION NO. D-3
DRILLING METHOD: reverse circ. w/air
DRILLER: Charles E. Shorey, Jr.
FIRM: Layne Christensen Company
SIGNATURE:
CONSULTING FIRM: IMCO General Construction
REPRESENTATIVE: Roger Dudley

COUNTY: Pierce
LOCATION: ___ ¼ ___ ¼ SEC 26 TWN 19N R 1E
STREET ADDRESS OF WELL: Fort Lewis, WA 98433-9500
WATER LEVEL ELEVATION: 11' BGS
GROUND SURFACE ELEVATION: 216
DATE INSTALLED: 8-5-96
DATE DEVELOPED: 8-12-96, 8-14-96

AS-BUILT



OF BORING 24 FT.

WELL DATA

STEEL SURFACE MONUMENT
W/LOCK 3 FT. ABOVE G.L.
PROTECTIVE POSTS no
CONCRETE SURFACE SEAL 2' TO +4" FT.
WELL CASING 14 TO +3 FT.
SCHEDULE 80 TFJ PVC 2"
ANNULAR SEALANT 8 TO 2 FT.
Material: Cement
SEAL 10 TO 8 FT.
Silica sand 12'-10'
FILTER PACK 24 TO 12 FT.
Material: 10-20 sand
SCREEN INTERVAL 24 TO 14 FT.
SCHEDULE 80 TFJ PVC 2"
.02 FACTORY SLOTTED
HOLE DIAMETER
9 IN. 24 TO 0 FT.
___ IN ___ TO ___ FT.

FORMATION DESCRIPTION

0'-5' Coarse sand with medium gravel, brown in color

5'-10' Coarse to medium sand, with large and medium cobbles

10'-15' Fine silty sand, wet, light brown

11' Static water level

15'-20' Fine, dense sand with silt and uniform cobbles

20'-24' Fine silty sand, dense with uniform cobbles

WELL DEVELOPMENT DATA

8-12-96 Bailed 15 gallons from well to remove sediments
Temperature: 60 degrees F
pH: 6.0 Very silty, brown

8-14-96 Pumped 150 gallons from well to stabilize.
Temperature: 60 degrees F
pH; 6.0 Clear, no sediment

Layne Christensen Company
1401 E 26th Street - Tacoma WA 98421 (206) 572-4222 FAX (206) 572-4223

WELL COMPLETION REPORT

Project CELL 5, LFS, FT. LEWIS
Completion date 2/25/93
Contractor ANDREW WELL DRILLING SERVICE
Rig INGERSOLL RAND T-4W
Operator BOB DEWILD/MATT GILBERT
Inspector RICHARD SMITH
Depth 35.0 Datum GROUND SURFACE

HOLE DATA
Size: 6" in. to 35' ft.
____ in. to ____ ft.
____ in. to ____ ft.

CASING
Type 6" DIAMETER, 5' LONG STEEL SURFACE CASING
Mfr.
Ht. above gnd. surf. 3.0'
Drive shoe NO
Size: 6" in. to 3' AGS ft.
6" in. to 3' BGS ft.
____ in. to ____ ft.

SCREEN - 20' -30' (10') THREADED
Type PVC SCH 80 MONOFLEX 20 SLOT
Mfr. CAMPBELL
Composition PVC Dia. 2" ID

Fittings:	Length	Dia.
Riser	22.8'	2" ID
Tailpipe	0.2'	2" ID

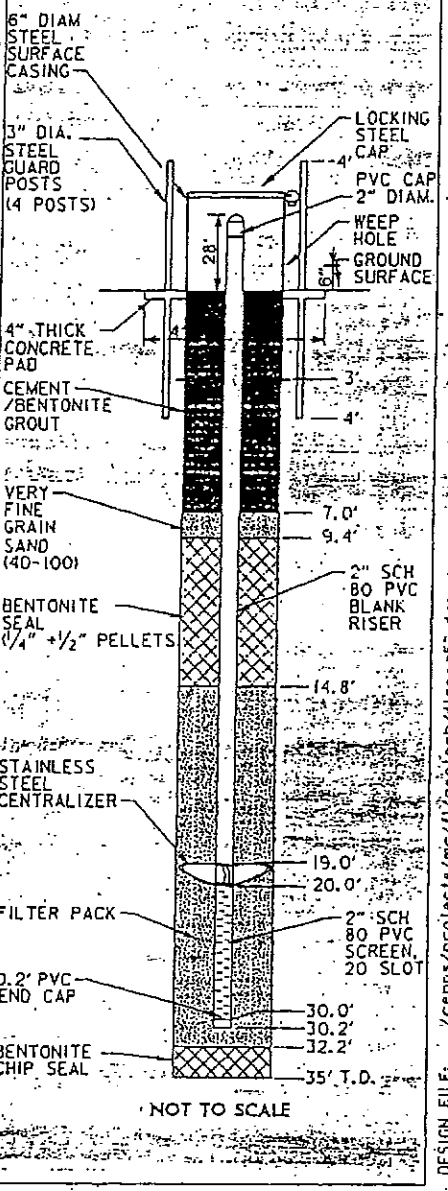
Centralizer- S.S. mounted on outside of PVC Riser 19' -20' BGS

FILTER
Source CSSI - ENVIRONMENTAL MEDIA
Composition SILICA SAND
Gradation 10-20
Inst. method POUR FROM SURFACE
Volume used 4 SACS (100 LB SAC)
Depth 14.8' to 32.2' ft.

GROUT
Composition CEMENT/BENT 5%/H20
Volume used 2-94 LBS BAGS CEMENT (12GAL)
Inst. method POUR DOWNHOLE W/BUCKET
Depth 0' to 7' ft.
____ to ____ ft.

REMARKS: BOTTOM PLUG BENT. CHIPS ½, 50 LB BAG
UPPER PLUG: BENT. PELLETS (⅜"), 2 - 50 LB
BUCKETS, VERY FINE SAND: ½ - 50 LB BAG.
FILLED CASING W/POTABLE WATER TO GROUND
SURFACE PRIOR TO INSTALLATION TO PREVENT
HEAVING AND AID IN PLACING BENT. PLUG.
GROUT RATIO: -1 SAC CEMENT (94 LBS)
6 GAL H20 - 5% BENT. BY WT

WELL DETAIL (AS BUILT)
93-MFS-C5-3



NOT TO SCALE

DESIGN FILE: /cenps/projects/mc/112geotech/11geoc53.dgn DATE AND TIME PLOTTED: 06-MAY-1993

DRILLING LOG	DIVISION NPO	INSTALLATION FORT LEWIS	SHEET 1 OF 1 SHEETS
1. PROJECT RCRA WELLS, CS, LF5		10. SIZE AND TYPE OF BIT 6" ODEX/6" ID TEMP CASING	
2. LOCATION (COORDINATES OR STATION) N 659,446.7 E 1,468,392.9		11. DATUM FOR ELEVATION SHOWN (TBM OR MSL) MSL	
3. DRILLING AGENCY ANDREW WELL DRILLING SERVICE		12. MANUFACTURER'S DESIGNATION OF DRILL INGERSOLL RAND T-4W	
4. HOLE NO. (AS SHOWN ON DRAWING TITLE AND FILE NUMBER) 93-WFS-CS-3		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 7; UNDISTURBED -0-	
5. NAME OF DRILLER BOB DEWILD, MATT GILBERT		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER 195.5	
7. THICKNESS OF OVERBURDEN +35'		16. DATE HOLE STARTED 930CT24 COMPLETED 930CT24	
8. DEPTH DRILLED INTO ROCK -0-		17. ELEVATION TOP OF HOLE 216.9	
9. TOTAL DEPTH OF HOLE 35'		18. TOTAL CORE RECOVERY FOR BORING	
		19. NAME AND SIGNATURE OF INSPECTOR BILL GOSS	

ELEVATION	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (DESCRIPTION)	% CORE RECOV-ERY	BOX OR SAMPLE NO.	REMARKS (DRILLING TIME, WATER LOSS, DEPTH OF WEATHERING, ETC., IF SIGNIFICANT)
	0		GP; POORLY GRADED SANDY GRAVEL; UNCONSOLIDATED, DRY, BROWN		A	DRILLED W/6; ODEX, 6" DRILLING CONCURRENT W/CASING, BIT LEADS CASING BY 6"
	10				B	SAMPLES TAKEN FROM DISCHARGE AT 5' INTERVALS
					C	AIR MONITORING WITH CGI AND PID - NO DETECT
	20		SWL 21.4'		D	
195.5			GP; POORLY GRADED SANDY GRAVEL; UNCONSOLIDATED, WET, BROWN		E	
	30				F	
	35		T.D. 35'		G	

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT RCRA WELLS, CS, LF5 HOLE NO. 93-WFS-CS-3

MAR 71
SEP 90 MODIFIED FOR CADD BY CEHQ

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 218.9 | Hole No. 93-MFS-CS-3

PROJECT RCRA WELLS, CS, LF5 | INSTALLATION FT LEWIS | SHEET 2 OF 4 SHEETS

ELEVATION	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (DESCRIPTION)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (DRILLING TIME, WATER LOSS, DEPTH OF WEATHERING, ETC., IF SIGNIFICANT)
	10		GP: POORLY GRADED SANDY GRAVEL; UNCONSOLIDATED, SAND FINE - COARSE, ROUNDED GRAVEL TO 1", DRY, BROWN		B	SAMPLE B @ 10'
	11					AIR MONITORING 10-15' PID (-0.8) PPM CGI 20.8%, 0.0.0
	12					
	13					
	14					
	15		GP: POORLY GRADED SANDY GRAVEL; UNCONSOLIDATED, SAND FINE - COARSE, ROUNDED GRAVEL TO 1½" - DRY, TO SLT. MOIST, BROWN		C	SAMPLE C @ 15'
	16					AIR MONITORING 15'-17' PID (-0.8)PPM CGI 20.8.0.0.0 - 1 9:25 - 10:15 @ 17' WELD CASING
	17					AIR MONITORING 17'-20' PID (-0.4)PPM CGI 21.0.1.0.0
	18					
	19					
	20					

ENG FORM 1836-A PREVIOUS EDITIONS ARE OBSOLETE. SEP 80 MODIFIED FOR CADD BY CEMPS

PROJECT RCRA WELLS, CS, LF5 | HOLE NO. 93-MFS-CS-3

DRILLING LOG	DIVISION: NPD	INSTALLATION: FORT LEWIS	SHEET 1 OF 4 SHEETS
1. PROJECT: RCRA WELLS, C5, LF5		10. SIZE AND TYPE OF BIT: 6" ODEX/6" ID TEMP. CASING	
2. LOCATION (COORDINATES OR STATION): N 659,446.7 E 1,368,392.9		11. DATUM FOR ELEVATION SHOWN: MSL	
3. DRILLING AGENCY: ANDREW WELL DRILLING SERVICE		12. MANUFACTURER'S DESIGNATION OF DRILL: INGERSOLL RAND T-4W	
4. HOLE NO. (AS SHOWN ON DRAWING) TITLE AND FILE NUMBER: 93-WFS-C5-3		13. TOTAL NO. OF OVERBURDEN & BEDROCK SAMPLES TAKEN: DISTURBED 7; UNDISTURBED -0-	
5. NAME OF DRILLER: BOB DEWILD, MATT GILBERT		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER: 195.5	
7. THICKNESS OF OVERBURDEN: ±35'		16. DATE HOLE: STARTED 930CT24; COMPLETED 930CT24	
8. DEPTH DRILLED INTO ROCK: -0-		17. ELEVATION TOP OF HOLE: 218.9	
9. TOTAL DEPTH OF HOLE: 35'		18. TOTAL CORE RECOVERY FOR BORING: 1	
		19. NAME AND SIGNATURE OF INSPECTOR: BILL GOSS	

ELEVATION	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (DESCRIPTION)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (DRILLING TIME, WATER LOSS, DEPTH OF WEATHERING, ETC., IF SIGNIFICANT)
	0		GP: POORLY GRADED SANDY GRAVEL; UNCONSOLIDATED. SAND FINE -COARSE ROUNDED GRAVEL TO 3". DRY. BROWN. OCCASIONAL COBBLE TO 6"			DRILLED W/6" ODEX, 6" CASING CONCURRENT W/DRILLING. BIT LEADS CASING BY 6" SAMPLES TAKEN FROM DISCHARGE LINE AT 5' INTERVALS AIR MONITORING W/PID & CGI AIR MONITORING @ 5' PID 1-0.4 PPM CGI 20,9,0,0,0
	5		GP: POORLY GRADED SANDY GRAVEL; UNCONSOLIDATED. SAND FINE - COARSE. ROUNDED GRAVEL TO 1". SLT. MOIST. BROWN		(1)	SAMPLE (1) @ 5'
	10					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. SEP 90 MODIFIED FOR CADD BY CEMPR

PROJECT: RCRA WELLS, C5, LF5 HOLE NO. 93-WFS-C5-3

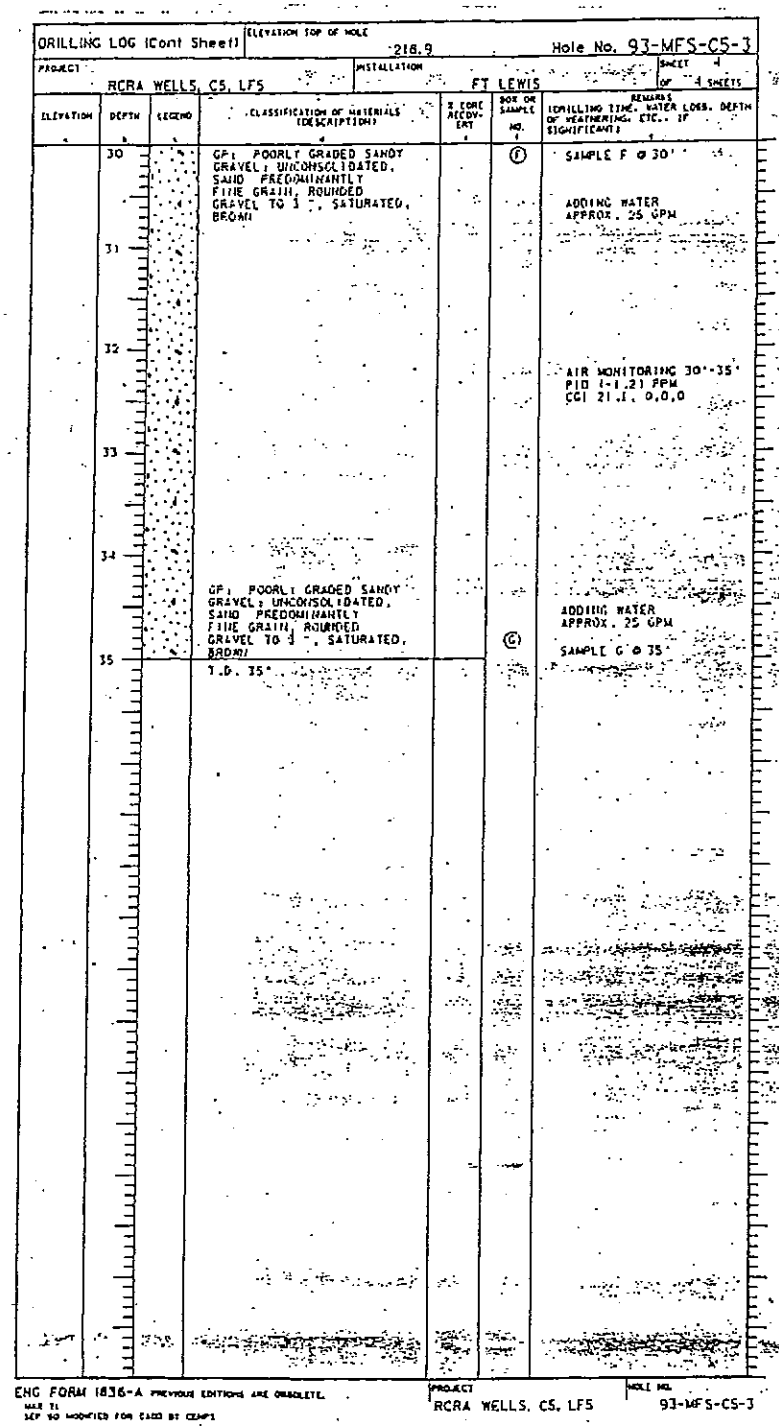
DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 216.9 | Hole No. 93-MFS-C5-3

PROJECT: RCRA WELLS, C5, LF5 | INSTALLATION: FT LEWIS | SHEET 3 OF 4 SHEETS

ELEVATION	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (DESCRIPTION)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (DRILLING TIME, WATER LOSS, DEPTH OF WEATHERING, ETC. - IF SIGNIFICANT)
	20		GP: POORLY GRADED SAND & GRAVEL; UNCONSOLIDATED, SAND FINE - COARSE, ROUNDED GRAVEL TO 1½", DRY, BROWN		(D)	SAMPLE D @ 20'
	21		@ 21' SAMPLE MOIST			AIR MONITORING 20'-25' PID (-0.4)PPM CGI 21, 1.0, 0
195.5			SWL 21.4			
	22					
	23					
	24					
	25		GP: POORLY GRADED SAND & GRAVEL; UNCONSOLIDATED, SAND FINE - COARSE, ROUNDED GRAVEL TO 1½", MOIST, BROWN		(E)	SAMPLE E @ 25'
						@ 25' ADD POTABLE WATER WHILE DRILLING APPROX. 2GPM
	26					FOOTEM LOSE FROZEN HOSE THAW HOSE & ADD WATER
	27					
	28					AIR MONITORING 25'-30' PID (-1.0) PPM CGI 21.0.0.0.1
	29		GP: AS ABOVE W/SAND PREDOMINANTLY FINE GRAIN			
	30					

ENG FORM 1836-A PREVIOUS EDITIONS ARE OBSOLETE. MAR 77 SEP 90 MODIFIED FOR CADD BY CEMPS

PROJECT: RCRA WELLS, C5, LF5 | HOLE NO. 93-MFS-C5-3



DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 218.9 | Hole No. 93-MFS-CS-3

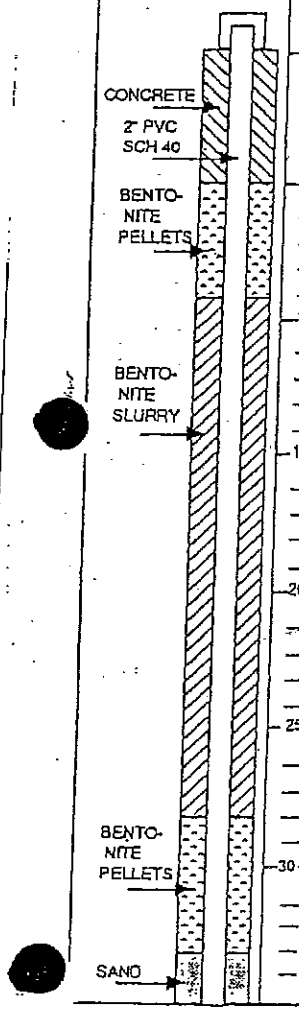
PROJECT: RCRA WELLS, CS, LF5 | INSTALLATION: FT LEWIS | SHEET 4 OF 4 SHEETS

ELEVATION	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (DESCRIPTION)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (DRILLING TIME, WATER LOSS, DEPTH OF WEATHERING, ETC., IF SIGNIFICANT)
	30		GP: POORLY GRADED SANDY GRAVEL; UNCONSOLIDATED, SAND PREDOMINANTLY FINE GRAIN, ROUNDED GRAVEL TO 3", SATURATED, BROWN		(F)	SAMPLE F @ 30'
						ADDING WATER APPROX. 25 GPM
	31					
	32					AIR MONITORING 30'-35' PID (-1.2) PPM CGI 21.1, 0.0,0
	33					
	34					
			GP: POORLY GRADED SANDY GRAVEL; UNCONSOLIDATED, SAND PREDOMINANTLY FINE GRAIN, ROUNDED GRAVEL TO 3", SATURATED, BROWN			ADDING WATER APPROX. 25 GPM
	35		T.D. 35'		(G)	SAMPLE G @ 35'

ENG FORM 1836-A PREVIOUS EDITIONS ARE OBSOLETE. MAR 71 SEP 80 MODIFIED FOR USED BY CEMP1

PROJECT: RCRA WELLS, CS, LF5 | HOLE NO. 93-MFS-CS-3

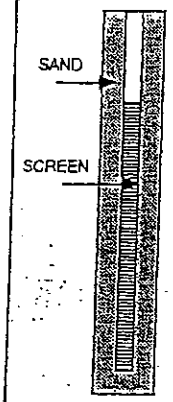
DRILLING LOG	PROJECT FT. LEWIS	PROJECT NUMBER 8820072A	SHEET 1 OF 2 SHEETS
LOCATION	LANDFILL #5	TOTAL NUMBER SAMPLES 0 (Sample Collected in Adjacent Hole)	
DRILLING AGENCY	HOLT	DEPTH TO WATER BELOW GRD SURFACE 22.06 FT	
HOLE NO.	88-2-VD	DATE HOLE STARTED 11/16/88	COMPLETED 11/17/88
NAME OF DRILLER	RANDY HOLT	ELEVATION AT REFERENCE POINT 220.03 FT	
TOTAL DEPTH OF HOLE	49.0 FT	SIGNATURE OF INSPECTOR	Warren Perkins William Deutsch



OPT (FT)	S T	B/FT	SAMP. NO.	% REC.	CLASSIFICATION OF MATERIALS (DESCRIPTION)	REMARKS Gals water added	
					Gravel with Sand		5
							5
					Yellow-gray, angular fragments	Bailed Material	5
							5
							5
							5
							5
					Yellow-gray, coarse sand with angular fragments, few 1-2" pebbles	Bailed Material	5
					Yellow-gray gravel with coarse sand fragments of some large cobbles to 5"	Bailed Material 11'10"	
					Yellow-gray gravel with some pebbles, not as many angular fragments	Bailed Material	5
					Yellow-gray pebbly gravel	Bailed Material	5
					Same as above, except more large angular fragments	Bailed Material	5
					As above, drilling harder at @ 18 ft similar to 88-1-SS	Bailed Material	
					Sandy gravel, yellow-gray, few 3-4" rock fragments; no pebbles	Vashon Recessional Gravel	5
						Bailed Material	5
					Sandy gravel, some silt, still hard drilling	Bailed Material	5
					As above		5
					Yellow-gray, sandy gravel, some silt; easier drilling	Water at 25' Bailed Material	5
					as above; drilling fairly hard	Bailed Material	2
					Yellow-gray, sandy gravel, angular fragments with some broken cobbles	Water bubbling into hole; drilling easier, able to drive casing ahead	
					Yellow-gray angular fragments	Vashon Till	7
					as above	Bailed sample; bailer full of water	7
					Sand/gravel, some silt	Hole making some water, not a lot	10
					as above	Hole making a little water	5

DRILLING LOG (Cont. Sheet) | HOLE NO. 88-2-VD

DIVISION | INSTALLATION FT. LEWIS | SHEET 2 OF 2 SHEETS



DPT (FT)	S T	B/FT	SAMP NO.	% REC.	CLASSIFICATION OF MATERIALS (DESCRIPTION)	REMARKS
						Water coming into
40					Well rounded coarse sand and gravel Some silt and crushed cobbles	hole in good quantity Vashon Advance Gravel Bailed sample
45					Slow drilling, large cobbles; cuttings all pulverized	Water at 28' below ground
					Heaving sand bottom 1 foot	
50					TOTAL DEPTH = 49 FT	

Woodward-Clyde Consultants

APPENDIX B

Field Data Sheets

DuPont Sampling and Analysis Plan

CalPortland -- Dupont, WA

Project Site/Location:	

Routine Station Maintenance			
Personnel:	Weather:	Arrival Date/Time:	
Station Battery Voltage:		Battery Changed? (Y/N -- New Voltage)	
Data Logger Desiccant OK? (Y/N)		Sensor(s) Cleaned & Secure? (Y/N)	
Flow Meter Desiccant OK? (Y/N)		Staff Plate Cleaned & Secure? (Y/N)	
Data Downloaded? (Y/N)		Rain Gage Cleaned & Secure? (Y/N)	
Water Level & Flow		**Water Quality Measurements & Observations (*In-Situ*)**	
Flow Meter Battery Voltage:		Data Logger Recorded Temp (°C) :	
Battery Changed? (Y/N -- New Voltage)		YSI Measured Temp (°C) :	
Date/time correct? (Y/N)		DO (mg/l) :	
Data Logger(s) Desiccant OK? (Y/N)		DO (% saturation) :	
Flow Meter Data Downloaded? (Y/N)		Salinity (ppt) :	
Staff Plate/Well Level (decimal-feet):		pH :	
Data Logger/Meter Recorded Level:		Turbidity (NTU) :	
Velocity (feet per second):		Water Color? (e.g., yellow, brown, grey)	
Flow Rate (CFS):		Floating Oil/Grease? (Y/N)	
Level Calibrated? (Y/N)		Floating Debris/Scum? (Y/N)	
Level Offset (Post-Calibration)		Potentially Harmful Materials? (Y/N)	
Level Offset (Post-Calibration)			

Notes, observations, and maintenance items for future visits. Include observations regarding channel/site conditions, such as: presence/absence of beaver dams; downed trees; streambed composition (e.g., embedded with sediment); vegetation; and particularly fast or slow flow velocities.

DuPont Sampling and Analysis Plan

CalPortland -- Dupont, WA

YSI Professional Handheld Multimeter Calibration Record	
CONDUCTIVITY and PH CALIBRATION*	DO CALIBRATION*
1. Press the Cal key. **2. Highlight the parameter you wish to calibrate and press enter. For Conductivity, a second menu will offer the option of calibrating Specific Conductance, Conductivity, or Salinity. Calibrating one automatically calibrates the other two. An additional sub-menu will require you to select the calibration units. For pH, auto-buffer recognition will determine which buffer the sensor is in and it will allow you to calibrate up to 6 points.** **3. Place the correct amount of calibration standard into a clean, dry or pre-rinsed container.** **4. Immerse the probe into the solution, making sure the sensor and thermistor are adequately immersed. Allow at least one minute for temperature to stabilize.** **5. For any of parameters, enter the calibration solution value by highlighting Calibration Value, pressing enter, and then using the alpha/numeric keypad to enter the known value. Once you have entered the value of the calibration standard, highlight <<<ENTER>>> and press enter.** **6. Wait for the readings to stabilize, highlight Accept Calibration and press enter to calibrate.** **7. For pH, continue with the next point by placing the probe in a second buffer and following the on-screen instructions or press Cal to complete the calibration.**	The Pro Plus offers four options for calibrating dissolved oxygen. The first is an air calibration method in % saturation. The second and third calibrates in mg/L or ppm to a solution with a known DO concentration (usually determined by a Winkler Titration). Calibration of any option (% or mg/L and ppm) will automatically calibrate the other. The fourth option is a zero calibration. If performing a zero calibration, you must perform a % or mg/L calibration following the zero calibration. For both ease of use and accuracy, YSI recommends performing the following 1-point DO % calibration: 1. Moisten the sponge in the cal/transport sleeve with a small amount of water and install it on the probe. The cal/transport sleeve ensures venting to the atmosphere. Disengage a thread or two to ensure atmospheric venting. Make sure the DO and temperature sensors are not immersed in the water. 2. Turn the instrument on. 3. Press the Cal key, highlight DO and press enter. 4. Highlight DO%, then press Enter. 5. Verify the barometric pressure and salinity displayed are accurate. Once DO and temperature are stable, highlight Accept Calibration and press enter.
*Additional calibration information can be found at: http://www.ysi.com/media/pdfs/605595-YSI-Pro-Plus-Quick-Start-Guide-RevB.pdf	

Date:	
Time:	
Staff:	

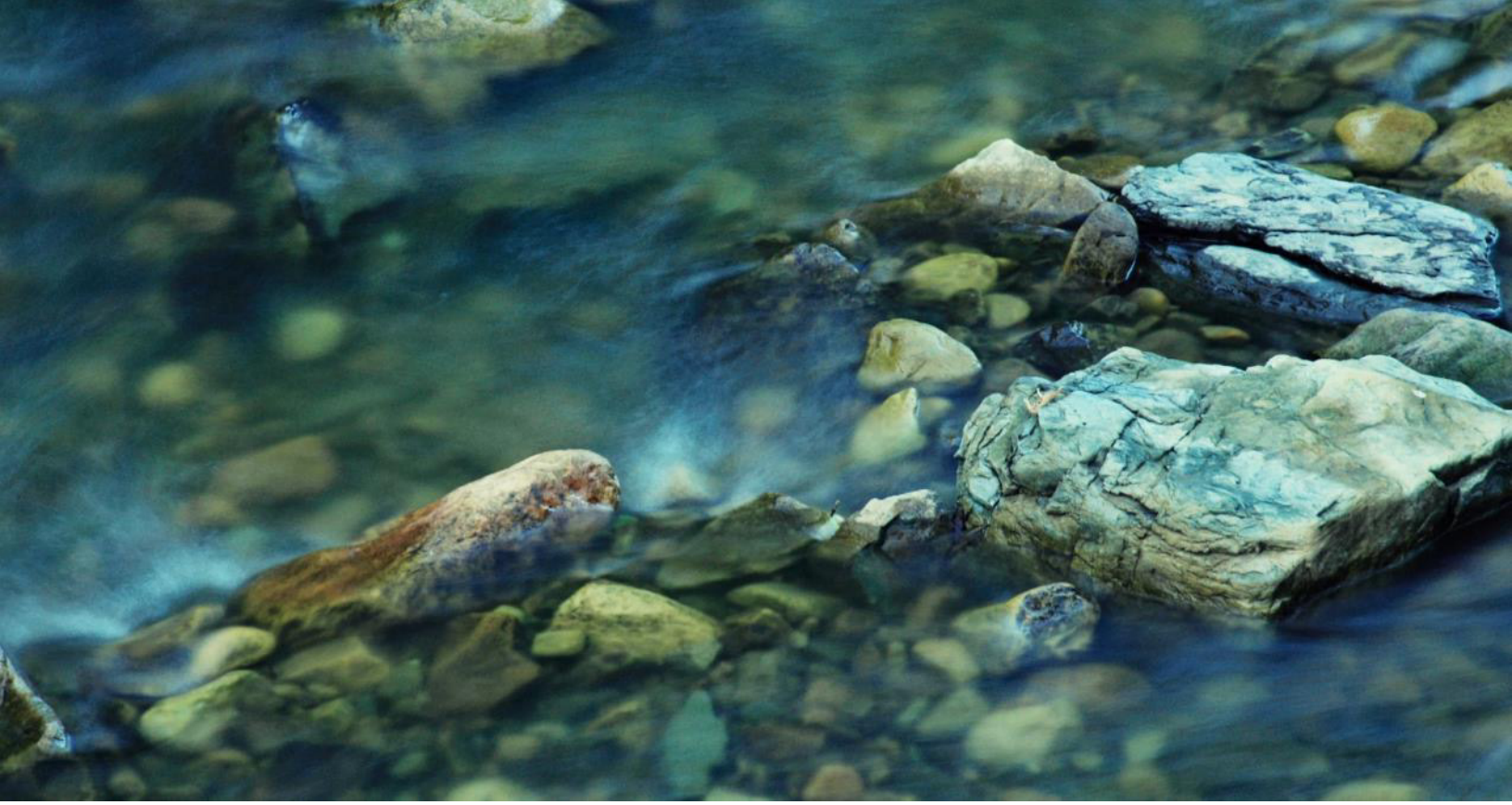
pH		
7	Initial	
	Calibration	
	Final	
4	Initial	
	Calibration	
	Final	
10	Initial	
	Calibration	
	Final	

Conductivity (Includes Salinity)		
Initial (µS/cm)	Calibration (µS/cm)	Final (µS/cm)

Dissolved Oxygen (1-Point DO Saturation Method)		
Initial (%)	Calibration (%)	Final (%)

Appendix G

Fisheries Technical Report



June 2023
Pioneer Aggregates South Parcel Project

ANCHOR QEA

Fisheries Technical Report

Prepared for CalPortland

June 2023
Pioneer Aggregates South Parcel Project

Fisheries Technical Report

Prepared for
CalPortland
3450 South 344th Way, Suite 201
Federal Way, Washington 98134

Prepared by
Anchor QEA
1201 Third Avenue, Suite 600
Seattle, Washington 98101

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ABBREVIATIONS

ASTM	ASTM International
cfs	cubic feet per second
DMC	City of DuPont Municipal Code
Ecology	Washington State Department of Ecology
EDT	Ecosystem Diagnosis and Treatment
EIS	Environmental Impact Statement
I-5	Interstate 5
JBLM	Joint Base Lewis-McChord
mg/L	milligram per liter
MLLW	mean lower low water
MRP	Manufacturing and Research Park
OS	Open Space
Project	Pioneer Aggregates South Parcel Project
R-4	Residential-4
Report	Fisheries Technical Report
RM	river mile
RR	Residential Reserve
SEPA	State Environmental Policy Act
South Parcel Project	Pioneer Aggregates South Parcel Project
WDFW	Washington Department of Fish and Wildlife

1 Introduction

Glacier Northwest, Inc. dba CalPortland is seeking regulatory approvals for the Pioneer Aggregates South Parcel Project (South Parcel Project or Project), which proposes to extend sand and gravel mine operations to the southeast of existing activities at the Pioneer Aggregates Mine in DuPont, Washington. This Fisheries Technical Report (Report) has been prepared in support of the South Parcel Project. Figure 1 provides an overview map of the South Parcel Project.

This document evaluates the environmental conditions and potential impacts of the South Parcel Project (Proposed Action) and No Action Alternative on fisheries resources. These analyses are being conducted as a component of the State Environmental Policy Act (SEPA) evaluation for the South Parcel Project.

The following Report describes existing conditions of fisheries (affected environment) and potential impacts from the Proposed Action. In addition, proposed monitoring and mitigation measures for the Proposed Action are presented. The Sequalitchew Creek Restoration Plan, developed by CalPortland and the Environmental Caucus in accordance with the 2011 Settlement Agreement, includes a commitment from CalPortland for funding, monitoring data, and advocacy. The plan also requires coordination between the Environmental Caucus, South Puget Sound Salmon Enhancement Group (SPSSEG), and Joint Base Lewis-McChord (JBLM). In the absence of CalPortland, the advocate and sponsor for the Sequalitchew Creek Restoration Plan under the No Action Alternative would be SPSSEG.

1.1 Description of the Proposed Action

Consistent with 2012 Settlement Agreement discussed later, the South Parcel Project includes horizontal expansion of mining into approximately 188 acres previously undisturbed by mining, and vertical expansion of approximately 125 acres where re-mining will deepen a portion of the existing mine. The South Parcel Project would extend mining at the current rate for approximately 14 additional years.

The Proposed Action activities would be focused southeast of the existing Pioneer Aggregates Mine in DuPont, southwestern Pierce County, Sections 22, 23, and 26, Township 19 North, Range 1 East, of the Willamette Meridian (Figure 1). The Project is bordered to the north and west by the existing Pioneer Aggregates Mine; to the east by industrial and distribution facilities including Amazon, Dania, Pier 1 Imports, and FedEx; and to the south by Sequalitchew Creek and the Creekside Village residential development. The Project would occur on lands owned by Weyerhaeuser Company and leased to CalPortland.

The South Parcel Project includes mining within areas previously undisturbed by mining (termed the "Expansion Area") and mining deeper within a portion of the existing mine, referred to as the "Re-Mine Area." The Expansion Area is approximately 188 acres composed of three subareas (see Figure 2). The Kettle Area is a 10.8-acre previously undisturbed area. The 9.2-acre Buffer Strip is a

strip of vegetation that was retained along the inside of the originally permitted mine bordering the South Parcel. The South Parcel is 168 acres located southeast of the original mine and inside the Mineral Resource Overlay in the City of DuPont's adopted Comprehensive Plan.

The Re-Mine Area consists of 125 acres in the southeastern portion of the existing mine where current conditions limit the depth of mining activities. Lowering of the groundwater elevation would allow vertical expansion of the mine.

The South Parcel Project was developed consistent with a 2012 Settlement Agreement between CalPortland, the City of DuPont, the Washington State Department of Ecology (Ecology), and a coalition of environmental groups collectively referred to as the Environmental Caucus. The Settlement Agreement describes a process for a Restoration Plan for the Sequalitchew Creek watershed to be permitted and implemented contemporaneously with mining of the South Parcel. The Restoration Plan is designed "to help restore and enhance the Sequalitchew Creek watershed, including flows along the entire length of the Creek." The Restoration Plan is not intended solely as mitigation for the South Parcel Project, but the benefits of implementing the Restoration Plan will mitigate for the impacts of the mine. The Restoration Plan is described in Section 4.

1.2 Existing Mine

CalPortland's original sand and gravel mine was permitted in 1997 (355 acres). As provided under the Settlement Agreement, CalPortland applied for permits in 2013 for the North Parcel Mine Expansion to allow mining of approximately 142 acres within the North Parcel. Following the publication of a Final Environmental Impact Statement (EIS) in June 2013, the North Parcel mining expansion was permitted in 2014.

Mining activities at the existing site include mining, processing, transport of sand and gravel, and manufacturing of concrete. The processing area is located adjacent to the mine site on a 52-acre parcel owned by Glacier. Sand and gravel is removed from the mine by bull dozers and wheel loaders and transferred to the processing area by conveyor belts. At the processing facility, the material from the mine is crushed, washed, and separated into different size gradations. Aggregate products are stored in stockpiles in the processing area for distribution.

After completion of the production process, the majority of the finished aggregate products are transported from the plant area by conveyors and placed onto barges (approximately 80%) at Glacier's dock and barge loading facility at Tatsolo Point. The remainder (approximately 20%) is sold as aggregate or used to make concrete on-site; in both cases it is transported by truck.

Water used to wash gravel during processing is recycled through a clarifying process to remove silt and clay. This fine material is then run through a belt press to remove excess water and transported by truck and placed in holding cells in the mine, where it is allowed to dry for up to 3 years.

After drying, fines may be used to raise the floor of the mine by placing the material in cells separated by rock curtains to facilitate drainage. The material is placed in approximately 6-inch lifts and compacted to a material dry density of 90% (ASTM International [ASTM]:D-1557) or greater. Once filled to the desired height with fines from the belt press in this manner, a gravel cap of not less than 10 feet is placed over the compacted fines to mitigate potential for settlement and facilitate drainage.

1.3 Description of No Action Alternative

This document also evaluates the No Action Alternative. A No Action Alternative is required by SEPA. "No action" is interpreted to mean that the City would take no action on the mining proposal, but it does not necessarily mean that nothing would happen on the subject site.

Under the No Action Alternative, the South Parcel would not be mined but the property could be developed for manufacturing and research and residential uses under existing land use and zoning designations.

Portions of the South Parcel are zoned for Manufacturing and Research Park (MRP; 136.2 acres), Residential-4 (R-4; 16.1 acres), Residential Reserve (RR; 22.3 acres), and Open Space (OS; 3.8 acres). The MRP zoned areas are subject to restrictive covenants related to the Former DuPont Works Cleanup Site. These covenants restrict use of the property to industrial uses and, barring further remediation activities, would prevent re-zoning of the MRP areas.

The extent of development could vary considerably depending on zoning, density, and Project-specific and regulatory elements such as setbacks, open space, and critical areas. Areas zoned MRP would be available for development of up to 112 acres of light manufacturing and research. Buildings may be up to 65 to 70 feet tall, and there are no maximum lot coverage requirements other than those necessary to meet required setbacks (25 feet on the front property line, 15 feet on the sides and rear) and landscaping requirements (20% of lot area). Provision of 0.3 to 1 parking space per employee working at maximum shift is required.

Under the No Action Alternative, development would occur consistent with the City of DuPont Municipal Code (DMC) critical areas chapter (DMC 25.105), which could allow for development near the top of the Sequalitchew Creek ravine with a setback to be determined by a geotechnical engineer or engineering geologist.

The areas of the South Parcel zoned R-4 can be developed at a density of up to 4.5 single-family residences per gross acre,[1] resulting in a total of approximately 76 residences. An additional 4 single-

1 "Gross acre" means land designated for residential purposes in the Comprehensive Plan, inclusive of related streets and neighborhood parks (DMC 25.10.040).

family residences could be developed in the smaller portion zoned for RR density (one dwelling unit per 5 gross acres).

There would be no changes in the use of the areas of the South Parcel zoned for OS. These areas currently include the naturally vegetated slope of the Sequalitchew Creek ravine and the Sequalitchew Creek pedestrian trail.

A summary of the parcels, zoning, and development potential of the South Parcel is presented in Table 1.

Table 1
Parcels, Zoning, and Development Potential of the South Parcel

Parcel No.	Zoning	Parcel Area in Acres	Potential Development
0119262015	MRP	21.0	16.8 acres MRP
	OS	3.8	None
	Total	**24.7**	**16.8 acres MRP**
0119262016	MRP	34.1	27.3 acres MRP
0119233016	MRP	20.0	16.0 acres MRP
0119233017	MRP	20.3	16.3 acres MRP
0119233014	MRP	20.3	16.3 acres MRP
0119233015	MRP	20.5	16.4 acres MRP
0119233011	R-4	16.1	72 residences
	R-R	22.3	4 residences
	Total	**38.4**	**76 residences**

Note:
Potential development for MRP areas includes buildings, parking lots, and access roads, but not vegetated areas.

Under the No Action Alternative scenarios, there would be no change in use of the areas within the existing mine. However, once the Re-Mine Area is reclaimed, it would likely be redeveloped according to its underlying zoning, similar to the South Parcel.

The Kettle Wetland is within the existing mine and would remain intact, the buffers would remain vegetated, and mining operations would continue in other portions of the existing mine. The Kettle Wetland and its buffer would be subject to local and state wetland protection statutes, but other mine-related buffers could potentially be removed once the existing mine is reclaimed and redeveloped for future uses.

2 Affected Environment

The affected environment for the fisheries analysis is focused on the lower 1.4 miles of Sequalitchew Creek, and the estuary and brackish marsh near the mouth of the creek. Other affected environments addressed in this analysis include the Puget Sound nearshore north of the Nisqually flats to Tatsolo Point and potential fish habitat in the Edmond Marsh Complex. These areas are all outside the footprint of the South Parcel Project but are subject to potential indirect effects from Project-related changes to the Vashon Aquifer and the Restoration Plan.

The fisheries resources that exist within the proposed mine expansion area have been previously described in the *Pioneer Aggregates Mining Facility and Reclamation Plan Final EIS* (City of DuPont 1993). Additional sources of fisheries information consulted for this analysis include the following:

- *Summary of Cumulative Effects of DuPont Mining and Restoration Projects on Aquatic Habitat, Surface Water and Groundwater* (Aspect 2016)
- *Pioneer Aggregates Mining Expansion and North Sequalitchew Project Surface Water and Geomorphology Technical Report* (Herrera Environmental Consultants 2005a)
- *Fish Habitat Benefit Evaluation for Sequalitchew Creek: Pioneer Aggregates North Sequalitchew Creek Project* (Anchor Environmental 2004a)
- *Supplemental Report: North Sequalitchew Creek Project* (Anchor Environmental 2004b)
- *Salmonid Habitat Limiting Factor Analysis: Chambers-Clover Creek Watershed WRIA 12* (Runge et al. 2003)
- *A Twentieth Century History of Sequalitchew Creek* (Andrews and Swint 1994)

2.1 Sequalitchew Creek

A description of the Sequalitchew Creek watershed and the physical and biological habitat characteristics of Sequalitchew Creek is presented in the following sections. Additional description of the historical, existing, and predicted conditions of water quality and quantity records in this document can be found in the *Earth and Water Resources Report, DuPont Mine South Parcel Project* (Aspect 2022).

2.1.1 Sequalitchew Creek Watershed

Sequalitchew Creek (Water Resource Inventory Area 12-0019) drains a watershed covering approximately 38.4 square miles that discharges into Puget Sound (Runge et al. 2003). Figure 1 illustrates the characteristics of the Sequalitchew Creek drainage basin. Above the headwaters of Sequalitchew Creek is a cryptorheic[2] basin with headwaters located at river mile (RM) 9.6 in Kinsey Marsh on the east side of Interstate 5 (I-5). Kinsey Marsh flows drain to Murray Creek which flows 3.8 miles to American Lake on the west side of I-5. American Lake (1,162 surface acres) has no

[2] A crytorheic basin is a watershed that terminates where flow goes entirely subsurface.

defined outflow channel; however, there is a weir that maintains the maximum elevation of the lake water. On rare occasions, runoff from American Lake flows into Sequalitchew Lake (81 surface acres) but the frequency of surface flow is too low to form a defined channel between the two waterbodies (CH2M Hill 2003). A regional groundwater table maintains the water level in American Lake and Sequalitchew Lake (Andrews and Swint 1994).

2.1.2 Physical Habitat Characteristics of Upper Sequalitchew Creek

Sequalitchew Creek is largely an artificial channel from its source at the Lake Sequalitchew weir to the west end of West Edmond Marsh. This channel is excavated within the existing wetland complex and has extremely low velocity where it flows in a culvert under DuPont Steilacoom Road. Except under extreme high flow conditions, all flow that passes through that culvert either infiltrates or evaporates within the Edmond Marsh Complex. The Edmond Marsh Complex is described in detail in the *Plants and Animals Technical Report, DuPont Mine South Parcel Project* (Anchor QEA 2022). Descriptions of direct, indirect, and cumulative impacts to the Edmond Marsh related to the alternatives can also be found in that document.

2.1.3 Physical Habitat Characteristics of Lower Sequalitchew Creek

Sequalitchew Creek above RM 1.0 and below Edmond Marsh is typically dry. Only rarely is there a surface water connection between Edmond Marsh and Lower Sequalitchew Creek. There are no gage data for this reach, but analysis of the mid-ravine and lower ravine gages suggests that they are infrequent (maybe a handful over 19 years) and short lived (approximately 1 to 5 days). Most appear related to storm events, but some are from humans removing or altering the beaver dam at the west end of Edmond Marsh. The source of water in the lower mile of the creek is groundwater discharged from the Vashon Aquifer as springs in the Sequalitchew Creek ravine, below elevations of approximately 195 feet down to the top elevation of the Olympia Bed deposits at elevations between approximately 100 and 120 feet, spanning a creek reach of approximately 0.7 mile. Based on stream gaging data, this groundwater discharge to the creek varies between approximately 0.5 cubic feet per second (cfs) in the summer to 2.5 cfs in the winter. Progressing downstream past the Olympia Bed Truncation, Sequalitchew Creek becomes a losing stream as the water table drops through the outwash to near sea level (Aspect 2022).

The slope of the thalweg[3] ranges from about 2% to 3% in the ravine and the width of the stream varies from about 12 to 20 feet. Pebble counts of the streambed material were conducted at 21 stations. At 15 stations, the median gravel size (D_{50}) was between 0.5 and 1.5 inches. At the remaining 6 sites, the gravel was finer.

[3] The thalweg is the line connecting the lowest points of successive cross-sections along the course of a stream.

Sequalitchew Creek in the lower ravine has average annual flow of 2.8 cfs. The flows rises to between 3 and 4 cfs during the spawning periods for the salmonid species using the creek (Figure 5). During summer, flows drop and sometimes the creek dries up completely, leaving only small pools wetted (Runge et al. 2003). As a result, fish are unable to use the creek throughout the year, and aquatic invertebrate prey production is reduced (Bell 1991).

Comparison of recent flow monitoring results with earlier gaging efforts in 1977 to 1978 (Thut et al. 1978) and 1984 to 1987 (Firth 1991) indicates that the streamflow is about 38% to 55% lower now than it was in those periods. Average monthly flow rates near the mouth of Sequalitchew Creek are shown in Table 2.

Table 2
Average Flows in Sequalitchew Creek Watershed

	Average Flow in cfs				
	Diversion Weir	Mid-Sequalitchew Creek Ravine	Lower Sequalitchew Creek Ravine		
Month	2003 to 2021	2004 to 2021	1977 to 1978	1984 to 1987	1999 to 2021
January	15.6	2.5	9.7	5.9	4.0
February	19.6	2.6	12.8	8.5	4.2
March	21.5	2.2	12.2	8.7	3.8
April	19.8	2.0	0.7	9.4	3.2
May	12.7	1.6	1.6	7.8	2.7
June	7.4	1.2	1.5	3.7	1.9
July	3.2	0.9	0.2	1.3	1.3
August	2.8	0.8	0.1	1.0	1.1
September	2.4	0.8	0.1	1.0	1.1
October	3.7	0.8	0.1	1.4	1.4
November	7.1	1.3	2.4	3.7	2.6
December	10.9	1.9	10.5	5.1	3.5
Mean annual flow	10.5	1.6	4.3	4.8	2.7

Note:
All results are in cfs.

This change in flows in Lower Sequalitchew Creek was the result of actions upstream in Edmond Marsh. The Washington Department of Fish and Wildlife (WDFW) created a channel through Edmond Marsh around 1976. The purpose of the channel was to facilitate the use of Lake Sequalitchew in a fish augmentation program. The channel was maintained to prevent beaver dams and vegetation from raising water levels in the marsh. With higher water levels in Edmond Marsh, more water flows out the Diversion Canal and less flows toward Lower

Sequalitchew Creek. Maintenance of the channel was necessary to attract juvenile fish to migrate to Puget Sound via Edmond Marsh and the Sequalitchew Creek Ravine rather than the Diversion Canal. The route of migration through the marsh and ravine would have a much larger rate of survival as it would provide opportunities for growth and acclimation in the estuary. It is assumed that any fish migrating via the Diversion Canal would be killed or stunned by the drop to Tatsolo Point.

2.1.4 Biological Habitat Characteristics of Sequalitchew Creek

The Sequalitchew Creek drainage basin contains both anadromous and resident fish that occur at different times of the year and use different portions of the creek. Figure 3 shows the extent of documented anadromous fish use reported for Sequalitchew Creek within the Project area including coho salmon (*Oncorhynchus kisutch*), chum salmon (*O. keta*), and cutthroat trout (*O. clarkii*) (Runge et al. 2003; WDFW 2022). The U.S. Fish and Wildlife Service also identifies bull trout (*Salvelinus confluentus*), a threatened species, as occurring in the Project vicinity (USFWS 2003, 2022). Native bull trout populations are known to be present in the Nisqually River, whose mouth is located approximately 1 mile south of Sequalitchew Creek (Runge et al. 2003; SalmonScape 2022). Although suitable habitat for bull trout does not exist within Lower Sequalitchew Creek, it is likely that this species is present in the nearshore habitat and could enter Lower Sequalitchew Creek estuary to forage during salmon smolt out-migration.

Resident fish reported or expected to occur in Sequalitchew Creek within the Project area include cutthroat trout (*O. clarkii*), rainbow trout (*O. mykiss*), sculpins (*Cottus* sp.), and western brook lamprey (*Lampetra richardsonii*) (City of DuPont 1992; Wydoski and Whitney 1979). Other resident fish reported to occur in the Sequalitchew Creek drainage basin, but outside the Project area, include kokanee salmon (*O. nerka*) and spiny ray fish in American Lake and Sequalitchew Lake (Pierce County 1996). Chum salmon have been reported to spawn in the lower 650 feet of Sequalitchew Creek in the past (City of DuPont 1993).

2.1.4.1 Historical Augmentation of the Fishery

WDFW augmented the fishery of Sequalitchew Creek intermittently from 1980 to 2001. Coho salmon smolts were released into Sequalitchew Creek from 1980 to 1994 and again in 2001. The annual number of coho salmon smolts released ranged from 2,280 to 987,480 with an average annual release of 238,477. These smolts were released in the spring (March 25 to May 31) between 1980 and 1994, and during the winter (December 11) in 2001. Fall Chinook salmon (O. *tshawytscha*) smolts were also released into Sequalitchew Creek in 1990 and 1991. These smolts were released in the spring (April 2 to 16) in numbers that ranged from 19,800 to 42,800 with an average annual release of 27,533. Coho salmon, chum salmon, and cutthroat trout are currently reported to utilize Sequalitchew Creek according to the most recent information from WDFW (SalmonScape 2022) and the *WRIA 12 Salmonid Habitat Limiting Factors Report* (Runge et al. 2003).

Coho salmon spawning survey records for Sequalitchew Creek indicate sporadic observations have been made by WDFW in 1962, and between 1982 and 1985. These surveys conducted in the winter (November 6 to December 27) extended from the mouth to RM 1.6. These data indicate that the annual number of adult coho salmon observed ranged from 0 to 145 with an annual average of 22. These surveys occurred during the period when smolts were released in the watershed, and flows were maintained by cutting a channel through Edmond Marsh.

The time of year when anadromous fish are reported to occur in Sequalitchew Creek within the Project area is as follows: Coho salmon smolts out-migrate from March to May, while returning adults spawn from late November to early January. Chum salmon spawn between December and February, and the fry out-migrate immediately after emerging from the gravels, which is usually between March and June (WDF 1975). Resident and sea-run cutthroat trout reside in Sequalitchew Creek throughout the entire year. Adults typically spawn in the spring and summer (February to August) and the fry emerge in late summer. Adult bull trout can potentially be present in the lowest portions of Sequalitchew Creek at any time of the year but are most likely to enter the stream to forage on out-migrating salmon smolts between March and June. Bull trout are not expected to use Sequalitchew Creek for spawning purposes due to the limited known distribution in the vicinity and the lack of spawning conditions that bull trout require (Runge et al. 2003).

2.1.4.2 Fish Habitat Under Existing Flows

Anchor Environmental (2004a, 2004b) completed an analysis of salmonid spawning and passage in Sequalitchew Creek based on water depth and flow. The analysis was conducted for coho salmon, chum salmon, and cutthroat trout. The Toe-Width Method and the Stage Discharge Analysis methods were combined to characterize the existing stream habitat. The Toe-Width Method provides a calculation for optimal flow conditions in cfs for the stream and uses data on the physical characteristics of the stream channel to estimate the streamflow that provides the maximum habitat for salmonid spawning and rearing. The Stage Discharge Analysis provides an analysis of minimum flow conditions for a given life stage. Both approaches utilize WDFW-developed and approved formulas.

The Toe-Width Method results indicate that optimal flows for both spawning and rearing in Sequalitchew Creek would be higher than current flows (Anchor Environmental 2004a). A discharge of 2.5 cfs was used in the analysis. This flow is representative of flows in a drier-than-average year during coho and chum salmon spawning. Based on a period of record from 2000 to 2001, the measured average flow during November, December, and January was 3.4 cfs (standard deviation of 2.0 cfs). At a discharge of 2.5 cfs, the lower reaches of Sequalitchew Creek provide unsuitably low depths for adult chum salmon passage and spawning, and unsuitably low depths for adult coho salmon passage and spawning. At a discharge of 2.5 cfs, depths are generally adequate to support resident cutthroat trout rearing and spawning. The monthly mean of flows for the driest month in each year (2000 to 2021)

averaged approximately 1 cfs, and there were many months when the average flow was 0.3 cfs or less. Cutthroat trout habitat would be severely limited during these periods.

A later study was conducted by ICF International (ICF 2013) using the Ecosystem Diagnosis and Treatment (EDT), a fish life-cycle habitat model that characterizes the aquatic environment temporally (monthly) and spatially (stream reaches). The model was run for both chum and coho salmon. This study found that, "habitat potential for the current condition suggests that Sequalitchew Creek could support a small quantity of natural chum salmon. However, the number of fish and productivity suggests the stream cannot support an independent population and is likely not self-sustaining" (ICF 2013). For coho salmon, the study found that the under current conditions, "adult capacity and abundance is essentially zero" (ICF 2013).

2.2 Marine Shoreline Description

Fish habitat along the marine shoreline at the mouth of Sequalitchew Creek and the barge loading facility has been previously described (City of DuPont 1993, 1995). A description of these physical and biological habitat characteristics, along with additional information collected for this study, are presented in the following sections.

2.2.1 Physical Habitat Characteristics of the Marine Shoreline

2.2.1.1 Mouth of Sequalitchew Creek

The Puget Sound shoreline at the mouth of Sequalitchew Creek is characterized by an armored slope above a gravel beach with minimal estuarine habitat. Farther offshore, a shallow soft sediment bench extends from the Nisqually River delta to just north of the mouth of Sequalitchew Creek. The BNSF railroad tracks paralleling the shoreline in this area are perched on a steep riprap berm. On the Case Inlet side of the railroad there are gravel deposits on either side of the mouth of Sequalitchew Creek that extend above the high tide line. These create more complete nearshore habitats, with beach grasses, drift logs, and low angle beaches extending into the subtidal zone. The railroad berm bisects the mouth of Sequalitchew Creek and influences tidal currents, wave action, and sediment deposition along the marine shoreline. There is a brackish marsh associated with Sequalitchew Creek on the upstream side of the railroad berm. Wind waves and tidal flows in the marsh are limited by a culvert under the railroad berm. The culvert draining Sequalitchew Creek through this railroad berm influences tidal exchanges, deltaic sediment deposition, and fish passage. There is limited rearing habitat in the brackish marsh on the upstream side of the railroad berm because this berm does not allow the channel to meander and otherwise naturally braid into multiple tidal channels. The loss of these natural processes limits the quantity and quality of fish habitat in this estuary.

2.2.1.2 Marine Shoreline West of the Existing Mine

The shoreline on the Puget Sound side of the railroad berm also has limited fish habitat because the steep slope influences wave action, sediment deposition, and estuarine vegetation. Waves formed by the predominant wind direction (from the southwest) break on the riprap-lined slope during high tides and do not allow for the deposition of fine-grained substrate in most areas. Substrate along the shoreline that is influenced by high-energy waves and wave reflection scouring is dominated by cobbles and gravel. In addition, the steep riprap embankment does not allow estuarine vegetation to grow above the high tide line. This limits the organic export of nutrients and benthic invertebrates that juvenile salmonids need during their acclimation to estuarine conditions. Within about a quarter mile on either side of the mouth of Sequalitchew Creek there is an accretionary sand bar at the shoreline. This sandbar reduces wave energy and scour. The sandier substrate off shore of the bar supports patches of eelgrass (*Zostera marina*; Ecology 2022). The bottom substrate farther offshore that is not influenced by wave scouring consists of fine-grained sediment overlying cobbles.

2.2.1.3 Barge Loading Facility

The Puget Sound shoreline at the Pioneer Aggregates barge loading facility near Tatsolo Point has previously been described in the Pioneer *Aggregates Barge Loading Facility and DuPont Shoreline Master Program Amendment—Supplemental EIS* (City of DuPont 1995). This shoreline is located where the BNSF railroad tracks also parallel the shoreline. The railroad tracks are perched on a steep berm composed of riprap that occupies the intertidal zone to nearly mean lower low water (MLLW) meaning there is little intertidal beach present. This railroad berm influences tidal currents, wave action, and sediment deposition along the marine shoreline. Although there is a gravel beach adjacent to the railroad berm approximately 200 feet north of the dock, the area has minimal nearshore habitat value.

The shoreline on the Puget Sound side of the railroad berm has limited fish habitat because the steep slope influences wave action, sediment deposition, and estuarine vegetation. Waves formed by the predominant wind direction (from the southwest) break on the riprap-lined slope and do not allow for the deposition or effective transport of fine-grained substrate. Substrate along the shoreline is influenced by high-energy waves and wave reflection, which scour away finer material leaving only cobbles and coarse gravel above -4 feet MLLW. In addition, the steep riprap embankment does not allow estuarine vegetation to grow above the high tide line. This limits the organic export of nutrients and benthic invertebrates that juvenile salmonids need during their acclimation to estuarine conditions. The bottom substrate farther offshore that is not influenced by wave scouring consists of coarse, sandy sediment overlying cobbles. Fine sand and silt gradually replace the coarser sediment until about -25 to -35 feet MLLW. Below this depth the sediment is predominantly silt and fine sandy mud (City of DuPont 1995).

2.2.2 Biological Habitat Characteristics of the Marine Shoreline

The reach of Case Inlet west of the existing mine and the nearshore from the mouth of Sequalitchew Creek are habitat for numerous species of fish and marine invertebrates. WDFW Priority Habitats and Species mapping documents the presence of key habitats for cutthroat trout, coho salmon, and chum salmon migration and rearing; and Pacific sand lance (*Ammodytes hexapterus*) and surf smelt (*Hypomesus pretiosus*) breeding. The reach is used by Dungeness crab (*Cancer magister*) and various genera of pandalid shrimp. Kelp and algae beds are present in the shallow subtidal, and there have been limited observations of eelgrass in the vicinity.

2.2.2.1 Mouth of Sequalitchew Creek

Although fish habitat along the marine shoreline at the mouth of Sequalitchew Creek is influenced by the railroad berm, this area is still used by a variety of species (City of DuPont 1993). These include plants and invertebrates in the intertidal and subtidal zones, as well as the marine and diadromous fish species described below.

Prior studies indicate that 75 plant species were found growing on the bottom substrate in the intertidal area (0 to 9 feet above MLLW). Of these intertidal plants, more than half were red algae (Rhodophytes) and green algae (Chlorophytes). The majority of the subtidal plants were found between 0 and -16 feet below MLLW. Small patches of eelgrass in sparse densities were observed near the mouth of Sequalitchew Creek (City of DuPont 1993).

Prior studies also identified 270 species of invertebrates in the intertidal area, with the majority of these species occurring near 0 feet MLLW (City of DuPont 1993). Several species of limpets, barnacles, and periwinkles were the dominant molluscan groups. The most productive area was the lower intertidal area near the mouth of Sequalitchew Creek. Subtidal invertebrates found in this area include snails (gastropods), worms (polychaetes), sea stars, and amphipod crustaceans.

Marine fish observed along the shoreline in this area include 31 species of bottomfish, 26 species of bottom-dwelling (demersal) fish, and 11 water-column (pelagic) species (City of DuPont 1993). The predominant bottomfish include English sole (*Parophrys vetulus*), rock sole (*Lepidosetta bilineata*), and starry flounder (*Platichthys stellatus*). The dominant demersal fish include buffalo sculpin (*Enophrys bison*), Pacific tomcod (*Microgadus proximus*), staghorn sculpin (*Leptocottus armatus*), rockfish species (*Sebastes* spp.), cabezon (*Scorpaenichthys marmoratus*), painted greenling (*Oxylebius pictus*), and pipefish (*Syngnathus griseolineatus*). The pelagic fish are represented by shiner perch (*Cymatogaster aggregate*), surfperches (Embiotocidae), and tubesnout (*Aulorhynchus flavidus*).

Salmonid species observed along the marine shoreline include coho, chum, Chinook, and pink salmon (City of DuPont 1993). Adult coho salmon were found along the shoreline at the Sequalitchew Creek mouth in September and October, but most of these fish were returning to

spawn in the Chambers Creek, McAllister Creek, and Nisqually River watersheds. Returning chum salmon are found along the shoreline at the Sequalitchew Creek mouth in December and January, but most of these fish spawn in the Nisqually River. Chinook and pink salmon observed along the marine shoreline are mainly migrating to the Nisqually River system.

Juvenile salmonids are found along the shoreline at the Sequalitchew Creek mouth during the spring out-migration, but many of these fish originate in the Nisqually River. Juvenile coho salmon are typically found between May and June. The peak migration of juvenile chum salmon occurred between mid-February and late July. Juvenile Chinook salmon were observed migrating from late May to July.

As noted previously, a native population of bull trout is known to inhabit the Nisqually River system (Runge et al. 2003; SalmonScape 2022). Fish from this population may utilize the nearshore environment near the mouth of Sequalitchew Creek and may also enter the lowest portion of the creek to forage on juvenile salmonids.

2.2.2.2 Barge Loading Facility

Habitat along the marine shoreline at the barge loading dock has previously been described in the *Pioneer Aggregates Barge Loading Facility and DuPont Shoreline Master Program Amendment—Supplemental EIS* (City of DuPont 1995). Like the area described at the mouth of Sequalitchew Creek, both areas are influenced by the railroad berm. However, the barge loading dock area has less diversity than the mouth of Sequalitchew Creek. The following provides a summary of the plants and invertebrates in the intertidal and subtidal zones; marine fish; and salmonids found in this area.

An intertidal flora and fauna survey conducted approximately 200 yards south of the barge loading dock in 1978 found little macroalgae above +6 feet MLLW. Only rockweed (*Fucus gardneri*) was present at +6 feet MLLW. At lower elevations, several species of red and green algae were common, and at 0 feet MLLW, several species of kelp dominated. Periodic bathymetric surveys have not detected significant material spills.

Subtidal plants are distributed at various depths and include macroalgae and kelp at around -8 feet MLLW. A narrow band of bull kelp (*Nereocystis leutkeana*) extends along the shoreline in both directions from the barge loading dock. Algae species are restricted to the area above -20 to -30 feet MLLW, and the most prevalent algae species was sea lettuce (*Ulva lactuca*). Ribbon kelp (*Laminaria saccharina*) was the second most common algae in this area. A variety of filamentous and foliose red algae species are present; the most common is *Sarcodiotheca gaucichaudii*. The cumulative percent cover of these algae ranged from 100% in the shallow subtidal zone to less than 5% at -20 to -30 feet MLLW. No eelgrass beds were observed in the vicinity of the dock.

Subtidal animals living within (infauna) and on top (epifauna) of the sea bed are present at various depths. The most common infauna group is polychaete worms, while the epifauna is dominated by shrimp and crab species. Larger animals included cockles (*Clinocardium nuttallii*), sea cucumbers (*Parastichopus californicus*), several species of sea stars, Dungeness crab (*Cancer magister*), rock crab (*Cancer productus*), and geoducks (*Panope abrupta*).

Marine fish observed along the shoreline in this area include shiner perch, Pacific herring (*Clupea harengus pallasi*), sand dab (*Citharichthys sordidus*), English sole, and starry flounder. Four salmon species (coho, chum, chinook, and pink) are expected to occur in this area. However, this area is less productive for juvenile salmon rearing and adult migration than the mouth of Sequalitchew Creek due to its greater distance from the Nisqually River. As noted previously, a native population of bull trout is known to inhabit the Nisqually River system (Runge et al. 2003). Fish from this population may utilize the nearshore environment in the vicinity of Sequalitchew Creek, including the barge loading facility.

3 Impacts of the Proposed Action and No Action Alternative

3.1 Impacts of the Proposed Action

This section is divided into two parts: direct impacts, which are directly related to the actions in the South Parcel Project Area; and indirect impacts, which are associated with aquifer drawdown outside the South Parcel Project Area (see Figure 2).

3.1.1 Direct Impacts of the Proposed Action

The Proposed Action would directly affect fish habitat by extending the operation of the marine barge loading dock within the marine shoreline. This would prolong shading beneath the facility, which can inhibit macroalgae growth and epibenthic productivity. These would have a small effect on the overall availability of nutrients for fish. The proposed mine expansion would extend by about 14 years the period when the barge loading dock continues to be used to transport aggregate to market. Fisheries impacts (e.g., shading, spill risk) associated with use of this barge loading dock have previously been described in the *Pioneer Aggregates Barge Loading Facility and DuPont Shoreline Master Program Amendment—Supplemental EIS* (City of DuPont 1995) and a previous *Fisheries Technical Report* (Herrera 2005).

Potential fisheries impacts to the marine shoreline include direct and indirect effects from the spillage of sand and gravel from the conveyor, overturning of barges during loading, accidental spills of pollutants, shading, and lighting, and are summarized as follows:

- Sand and gravel spilled in sufficient quantities could smother the benthic community where the spill occurs.
- Accidental spills of petroleum products (diesel) and other pollutants (hydraulic oil) could potentially occur during barge loading and maintenance activities.
- Extending the life of the conveyor and barge loading dock by about 14 years would extend any impacts to areas directly beneath the dock by shading the shallow water, as well as impacts associated with dock lighting. These impacts would occur until the dock is eventually removed.
- Ecology maintains a record of all reported oil spills of 1 gallon or more. These records go back to 2015. There were no recorded spills in the vicinity during that time (Ecology 2023).

3.1.2 Indirect Impacts of the Proposed Action

The Proposed Action would not directly affect Sequalitchew Creek, but the drawdown of the Vashon Aquifer would indirectly reduce flow in Lower Sequalitchew Creek. Lower Sequalitchew Creek is entirely spring fed (as described in Section 2.1.3). Groundwater discharge to Sequalitchew Creek during active dewatering is predicted to be 79% less than baseline conditions, on average, resulting

in a decrease in average flow in Sequalitchew Creek from 1.6 cfs to 0.34 cfs at the mid-ravine gage. The greatest decrease would occur during the wet season.

Without restoration, these indirect impacts would reduce flows during the spawning life stage of chum salmon and the spawning and rearing life stages of coho salmon and cutthroat trout. Impacts during the spawning season would be severe: seriously limiting the amount of habitat for resident cutthroat trout and eliminating spawning habitat for anadromous species. This would reduce the spatial extent of habitat available and reduce the portion of the year when fish habitat is accessible.

3.2 Impacts of the No Action Alternative

Under the No Action Alternative, the condition of the Sequalitchew Creek fish populations and fish habitat would remain similar to existing conditions. Suitable and accessible habitat for all species of fish currently and historically present would continue to be a fraction of what they were a few decades ago. Surface flows from Edmond Marsh into Lower Sequalitchew Creek would continue to occur during extreme precipitation events and would not contribute meaningfully to habitat. The creek would continue be unused or used very little by chum and coho salmon and cutthroat trout.

4 Cumulative Effects of Proposed Action and Restoration Plan

The South Parcel Project, described in Section 1.2, includes implementation of the Restoration Plan, reflected in the 2012 Settlement Agreement and developed by CalPortland and the Environmental Caucus. The Restoration Plan, which is a related action, seeks to restore and enhance streamflow and ecological functions from Sequalitchew Lake through Edmond Marsh into Sequalitchew Creek ravine. The Restoration Plan is intended to sequentially restore diverted flows back to the creek, improve the sustainability of flows through the system, and restore aquatic habitat by removing flow-related fish passage barriers and increasing the habitat available to aquatic species.

This section identifies what is currently known about the cumulative effects of the Proposed Action and the Restoration Plan. The Restoration Plan is being designed and permitted independently, and the specific impacts of the plan will be evaluated in those documents. Since the effects of the restoration will be evaluated in a subsequent SEPA document, these conclusions should be framed as general and preliminary. A cumulative effects analysis is an evaluation of the combined effects on biological resources for the Proposed Action, including the effects of reasonable and foreseeable development projects in the vicinity of the study area. One such set of reasonable and foreseeable effects would be from the cumulative impacts of continued growth in the region. These will occur regardless of whether or not the Project occurs. The other set of reasonable and foreseeable effects on Sequalitchew Creek, the marine nearshore, and wetlands is the impacts of the Restoration Plan. This analysis of impacts is based on the current understanding of the Restoration Plan actions being carried out by JBLM, SPSSEG, or others. These actions may change as they are being further designed and permitted. Therefore, much of this analysis is based on the restoration targets of the plan, such as increased flows in Sequalitchew Creek.

4.1 Benefits

The cumulative effects of the mining and full implementation of the Restoration Plan for the Sequalitchew Creek watershed would reverse many of the adverse impacts to the watershed and creek that have occurred over decades. The benefits would be noticeable over a large portion of the stream and wetland habitats in the basin and would largely restore lost and reduced ecosystem functions including the movement of water, sediment, nutrients, biota, and dissolved gasses through the watershed from the headwater springs on Sequalitchew Lake to Puget Sound. The reconnection of Sequalitchew Creek to its historical primary source of flow, Sequalitchew Lake, would address the root cause of the primary historical impacts to the system.

These projects cumulatively have the potential to restore an annual average of 10.8 cfs to a 1,200-foot reach of Sequalitchew Creek that currently experiences little to no consistent flow. Seasonally, the flows in this reach following restoration are predicted to be between 2.2 cfs in August up to just over 22 cfs in March. Flows of this magnitude would re-establish a functioning stream in the now frequently dry

channel, providing new aquatic and riparian habitat and a connection between the Sequalitchew Creek ravine and the marshes. This would provide a corridor for both aquatic and terrestrial species and would provide new opportunities for species expansion and recovery.

In the Sequalitchew Creek ravine, the restoration and mining projects would result in a seven-fold increase in flow on an annual average basis, from the current 1.6 cfs up to 11.2 cfs. Peak flows could reach up to 60 cfs, sufficient to restore the natural channel-forming processes necessary to improve habitat conditions in the ravine. Currently, the flows in the ravine are inadequate to move sediment effectively, create pools, or scour finer-grained materials from the substrate to create conditions suitable for spawning. Peak flows could be adaptively managed by adjusting the weir at the Diversion Canal and limiting flow through Edmond Marsh to prevent flooding or detrimental effects to the wetlands or the stream channel.

The restoration project would also restore fish passage from Sequalitchew Creek to East and West Edmond Marshes. Two fish barrier culverts will be replaced by fish-passable structures, which in combination with increased flows will allow migratory access above the ravine springs and into Edmond Marsh. Restoration would affect the conditions sufficiently to allow establishment of emergent vegetation in the western extent of the complex where inundation will persist through more of the growing season, providing excellent rearing habitat for juvenile coho salmon and cutthroat trout. These effects would increase the size, diversity, and complexity of available fish habitat types.

The greatly increased flow through Edmond Marsh would also improve water quality conditions by increasing dissolved oxygen concentrations and diluting and flushing an area of elevated iron concentrations in the center of the marsh.

4.2 Impacts

The greatest potential impacts to fish associated with restoring the natural flow regime to the Sequalitchew Creek watershed would be increased summer stream temperatures, and increased frequency of periods of high flow in winter and spring. These impacts will be mitigated through adaptive management by the restoration implementation team. These same impacts would occur with or without the change in groundwater elevation resulting from mining. Summer low flows below the Sequalitchew Creek Ravine Springs would be reduced during prolonged dry summers. At all other times, the benefits of increased flow would not be affected by lower groundwater.

The implementation of the Restoration Plan would result in water levels in Sequalitchew Creek Marsh and Edmond Marsh that are more consistent with conditions when the Diversion Canal only flowed during severe precipitation events. That change would also result in a loss of current wetland area

and, likely, a return to the shape and extents of the marsh in the 1970s. See the accompanying *Plants and Animals Technical Report* (Anchor QEA 2022) for more discussion of wetland impacts.

The flow from Sequalitchew Lake is also warmer in summer than the current flow in the ravine. The Project effects would represent a return to a more natural, surface-flow-dominated condition, but one with warmer stream temperatures. Sequalitchew Creek would experience temperatures up to 21°C in June, July, and August and cool temperatures down to 5°C in winter. The seasonal pattern of average monthly temperatures in Sequalitchew Creek with mining and restoration are shown in Figure 4. The predicted stream temperatures would be considerably warmer than the current spring discharge in the creek for most of the year. The surface water quality criterion for temperature applicable to Sequalitchew Creek is 16°C for the 7-day average of daily maximums. The analysis based on grab samples suggests this threshold may be exceeded from May through September.

Finally, there are predicted to be infrequent periods when the mining and restoration projects would result in streamflows that are lower than currently occur. This condition would occur during extended dry periods, when outflow from Sequalitchew Lake is naturally low or non-existent. Streamflows would be lower than existing conditions about 10% of the time, typically in August and September of particularly dry years. Existing flows during these periods currently average 0.83 cfs and do not provide aquatic habitat for anadromous fish; mining and restoration would further reduce these flows during these periods (to 0.44 cfs). This means that fish in the system below Edmonds Marsh will have less habitat as the population moves downstream to the remaining channel area.

4.3 Cumulative Effects for Fish Habitat in the Watershed

The combined effects of the mining and restoration projects on stream habitat would include a re-establishment of flow from Sequalitchew Lake to flow through the marshes and into Sequalitchew Creek ravine. The projects would also result in re-establishing ecosystem processes, specifically, the movement of water, sediment, nutrients, biota, and dissolved gasses through the watershed from the headwater springs on Sequalitchew Lake to Puget Sound. The increase in hydrology and stream energy would increase aquatic ecosystem productivity and create and maintain habitat diversity.

Re-establishment of peak flows and the associated sediment movement is key to restarting the arrested habitat-forming processes downstream of Edmond Marsh and is a key objective of the Restoration Plan. Currently, even where flows persist perennially, they are inadequate to move sediment effectively, create pools, or scour finer-grained materials from the substrate to create conditions suitable for spawning. The input of sediment and organic matter will stimulate biological productivity and develop greater resources at the lower trophic levels. Restoration would also result in pool and riffle habitat formation over time.

This habitat and development of lower trophic productivity are key to developing conditions sufficient to restore target species such as chum salmon and cutthroat trout in the system. Chum salmon will also benefit from the restoration of a more varied hydrograph. Puget Sound stocks typically spawn in freshwater systems in November and December as flows rise in response to winter rains. This effect has been limited in the system due to the current lack of surface water connectivity.

Previous studies by Anchor Environmental (2004a) and ICF (2013) showed that additional flow would result in increased capacity of the stream to support spawning and rearing of coho and chum salmon. These studies pre-date the completion of the Restoration Plan, but both approaches used predicted flow restoration scenarios similar to flows resulting from the cumulative effects of mining and restoration. The Anchor Environmental (2004a) study analyzed the effects of higher flows in the lower ravine within the lower 3,600 feet of the stream (not the upper ravine). The report concluded that additional flow in the lower reaches of Sequalitchew Creek would "provide significantly enhanced habitat conditions to support coho and chum salmon and cutthroat trout. Existing conditions in Lower Sequalitchew Creek indicate the habitat potential is significantly suppressed, and opportunities for salmon to access and use stream habitat is also very limited. Habitat features exist (e.g., appropriate spawning gravel, LWD and SWD, limited physical barriers) that will provide conditions important for coho and chum salmon and cutthroat trout spawning and rearing with more water present in the stream channel." The ICF (2013) study found that restoring chum access to lower gradient reaches of Sequalitchew Creek near the midpoint of the ravine "is predicted to improve overall productivity and nearly double abundance from the current condition."

4.3.1 Water Quality

The mining and restoration projects would introduce surface water from the upper watershed to the creek. Water passing through Edmond Marsh has low levels of turbidity and pollutants (Aspect Consulting 2022). The projects will affect stream temperature in the Sequalitchew Creek ravine by restoring the flow of surface water in the system which has a different temperature. The effects would vary seasonally as the volume of water from Sequalitchew Lake and its associated temperature vary. In summer, the outflow from Sequalitchew Lake is warmer than Sequalitchew Creek; in winter, it is colder.

Sequalitchew Creek would experience warm temperatures in June, July, and August, with temperatures reaching up to 21°C (70°F) and cool temperatures in winter, down to 5°C to 6°C (41°F to 43°F) as shown in Figure 6. The predicted stream temperatures would be considerably warmer than the current spring discharge in the creek for most of the year. The surface water quality criterion for temperature applicable to Sequalitchew Creek is 16°C for the 7-day average of daily maximums. The analysis based on grab samples suggests that this threshold may be exceeded from May to September.

This temperature increase may have the potential to alter habitat for juvenile fish present. Increased stream temperatures have been shown to decrease time to emergence in several salmonid species, including coho salmon (Quinn 2005). Cutthroat trout, which spawn and rear later in the season, have been shown to hatch earlier as temperatures increase (Quinn 2005). Although sub-lethal, this temperature increase may impact growth and survival, with juveniles potentially competing for resources earlier in the year (Anlauf-Dunn et al. 2022; Leach 2012; Quinn 2005).

Historically, the stream temperatures in Sequalitchew Creek were likely closer to those observed today in the lake outflow. The steady, cool temperatures currently observed in the ravine reflect the proportionally greater input of groundwater resulting from diversion of the lake outflow from the system.

The dissolved oxygen levels in Lake Sequalitchew and Lower Sequalitchew Creek are high (>9 milligrams per liter [mg/L]). Water quality in the marshes is more typical of stagnant waterbodies exposed to the life cycle of aquatic plants. Dissolved oxygen concentrations are lower (typically <4 mg/L) and are predicted to be raised with the addition of water flowing more rapidly through the system.

4.3.2 Water Quantity

The cumulative effect of the mining and restoration projects on streamflow was evaluated and streamflows were predicted at two locations (Aspect 2022). These locations are the dry reach near Center Drive, and in Sequalitchew Creek at the mid-ravine gage.

4.3.2.1 Flows in the Dry Reach

Under existing conditions, the dry reach currently experiences no consistent flow passing through the entire reach. The bottom of the dry reach is above the current groundwater levels, so ground infiltration in the dry reach would not be affected by lowering of groundwater with mining.

The mining and restoration projects are predicted to result in an average flow of 12.6 cfs in the dry reach. The flow would vary seasonally from a monthly average of 2.5 cfs in August to 25.7 cfs in March as shown in Figure 5. Peak flows could be as high as 65 cfs if all water is routed through the wetlands during peak flow events. To avoid flooding during peak flows, the highest flows could be directed to the Diversion Canal or detained in the marshes. The results presented here do not account for the diversion of peak flows or detention in the marshes.

Modeling indicates there would be periods when there would be no outflow from West Edmond Marsh, and thus no flow in the dry reach. These occur on 401 days of the 19-year period of record (or 7.7% of the time) and typically occur in July and August. These periods last for multiple weeks and occurred in 5 of the 19 years simulated (2004, 2005, 2015, 2017, and 2018). The occurrence of these dry periods could be reduced or eliminated if beaver management structures are built to store water and release it slowly and consistently during periods when there is no flow from Sequalitchew

Lake. Should flow be disrupted, it would temporarily disrupt the habitat and migratory functions of the stream reach between the Sequalitchew ravine springs and Edmond Marsh.

4.3.2.2 Flows in Sequalitchew Creek at Mid-Ravine Gage

After passing through the dry reach, streamflows would enter the Sequalitchew Creek ravine. The vast majority of flow would originate from Sequalitchew Lake, but there would be contribution from springs within the ravine, although the contribution from these springs would be lower than it is under existing conditions.

Spring flow in the upper reaches of the Sequalitchew Creek ravine would be affected by the lowered groundwater levels associated with mining. The groundwater model results for active dewatering, and the long-term condition that would persist after active dewatering has ceased, predict a reduction in spring flow of 79%, varying from 73% in January to 86% in summer.

On average, flow in Sequalitchew Creek at the mid-ravine gage would generally be similar to but slightly higher than the flows in the dry reach (i.e., 0.4 cfs greater), reflecting the input of spring flow. The annual average flow at the mid-ravine gage would be 12.9 cfs. Monthly average flows would range from 2.5 cfs in August to 26.3 cfs in March as shown in Figure 6. Peak flows would be generally the same magnitude (approximately 65 cfs) as in the dry reach.

There would be periods when the cumulative effects of the mining and restoration projects would result in a reduction in flows at the mid-ravine gage when compared with the existing condition. Of the 19 years evaluated, flows would be lower with the projects during 45 periods, lasting a total of 475 days, or about 10.% of the time. Included in this tally are 24 days when there would be no flow at the mid-ravine gage. Under existing conditions, there were 7 days with no measurable flow at the gage. As noted previously, these effects could be mitigated in part or in whole by careful implementation of the beaver management actions called for in the Restoration Plan.

The median duration of a period when flows would be lower with mining and restoration (hereafter referred to as a "lower flow event") was 3 days, but there were seven lower flow events lasting more than 2 weeks. The longer events occurred in 6 of the 19 years simulated (2004, 2005, 2015, 2016, 2017, and 2018). The longest single lower flow event was 98 days, ending in October 2017. However, lower flow events dominated the summer and fall of 2005, when there were four lower flow events between July 20 and December 23 lasting a total of 134 days. Lower flow events occurred most commonly in July, August, and September, but occasionally occurred all months except March. The average streamflow during lower flow events was 0.83 cfs under existing conditions and would be 0.44 cfs with mining and restoration. The decrease in streamflow during lower flow events ranged from 0.1 cfs up to 1.6 cfs. Again, these effects could be mitigated in part or in whole by careful implementation of the beaver management actions called for in the Restoration Plan.

4.3.3 Edmond Marsh

An aspirational goal of the Restoration Plan is to reintroduce a sustainable population of coho salmon. If successful, the aquatic area of West Edmond Marsh will provide excellent rearing habitat for juveniles. Juvenile coho salmon typically stay in freshwater wetlands and small streams for 2 years or more after spawning.

4.3.4 Nearshore Habitat

The additional flow in Sequalitchew Creek will transport more nutrients and fine sediment to the nearshore. The mouth of the creek is near the south end of a drift cell with net transport to the north. The additional sediment would benefit the nearshore by replacing some of the sediment that would naturally come from the exposed bluffs above the railroad. Currently this sediment cannot cross the tracks, and the lower shoreline is heavily armored, preventing erosive forces from recruiting sediment below the railroad. Additional nutrients and sediment will also increase biotic productivity on the Puget Sound shoreline at the mouth of the creek, increasing prey resources for fish. Conditions in the brackish marsh are expected to remain stable. Although salinity at the surface may drop, the saltwater wedge that enters the marsh at high tide will still cover the entire vegetated surface of the marsh.

5 Monitoring and Mitigation Measures

Specific mitigation measures associated with dewatering and other aspects of the mining project are discussed in the Groundwater Section of the Earth and Water Resources Report (Aspect 2022).

Existing mitigation measures at the barge loading facility at Tatsolo Point will continue. The facility is designed in accordance with adopted federal, state, and local regulations and guidelines to reduce the likelihood of spills of lubricants, fuels, and chemicals employed in the processing and manufacturing processes proposed for the site. The overwater portion of the conveyor shall be enclosed to prevent spillage of gravel. The dock is not used for the delivery of supplies, or chemical or other materials by water; a spill plan has been prepared for all elements and operations of the facility (marine and upland). Appropriate oil spill containment equipment is available at the dock site.

Mining operations will continue to manage fugitive dust, and forested buffers around Sequalitchew Creek will remain to protect water quality. Site water and stormwater is recycled and/or infiltrated in the mine, eliminating turbid runoff. During construction of the mitigation wetland and other excavation of soils, construction best management practices will be used to prevent erosion of soils.

The restoration and mining projects both include monitoring and adaptive management programs aimed at ensuring the projects achieve their objectives. A main purpose of ongoing monitoring and adaptive management is to look for detrimental cumulative effects and, if identified, adaptively respond to minimize them.

The adaptive management process is built around the following five steps:

1. Assess
2. Design
3. Implement and monitor
4. Evaluate
5. Adjust

The process is iterative and would continue throughout the projects. Adaptive management plans are in development for each project and will be incorporated into the Restoration Plan and Monitoring Plan.

Monitoring will include continued collection of groundwater and surface water observations at the existing monitoring network, as well as the installation of new monitoring locations and focused monitoring efforts associated with the implementation of the projects. Monitoring data would be shared between the project implementers to allow both adaptive management processes to proceed with the best available information.

6 Significant Unavoidable Adverse Impacts

6.1 Proposed Action

The cumulative impacts of the Project and restoration would generally improve all aspects of the freshwater fish habitat in the Sequalitchew Creek watershed. However, the cumulative impacts of the Project and restoration would permanently and unavoidably reduce the flow of the Sequalitchew Creek springs. This could reduce flows in the creek during drought years when surface water flow from Edmond Marsh is extremely low. Increased water temperature in the summer will create sub-lethal conditions that would reduce fish movement and growth until temperatures are reduced again in the fall. The overall effect of beaver management in storing winter water for summer release is not yet fully quantified, but the dry reach could still go dry and flows below the Sequalitchew Creek springs could be reduced during those periods.

6.2 No Action Alternative

Under the No Action Alternative, the dry reach would remain dry and Edmond Marsh would remain inaccessible to fish downstream. Lower Sequalitchew Creek would continue to have only a fraction of its historical flow and would remain unlikely to support spawning of chum and coho salmon. Rearing habitat for coho salmon and cutthroat trout would remain limited to just a few specific areas within the system.

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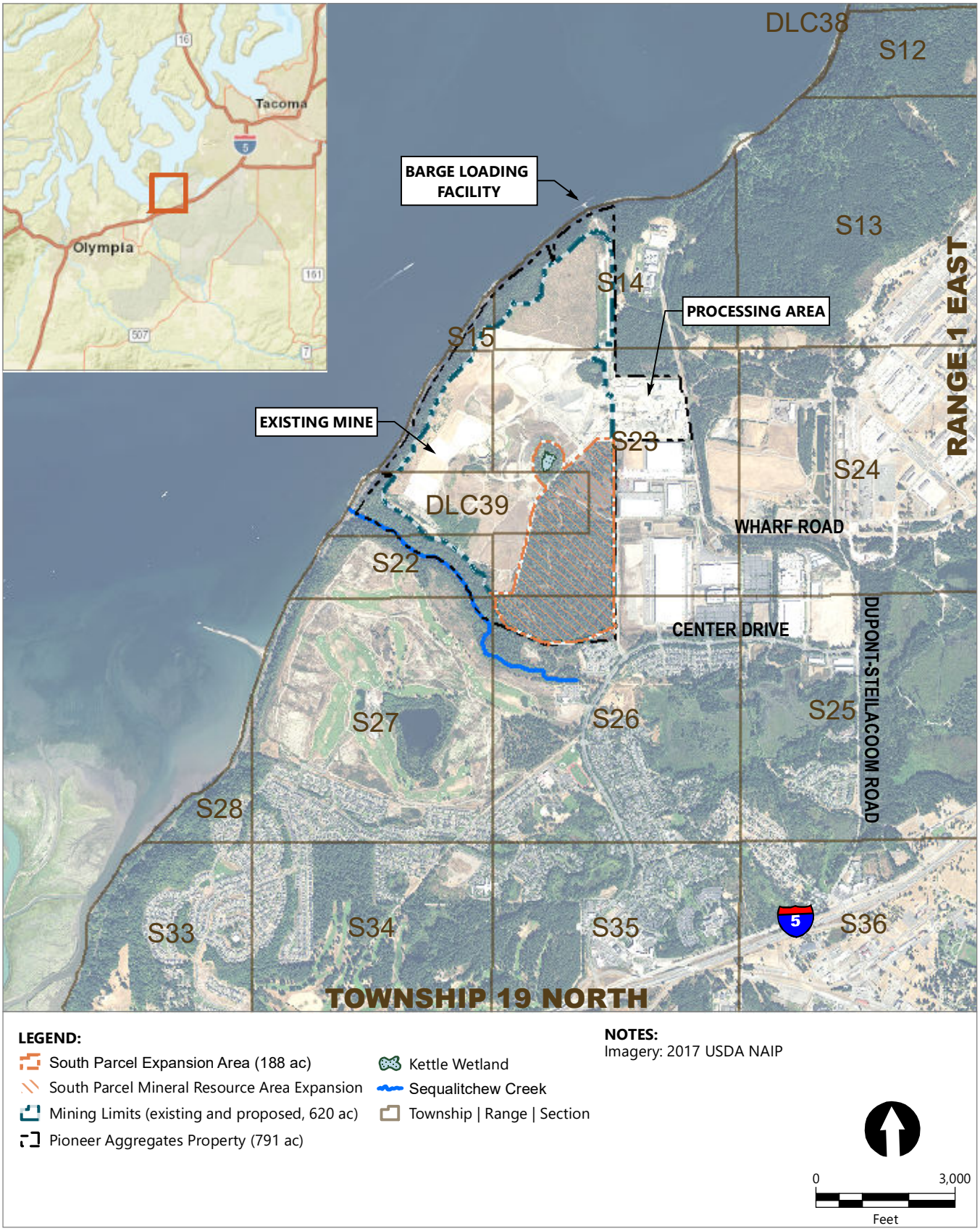
Figures



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ANCHOR QEA

Figure 1
Vicinity Map
Fisheries Technical Report
Pioneer Aggregates South Parcel Project

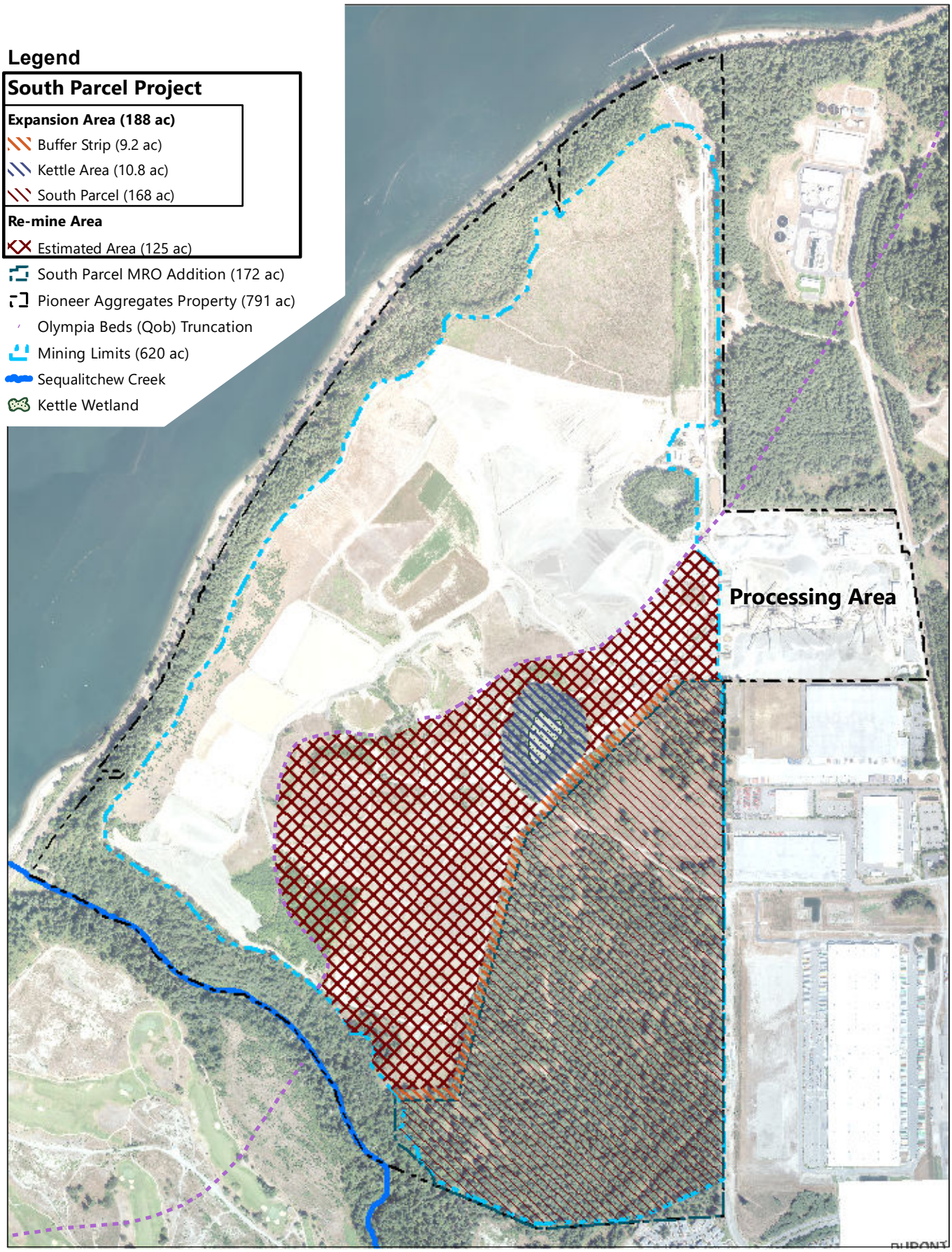

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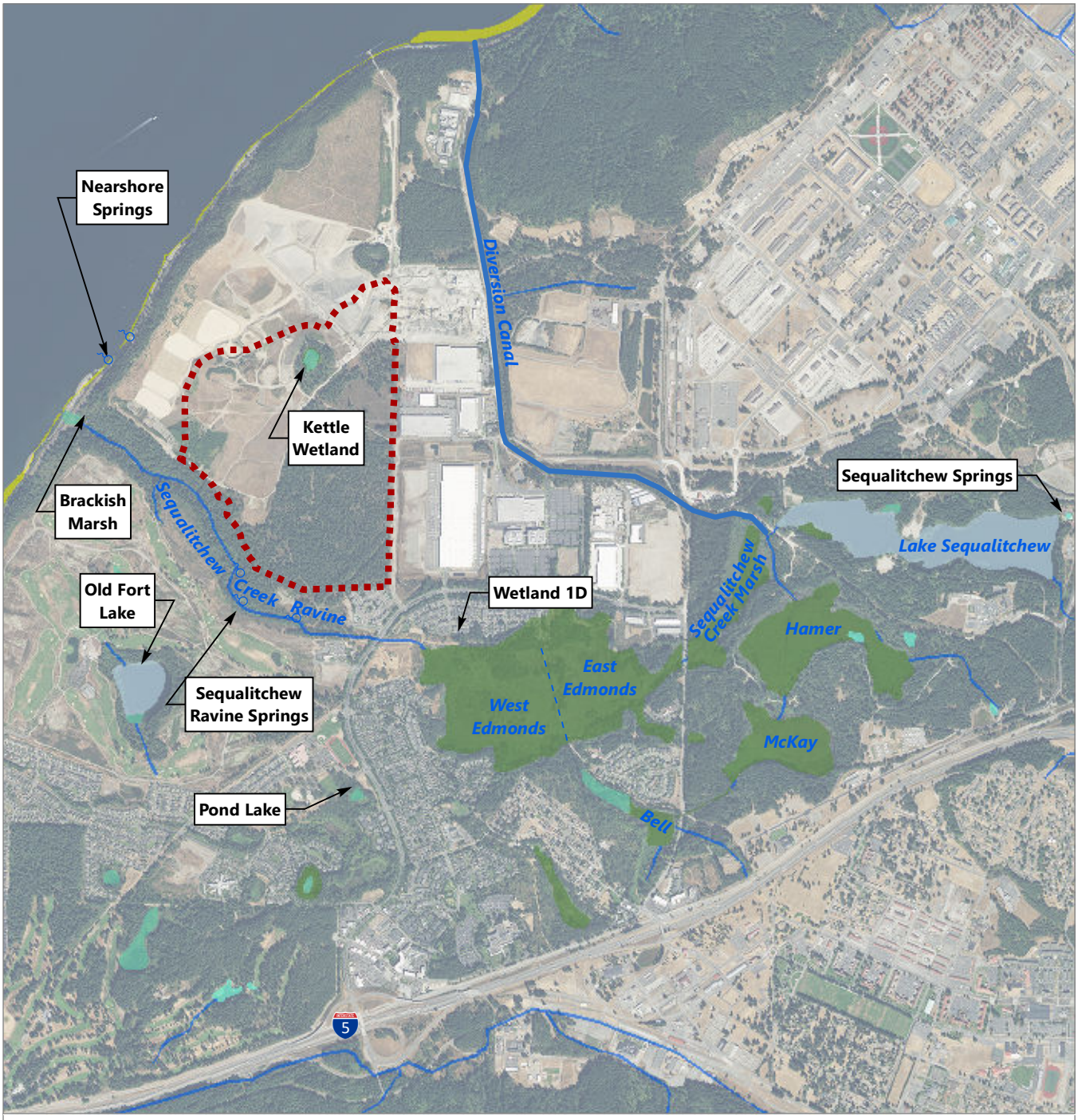
Figure 2
Project Components
Fisheries Technical Report
Pioneer Aggregates South Parcel Project



LEGEND:

- South Parcel Project

Aquatic Resources

- Stream/ Canal
- Freshwater Pond
- Spring
- Lake
- Estuarine and Marine Wetland
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland

NOTES:
This map was created by modifying the USFWS National Wetland Inventory to correct inaccuracies and add additional detail

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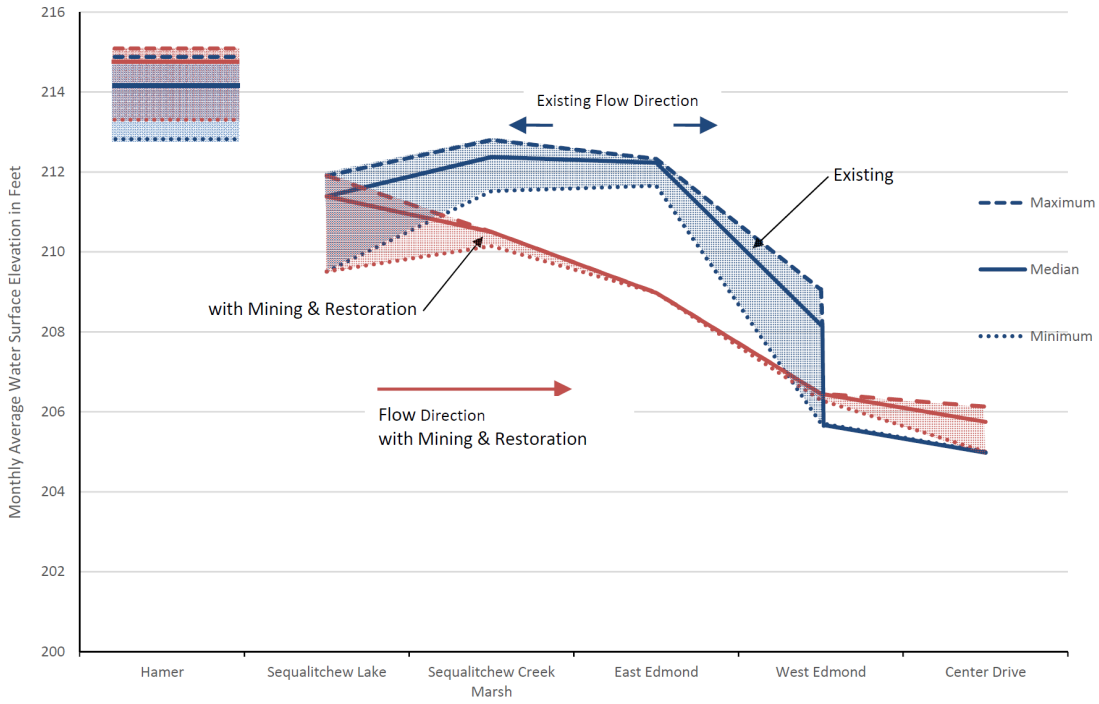
Figure 3
Aquatic Resources
Fisheries Technical Report
Pioneer Aggregates South Parcel Project

Predicted Surface Elevations in the Sequalitchew Creek Watershed



Predicted Annual Average Hydrograph in Sequalitchew Creek

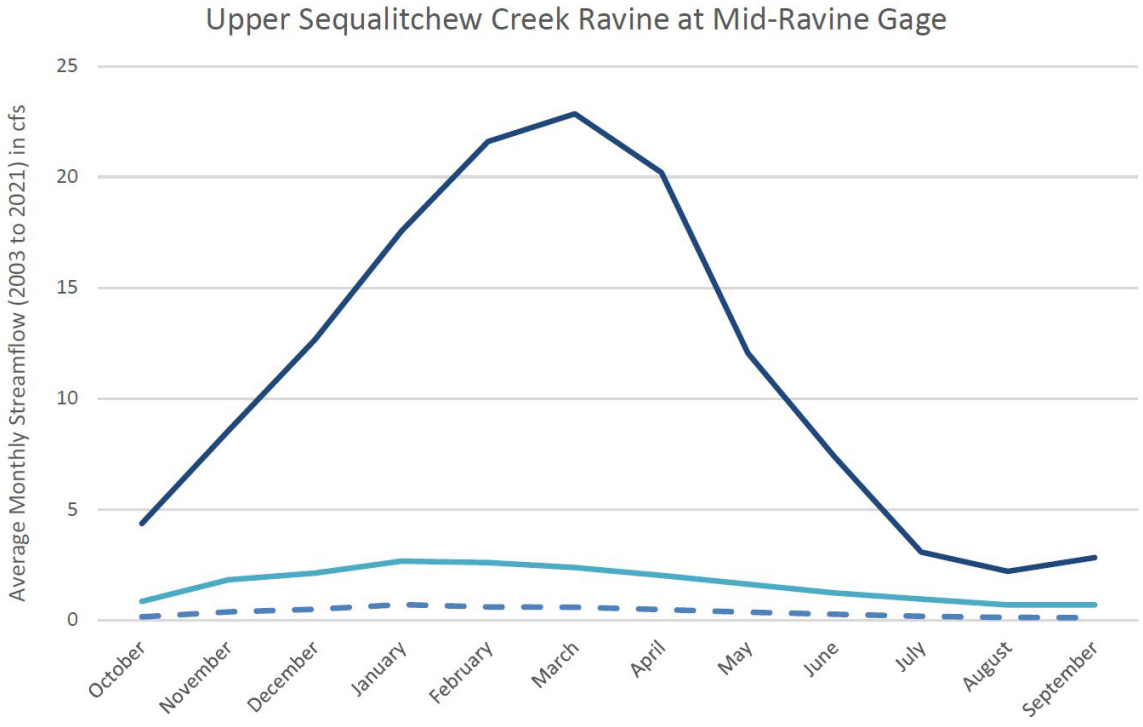


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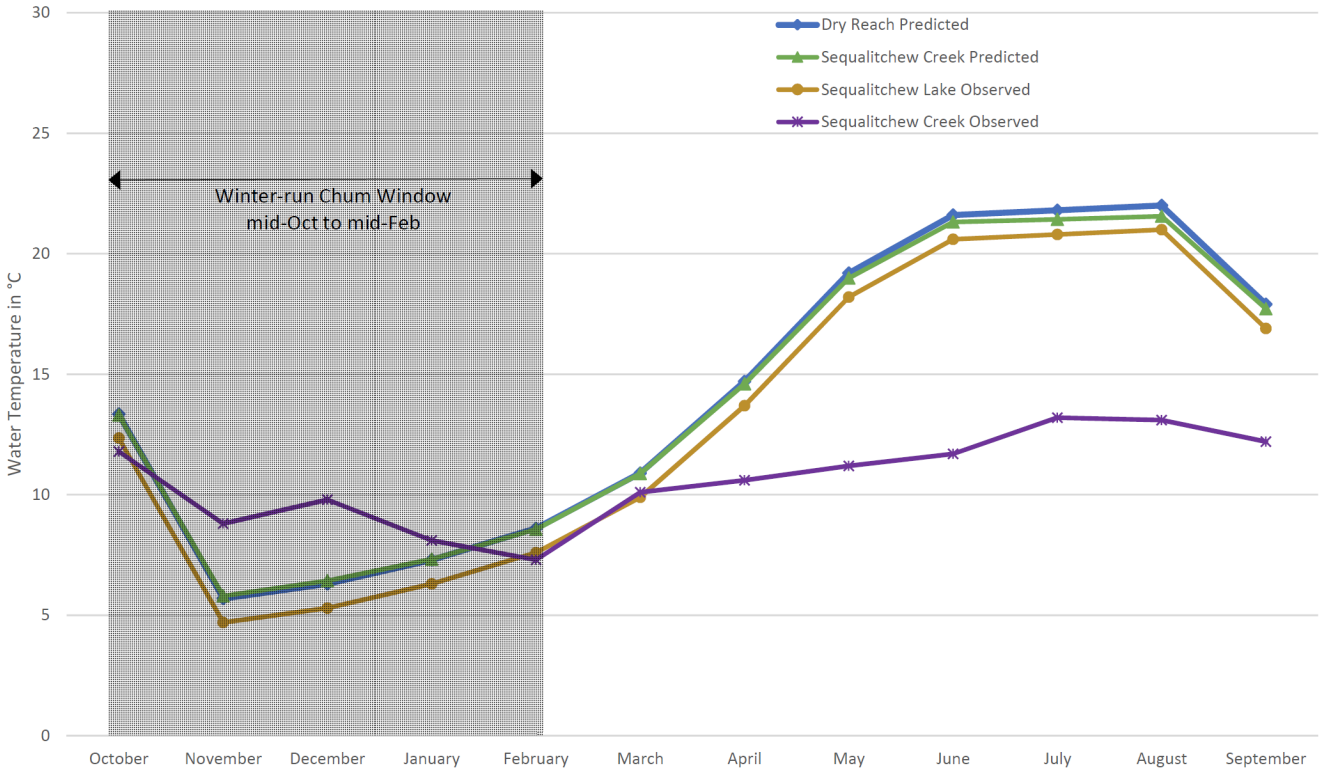
Figure 4
Predicted Water Surface Elevations and Flows
Fisheries Technical Report
Pioneer Aggregates South Parcel Project

Predicted Effects on Stream Temperature in Sequalitchew Creek Before and After Mining and Restoration



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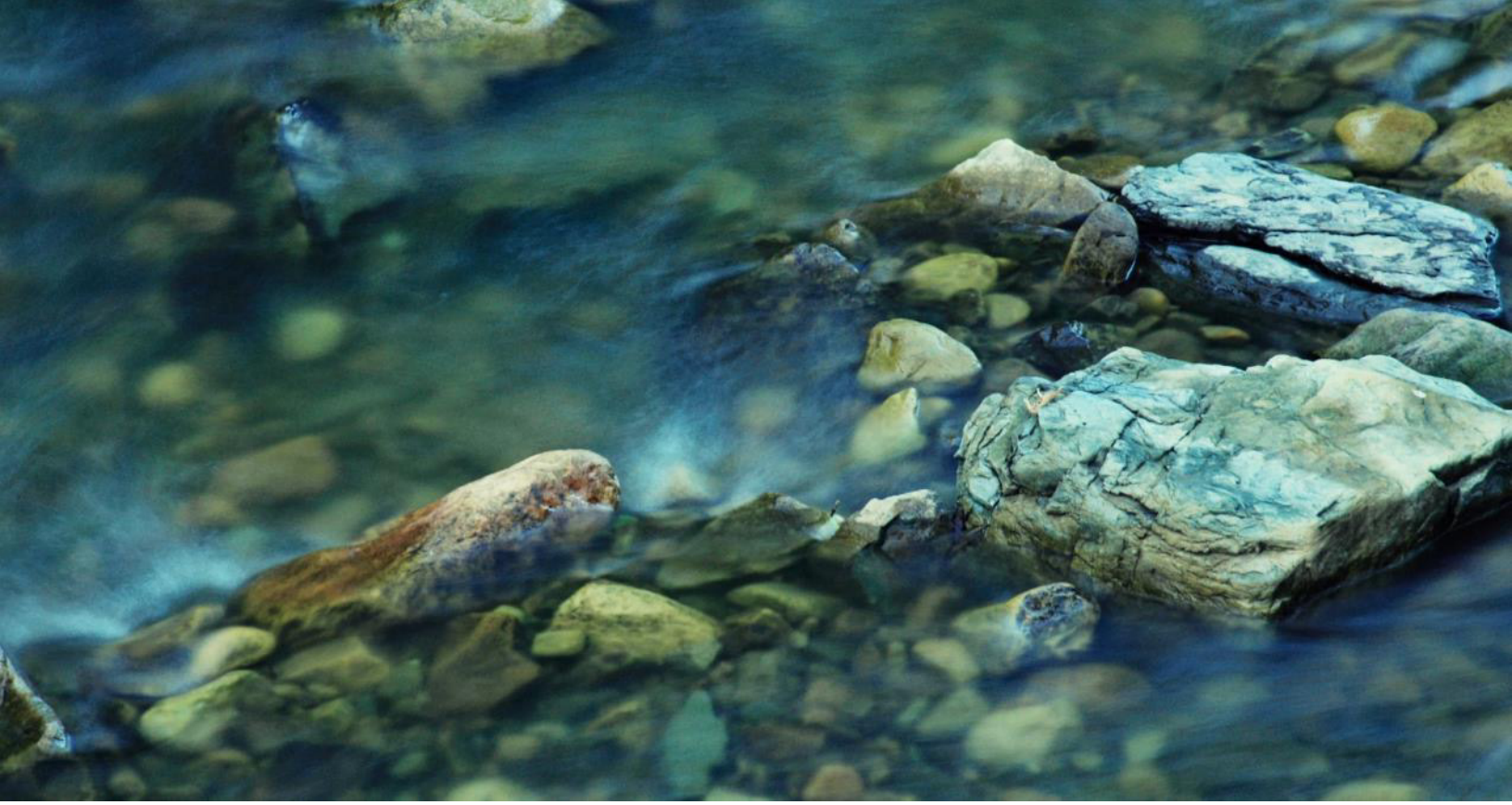
Appendix H

Plants and Animals Report



June 2023
Pioneer Aggregates South Parcel Project

ANCHOR QEA

Plants and Animals Technical Report

Prepared for CalPortland

June 2023
Pioneer Aggregates South Parcel Project

Plants and Animals Technical Report

Prepared for
CalPortland
3450 South 344th Way, Suite 201
Federal Way, Washington 98001

Prepared by
Anchor QEA
1201 Third Avenue, Suite 2600
Seattle, Washington 98101

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APPENDICES

Appendix A Washington Department of Fish and Wildlife Priority Habitats and Species in the Project Area

Appendix B Tables of Plant and Animal Species Surveyed in the Project Area

ABBREVIATIONS

ASTM	ASTM International
cfs	cubic feet per second
cy	cubic yard
DMC	City of DuPont Municipal Code
DNR	Washington State Department of Natural Resources
Ecology	Washington State Department of Ecology
ESA	Endangered Species Act
JBLM	Joint Base Lewis-McChord
PHS	Priority Habitats and Species
Project	Pioneer Aggregates South Parcel Project
Report	Plants and Animals Technical Report
SEPA	Washington State Environmental Policy Act
South Parcel Project	Pioneer Aggregates South Parcel Project
USFWS	U.S. Fish and Wildlife Service
WDFW	Washington State Department of Fish and Wildlife

1 Introduction

Glacier Northwest, Inc. dba CalPortland is seeking regulatory approvals for the Pioneer Aggregates South Parcel Project (South Parcel Project or Project), which proposes to extend sand and gravel mine operations to the southeast of existing activities at the Pioneer Aggregates Mine in DuPont, Washington. This Plants and Animals Technical Report (Report) has been prepared in support of the South Parcel Project. Figure 1 provides an overview map of the South Parcel Project.

This document evaluates the environmental conditions and potential impacts of the South Parcel Project, and potential alternative actions, on plant and animal resources. These analyses are being conducted as a component of the State Environmental Policy Act (SEPA) evaluation for the South Parcel Project.

The following Report describes existing conditions of plants and animals (affected environment), as well as analyzes potential impacts to plants and animals, including aquatic resources, from the proposed Project. In addition, proposed monitoring and mitigation measures for the proposed Project are presented. The proposed Project includes implementation of a Restoration Plan, a related project that will undergo separate environmental review, to mitigate and offset potential Project impacts and improve aquatic resource habitat within the South Parcel Project Area.

1.1 Description of the Proposed Action

The South Parcel Project includes horizontal expansion of mining into approximately 188 acres previously undisturbed by mining, and vertical expansion of approximately 125 acres where re-mining will deepen a portion of the existing mine. The South Parcel Project would extend mining at the current rate for approximately 14 additional years.

The proposed Project activities will be focused southeast of the existing Pioneer Aggregates Mine in the City of DuPont, southwestern Pierce County, Sections 22, 23, and 26, Township 19 North, Range 1 East of the Willamette Meridian (Figure 1). The Project is bordered to the north and west by the existing Pioneer Aggregates Mine; to the east by industrial/distribution facilities including Amazon, Dania, Pier 1 Imports, and FedEx; and to the south by Sequalitchew Creek and the Creekside Village residential development. The Project would occur on lands owned by Weyerhaeuser Company and leased to CalPortland.

The South Parcel Project includes mining within areas previously undisturbed by mining (termed the "Expansion Area") and mining deeper within a portion of existing mine, referred to as the "Re-Mine Area." The Expansion Area is approximately 188 acres and is comprised of three subareas (see Figure 2). The Kettle Area is a 10.8-acre previously undisturbed area. The 9.2-acre Buffer Strip is a strip of vegetation that was retained along the inside of the originally permitted mine bordering the South Parcel. The South Parcel Project is located southeast of the original mine and all portions of

the South Parcel Project are within the Mineral Resource Overlay in the City of DuPont's current adopted Comprehensive Plan.

The Re-Mine Area consists of 125 acres in the southeastern portion of the existing mine where groundwater limits the depth of current mining activities.

The South Parcel Project has been developed consistent with a 2012 Settlement Agreement between CalPortland, the City of DuPont, the Washington State Department of Ecology (Ecology) and a coalition of environmental groups collectively referred to as the Environmental Caucus. The Settlement Agreement describes a process for a Restoration Plan for the Sequalitchew Creek watershed to be permitted and implemented contemporaneously with mining of the South Parcel. The Restoration Plan is designed "to help restore and enhance the Sequalitchew Creek watershed, including flows along the entire length of the Creek." The Restoration Plan would provide substantial regional benefits and is not intended solely as mitigation for the South Parcel Project. The Restoration Plan is described in Section 4.4.3.

1.1.1 Existing Mine

CalPortland's original sand and gravel mine was permitted in 1997 (355 acres). As provided under the 2012 Settlement Agreement, CalPortland applied for permits in 2013 for the North Parcel Mine Expansion to allow mining of approximately 142 acres within the North Parcel. Following the publication of a Final EIS in June 2013, the North Parcel mining expansion was permitted in 2014.

Mining activities at the existing site include mining, processing, transport of sand and gravel, and manufacturing of concrete. The processing area is located adjacent to the mine site on a 52-acre parcel. Sand and gravel is removed from the mine by bull dozers and wheel loaders and transferred to the processing area by conveyor belts. At the processing facility, the material from the mine is crushed, washed, and separated into different size gradations. Aggregate products are stored in stockpiles in the processing area for distribution.

After completion of the production process, the majority of the finished aggregate products are transported from the plant area by conveyors and placed onto barges (approximately 80%) at Glacier's dock and barge-loading facility at Tatsolo Point. The remainder (approximately 20%) is sold as aggregate or used to make concrete on-site; in both cases it is transported by truck.

Water used to wash gravel during processing is recycled through a clarifying process to remove silt and clay. This fine material is then run through a belt press to remove excess water and transported by truck and placed in holding cells in the mine where it is allowed to dry for up to 3 years.

After drying, fines may be used to raise the floor of the mine by placing the material in cells separated by rock curtains to facilitate drainage. The material is placed in approximately 6-inch lifts and

compacted to a material dry density of 90% (ASTM International [ASTM]:D-1557) or greater. Once filled to the desired height with fines from the belt press in this manner, a gravel cap of not less than 10 feet is placed over the compacted fines to mitigate potential for settlement and facilitate drainage.

1.1.2 South Parcel Project

The proposed South Parcel Project includes expansion of the mine footprint by approximately 188 acres and extension of the existing rate of mining for an additional approximate 14-year period (depending on market conditions), increasing the available sand and gravel resources by 30 to 40 million tons. The entire South Parcel Project, including the Expansion Area, is located within a Mineral Resource Overlay applied by the City of DuPont's Comprehensive Plan. The purpose of the overlay is to conserve mineral resources of long-term commercial significance for future extraction, as required by the Growth Management Act. The South Parcel Project would involve six primary activities: logging, clearing and topsoil removal, groundwater management, mining, processing and transport, and reclamation. These activities would overlap, with multiple actions occurring at any one time.

1.1.2.1 Logging

Timber was logged from the South Parcel several years ago, but tree cutting would still be needed prior to clearing and mining in the Expansion Area. A substantial portion of the proposed mining would occur within previously reclaimed areas of the existing mine (i.e., the Re-Mine Area) or in previously unmined areas where the non-native invasive shrub species Scot's broom (*Cytisus scoparius*) dominates the landscape. The Expansion Area would be logged at a single time prior to initiating mining.

1.1.2.2 Clearing and Topsoil Removal

Clearing and topsoil removal would occur in the mine area, in segments as mining advances into the Expansion Area, over the life of the Project. Prior to mining, excavators would be used to remove stumps and vegetation. This material would then be processed through a portable tub grinder and used to amend topsoil for use in reclamation.

The Expansion Area is located downwind of the former Asarco copper smelter and refinery in Ruston, Washington. Airborne pollution emitted from the former smelter has resulted in a 1,000-square-mile, area-wide plume of arsenic- and lead-contaminated soil known as the Tacoma Smelter Plume. Surficial soils in the Expansion Area that have been undisturbed since the mid-1980s may contain arsenic and lead at concentrations above cleanup levels. These soils would be cleaned up under an approved plan developed in consultation with Ecology through the Voluntary Cleanup Program. The plan will incorporate the same process that is being successfully implemented on the North Parcel.

1.1.2.3 Groundwater Management

A portion of an existing aquifer is present in the sands and gravels to be mined under the South Parcel Project. Wells will be installed and pumped in advance of mining to intercept groundwater and dry out the gravels for mining. The mining plan is designed to minimize the amount of time that active dewatering by pumping wells is required.

Mining under the South Parcel Project will proceed slowly from the north to the south, extracting gravel to create a broad trough along the eastern property boundary, over a period of 5 to 8 years. Once mining of each section of the trough is completed, the adjacent wells can be turned off, allowing groundwater to passively seep from the stable mine slope and flow by gravity to an infiltration facility on the floor of the existing mine. After mining the trough along the perimeter, gravel will be extracted from the interior area.

A detailed dewatering plan has been developed and is described in detail in the Monitoring Plan. The dewatering plan involves four steps, occurring over different time scales. The four steps are:

- **The initial step** is a 60-day pumping test that is completely reversible (i.e., no gravel would be extracted during the test). The results of that test would be analyzed to confirm predictions from the groundwater drawdown model and used to adjust the dewatering plan (well spacing, well screening, etc.) as necessary prior to commencing the next phase.
- **The second step** involves installing and pumping additional dewatering wells to lower water levels in the first mine segment in preparation for mining. This step would last about 6 months and functions as a greatly expanded pumping test. As with the initial step, it is also completely reversible. Groundwater observations during pumping would be compared to model predictions in order to confirm that actual changes in groundwater are within the range predicted during Project planning, when potential impacts from the Project are evaluated. This step will confirm model predictions before any gravel is removed from the Expansion Area.
- **The third step**—active dewatering during mining—involves mining the trough described above. Additional dewatering wells will be installed and pumped as mining progresses. Mining would begin at the location farthest from the Edmond Marsh and Sequalitchew Creek and proceed slowly south. Completing the trough would require 5 to 8 years depending on market conditions and the success in meeting predicted groundwater levels. The potential impact on groundwater levels builds slowly over time as wells are added and mining progresses south. This allows ample opportunity to monitor, confirm model predictions, and adapt to the conditions observed before mining proceeds into each dewatered segment.
- **The final step**—passive dewatering—begins when mining of the trough described above is complete and the last dewatering well is turned off. Passive dewatering represents the groundwater condition that will continue in perpetuity. Groundwater, no longer intercepted

by wells, would form seeps at the toe of the eastern mine slope. It would flow by gravity through a conveyance ditch to newly created wetlands on the bottom of the existing mine and eventually to an infiltration pond. Once this step has begun, further mining activities in the interior of the South Parcel would not affect groundwater.

1.1.2.4 Mining

The method of mining for the South Parcel Project will be identical to that currently used in the permitted mine areas. A dozer would push excavated material from the top of the mine face to two front-end loaders working on the mine floor. The front-end loaders would scoop-up the sand and gravel and dump it into portable hoppers that feed conveyors leading to the processing area.

The mine face of each sequence area will be a maximum of 80 feet high and will decrease as mine activities progress. During reclamation, the graded side slopes and mine areas will be revegetated and stabilized in accordance with the mine reclamation plan.

A conveyor will start at the north end of the Expansion Area and will be extended south as mining progresses. The conveyor is comprised of a 48-inch-wide rubberized belt that is supported by a series of rollers, called idlers, mounted on steel framed segments that support the conveyor about 5 feet off the ground.

As mentioned above, clearing of the Expansion Area will occur in a sequence of segments, with one segment being cleared approximately each year, in coordination with mining and construction activities. Mass clearing of the site will not occur.

A 20-foot-high noise berm would be constructed along the southern boundary of the South Parcel. It would be located behind vegetation retained in a buffer. The berm will also be vegetated and would help reduce potential noise associated with mining for adjacent land uses. The berm will be constructed at the beginning of the Project prior to clearing in the adjacent portion of the South Parcel.

The Project will directly impact an approximately 1.78-acre Kettle Wetland located within the existing mine just west of the South Parcel. The Kettle Wetland will be impacted by dewatering in preparation for mining, then removed during the initial phases of mining of the South Parcel Project. Impacts to the Kettle Wetland will be mitigated by creation of a larger wetland within the existing mine. Detailed analysis of the wetland impacts and mitigation are described in the Wetland Mitigation Plan (Anchor QEA 2021a).

1.1.2.5 Processing and Transport

Material mined under the South Parcel Project would be conveyed from the mine to the existing processing facility and would be processed in the same general manner as at present. The material extracted under the South Parcel Project is anticipated to have a higher moisture content and fines

content than the aggregate currently being extracted. As a result, there may be minor adjustments to some of the equipment used in the processing area, but the overall process and most of the equipment would remain unchanged.

Water is used to wash the raw material conveyed from the mine to remove silt and clay. Sand and gravel smaller than 1.5 inches pass through a screening and classifying process that separates and conveys the material to a series of stockpiles sorted by size and stacked on the south side of the processing plant. Stones larger than 1.5 inches are crushed, sorted by size and conveyed to a series of crushed-rock stockpiles sorted by size north of the processing plant. Screening equipment, rock crushers and other processing equipment are located between the stockpiles of sorted rock products. Custom blended rock products are also made to customer specifications.

More than 95% of water used to process the mined material is recycled through a treatment system where silt and clay is removed so the water can be reused to process more raw material from the mine.

The mode and extent of transporting aggregate products from the site would not change relative to existing operations. Approximately 80% of the product would be loaded onto barges at the existing dock at Tatsolo Point and transported to the Puget Sound regional market by barges.

Approximately 20% of the product would be transported to the local market by truck. Some material would continue to be incorporated into concrete at the existing on-site concrete batch plant serving the local market.

1.1.2.6 Reclamation

As mining progresses, completed mine segments would be reclaimed. The reclamation plan will be reviewed by the Washington State Department of Natural Resources (DNR) for consistency with the Surface Mining Act (Revised Code of Washington 78.44). In general, reclamation will consist of regrading, replacement of topsoil, and revegetation, Glacier is in the process of preparing an application to revise the existing reclamation plan incorporated into the surface mine reclamation permit. The DNR cannot approve the revised reclamation permit until after the City's permits are issued. The proposed reclamation plan will be similar to the plan approved by the DNR for the existing mine.

A summary of the change in land uses that would occur as a result of the South Parcel Project after completion of mine reclamation is presented in Table 1. Table 1 also presents information about the portions of the existing mine where no changes are proposed as a result of the South Parcel Project, such as the North Parcel and Processing Area.

Table 1
Land Use Change as a Result of the South Parcel Project After Reclamation

Land Use	Area [1] in Acres									
	Existing Conditions					Proposed Action - Post-Reclamation				
	Expansion Area			Re-Mine Area	Total	Expansion Area			Re-Mine Area	Total
	South Parcel	Kettle Area	Buffer Strip			South Parcel	Kettle Area	Buffer Strip		
Built Areas										
Buildings	--	--	--	--	0.00	--	--	--	--	0.00
Roads, Access, and Parking	--	--	0.4	9.2	9.55	--	--	--	--	0.00
Processing Areas	--	--	0.2	17.9	18.08	--	--	--	--	0.00
Active Mining	--	--	--	--	0.00	--	--	--	--	0.00
Active Reclamation	--	--	0.2	20.5	20.62	--	--	--	--	0.00
Cleared for Mining	--	--	--	--	0.00	--	--	--	--	0.00
Water Management Ponds	--	--	--	--	0.00	--	--	--	--	0.00
Total Built Areas	0	0	0.8	47.5	48.26	0	0	0.00	0.00	0.00
Natural & Reclaimed Areas										
Areas Reclaimed as Forest	--	--	--	3.3	3.3	29.4	0.6	0.6	35.8	66.3
Areas Reclaimed as Grass	--	--	--	68.5	68.5	138.2	10.2	8.6	89.4	246.4
Wooded Areas	146.2	5.6	7.4	5.8	165.1	--	--	--		0.0
Grass Areas	21.3	--	1.0	0.21	22.5	--	--	--		0.0
Wetland	--	1.8	--		1.8	--	--	--		0.0
Wetland Buffer	--	3.4	--		3.4	--	--	--		0.0
Total Natural & Reclaimed Areas	167.5	10.8	8.4	77.7	264.5	167.5	10.8	9.2	125.2	312.7
Total	167.5	10.8	9.2	125.2	312.7	167.5	10.8	9.2	125.2	312.7

Notes:
-- Indicates no area of this type.
1) Totals may not exactly equal the sum of their components due to rounding.

As shown in Table 1, the primary change occurring as a result of the South Parcel Project is the conversion of existing wooded areas into areas reclaimed as forest and as grass. Generally, the steeper slope areas will be reclaimed as forest and flat and gently sloping areas will be reclaimed as grass lands to support future redevelopment. This is true for areas within the South Parcel as well as the Kettle and Buffer Area and the Re-Mine Area.

1.1.2.7 Estimated Volume and Extraction Rates

Based on past market demand, material would be extracted at an average rate of approximately 2.8 million cubic yards per year. An estimated 30 to 40 million cubic yards of material would be extracted as part of the Project, which would extend the life of the current operation by about 14 years. The actual extraction rate and life of the mine will depend on the market demand for materials. Estimated mining quantities are shown in Table 2.

Table 2
Estimated Annual Quantities and Timing of Aggregate Mining

Timing	Existing Mine[1]	South Parcel Project
Years 1 through 14	1.4 million cy	1.4 million cy
Years 14 through 19	0	2.8 million cy

Note:
Existing Mine includes North Parcel

1.2 Description of the Restoration Plan

The Restoration Plan, developed by CalPortland and the Environmental Caucus, seeks to restore and enhance streamflow and ecological functions from Sequalitchew Lake through Edmond Marsh into Sequalitchew Creek ravine. The Restoration Plan is a related action and is undergoing separate, contemporaneous SEPA review as part of the permitting for the actions specified in the plan. Restoration of Sequalitchew Creek is necessary because of almost two centuries of human manipulation. Today, portions of Sequalitchew Creek are dry, and the majority of what would be the natural flow in the creek is diverted out of the system. The Restoration Plan is intended to sequentially restore diverted flows back to the creek, improve the sustainability of flows through the system, and restore aquatic habitat by removing flow-related fish passage barriers and increasing the habitat available to aquatic species.

1.3 Description of the No Action Alternative

This document also evaluates the No Action Alternative. A No Action Alternative is required by SEPA. "No action" is interpreted to mean that the City would take no action on the mining proposal, but it does not necessarily mean that nothing would happen on the subject site.

Under the No Action Alternative, the South Parcel would not be mined and the property could be developed for manufacturing and research and residential uses under existing land use and zoning designations.

Portions of the South Parcel are zoned for Manufacturing and Research Park (MRP; 136.2 acres), Residential-4 (R-4; 16.1 acres), Residential Reserve (RR; 22.3 acres), and Open Space (3.8 acres) uses. The MRP zoned areas are subject to restrictive covenants related to Former DuPont Works Cleanup Site. These covenants restrict use of the property to industrial uses and, barring further remediation activities, would prevent re-zoning of the MRP areas.

The extent of development could vary considerably depending on zoning/density, and Project-specific and regulatory elements such as setbacks, open space, and critical areas. Areas zoned MRP would be available for development of up to 112 acres of light manufacturing and research. Buildings may be up to 65 to 70 feet tall and there are no maximum lot coverage

requirements other than necessary to meet required setback (25 feet on the front property line, 15 feet on the sides and rear) and landscaping (20% of lot area) requirements. Provision of 0.3 to 1 parking space per employee working at maximum shift is required.

Under the No Action Alternative, development would occur consistent with the City of DuPont Municipal Code (DMC) Critical Areas chapter (DMC 25.105), which could allow for development near the top of the Sequalitchew Creek ravine with a setback to be determined by a geotechnical engineer or engineering geologist. Development would also occur consistent with stream and wetland buffers and setbacks in DMC 25.105.

The areas of the South Parcel zoned R-4 can be developed at a density of up to 4.5 single-family residences per gross acre,[1] resulting in a total of approximately 76 residences. An additional four single-family residences could be developed in the smaller portion zoned for Residential Reserve density (one dwelling unit per 5 gross acres).

There would be no changes in the use of the areas of the South Parcel zoned for Open Space; these areas currently include the naturally vegetated slope of the Sequalitchew Creek ravine and the Sequalitchew Creek pedestrian trail. A summary of the parcels, zoning, and development potential of the South Parcel is presented in Table 3.

Table 3
Parcels, Zoning, and Development Potential of the South Parcel

Parcel No.	Zoning	Parcel Area in Acres	Potential Development
0119262015	MRP	21.0	16.8 acres MRP
	OS	3.8	None
	Total	24.7	16.8 acres MRP
0119262016	MRP	34.1	27.3 acres MRP
0119233016	MRP	20.0	16.0 acres MRP
0119233017	MRP	20.3	16.3 acres MRP
0119233014	MRP	20.3	16.3 acres MRP
0119233015	MRP	20.5	16.4 acres MRP
0119233011	R-4	16.1	72 residences
	R-R	22.3	4 residences
	Total	38.4	76 residences

Note:
Potential development for MRP areas includes buildings, parking lots, access roads, but not vegetated areas.

[1] "Gross acre" means land designated for residential purposes in the comprehensive plan, inclusive of related streets and neighborhood parks. DMC 25.10.040.

Under the No Action Alternative scenarios there would be no change in use of the areas within the existing mine. However, once the Re-Mine Area is reclaimed it would likely be redeveloped according to its underlying zoning, similar to the South Parcel.

The Kettle Wetland is within the existing mine and would remain intact, the buffers would remain vegetated, and mining operations would continue in other portions of the existing mine. The Kettle Wetland, its buffer, and other mine-related buffers would potentially be removed once the existing mine is reclaimed and redeveloped for future uses. Parcels, zoning, and potential development under the No Action Alternative are shown in Table 3.

2 Affected Environment

The affected environment for the plants and animals analysis includes the geographic areas that could be affected (directly and indirectly or cumulatively) by the proposed Project, including the South Parcel Project Area and the Restoration Plan Area. The South Parcel Project Area includes the approximately 125-acre Re-Mine Area and the approximately 188-acre Expansion Area (Figure 2). The Re-Mine Area is where re-mining will deepen a portion of the existing mine. This area contains a mixture of bare ground and patches of vegetation and no aquatic resources.

The Expansion Area is composed of three areas previously undisturbed by mining: the 168-acre South Parcel, the 10.8-acre Kettle Area, and the 9.2-acre Buffer Strip between the existing mine and the South Parcel. The Kettle Area includes the Kettle Wetland and forested wetland buffer. The Buffer Strip is a strip of vegetation that was retained along the inside of the originally permitted mine bordering the South Parcel. The South Parcel is a mixture of coniferous forest and shrubland habitat.

The Restoration Area includes the aquatic resources of Sequalitchew Creek and the following four wetland systems: East Edmond Marsh, West Edmond Marsh, Sequalitchew Creek Riparian Wetlands, and the Brackish Marsh (Figure 3). These aquatic resources are also within the area that could be affected by changes to groundwater levels (City of DuPont 2007; Herrera Environmental Consultants 2005a).

Three additional aquatic resources could be indirectly affected because they are within the area in which a change in groundwater levels is predicted. These areas include Sequalitchew Creek Ravine Seep Wetlands, Pond Lake, and Wetland 1D (Figure 3). Sequalitchew Creek Ravine Seep Wetlands, Pond Lake, and Wetland 1D are identified in this Report as Nearby Wetlands.

To identify and assess plants and animals, information was gathered from a variety of sources including existing literature, agency information, resource maps, and aerial photographs and site visits performed in 2017, 2019, and 2021 (Anchor QEA 2017, 2019, 2021a). A variety of extensive studies have been performed for this Project and previously proposed projects to mine the South Parcel. The analysis in this Report is based substantially on the information in the following existing documents and information from these documents are included by reference in this Report:

- *Glacier Northwest DuPont Mining Area Expansion and North Sequalitchew Creek Project Final Supplemental Environmental Impact Statement* (City of DuPont 2007)
- *Pioneer Aggregates Mining Facility and Reclamation Plan—Draft Environmental Impact Statement* (City of DuPont 1992)
- *CalPortland DuPont North Parcel Mining Project Final Supplemental Environmental Impact Statement* (City of DuPont 2013)
- *Pioneer Aggregates Mining Expansion and North Sequalitchew Project Surface Water and Geomorphology Technical Report* (Herrera Environmental Consultants 2005a)

- *Pioneer Aggregates Mining Expansion and North Sequalitchew Project Plants and Animals Technical Report* (Herrera Environmental Consultants 2005b)
- *Pioneer Aggregates South Parcel Project Landmark Tree Inventory Report* (Anchor QEA 2021a)
- *Pioneer Aggregates Mine Expansion* (*South Parcel*) *Project Wetland Mitigation Plan* (Anchor QEA 2021b)
- *Addendum to the 2007 North Sequalitchew Creek Project Impact Area Wetland Delineation Report* (Anchor QEA 2018)
- Kettle Wetland Delineation Verification, October 22 and December 5, 2019 (Anchor QEA 2019)
- *Pioneer Aggregates Mine Expansion (South Parcel) Kettle Wetland Delineation Report* (Anchor QEA 2021c)
- *Supplemental Analysis of Sequalitchew Creek Area Wetlands Wetland Evaluations, Ratings, and Field Data* (Wetland Science Applications and Anchor Environmental 2005)

2.1 Plants and Habitat

Dominant plant communities and habitats within the South Parcel Project Area, the Restoration Area, and the areas subject to changes in groundwater levels include coniferous forests, shrublands, grassland, and aquatic resources (streams and wetlands). Rare plants and plant communities are also described.

2.1.1 Conifer Forests

Conifer forests cover most of the Expansion Area (Figure 4), including approximately 135 acres of the approximately 188 acres that would be cleared for mining (Figure 2). Second-growth conifer forests are interspersed with young regenerating stands as a result of previous timber harvest practices. Douglas-fir (*Pseudotsuga menziesii*) dominates the canopy and regeneration in most areas. Western red cedar (*Thuja plicata*) and Oregon white oak (*Quercus garryana*) also occur in smaller numbers within the conifer forest (Anchor QEA 2021a).

Common understory shrub species include beaked hazelnut (*Corylus cornuta*), snowberry (*Symphoricarpos albus*), trailing blackberry (*Rubus ursinus*), Scot's broom, and salal (*Gaultheria shallon*). Other species include twin flower (*Linnea borealis*), low Oregon grape (*Mahonia nervosa*), sword fern (*Polystichum munitum*), bald-hip rose (*Rosa gymnocarpa*), red huckleberry (*Vaccinium parvifolium*), ocean spray (*Holodiscus discolor*), black-cap raspberry (*Rubus leucodermis*), kinnikinnick (*Arctostaphylos uva-ursi*), bracken fern (*Pteridium aquilinum*), St. John's wort (*Hypericum perforatum*), western and hairy honeysuckles (*Lonicera ciliosa* and *L. hispidula*, respectively), wild strawberry (*Fragaria vesca*), yarrow (*Achillea millefolium*), yerba buena (*Satureja douglasii*), wood rush (*Luzula parviflora*), velvet grass (*Holcus lanatus*), and colonial bentgrass (*Agrostis capillaris*) (City of DuPont 2007, 2013; Herrera Environmental Consultants 2005b).

The Re-Mine Area is an active mining area dominated with grassland, with patches of shrubland and young stands of red alder (*Alnus rubra*). An approximately 5-acre patch of conifer forest located at the south end of the Re-Mine Area with similar species composition as the Expansion Area (Figure 2).

Forest vegetation within the Restoration Area includes riparian habitat associated with Sequalitchew Creek and wetland buffer habitat of wetlands within the Restoration Area. These forested areas are a mixture of coniferous and deciduous trees with a diverse shrub and herbaceous understory. Sequalitchew Creek, wetlands within the Restoration Area, and nearby wetlands are described in Section 2.1.3, Aquatic Resources.

2.1.1.1 Landmark Trees

A landmark tree survey was performed within the Expansion Area and Re-Mine Area per DMC Critical Area Chapter 25.10.120.005 criteria (Anchor QEA 2021a). Five species and a total of 116 landmark trees were identified during the survey. Landmark tree species include Douglas-fir, Oregon white oak, Pacific madrone, (*Arbutus menziesii*) Pacific yew (*Taxus brevifolia*), and western red cedar. The species and number of landmark trees within the Expansion Area and Re-Mine Area are shown in Table 4.

Table 4
Summary of Landmark Trees Within the Expansion Area and Re-Mine Area

Common Name	Scientific Name	Expansion Area Total Trees[1]	Re-Mine Area Total Trees
Douglas-fir	*Pseudotsuga menziesii*	81	1
Oregon white oak	*Quercus garryana*	17	2
Pacific madrone	*Arbutus menziesii*	2	0
Pacific yew	*Taxus brevifolia*	2	0
Western red cedar	*Thuja plicata*	10	1
Total		**112**	**4**

Note:
1. Includes adjacent buffer.

2.1.2 Shrublands

Shrublands within the Expansion Area are dominated by the non-native invasive species Scot's broom (Figure 2). This non-native invasive plant community covers approximately 42 acres of the approximately 188 acres proposed for clearing under the Project. Plant coverage beneath this layer is restricted to mosses and small patches of colonial bentgrass. Native shrub species are mostly absent and are present in only a few areas adjacent to patches of native tree species. The native herbaceous species include Idaho fescue (*Festuca idahoensis*), chocolate lily (*Fritillaria lanceolata*), early blue

violet (*Viola adunca*), and Pacific sanicle (*Sanicula crassicaulis*) (City of DuPont 2007, 2013; Herrera Environmental Consultants 2005b).

The Re-Mine Area is an active mining area dominated with grassland areas that were hydroseeded during reclamation. The presence of the non-native invasive species Scot's broom and the native species red alder are controlled as part of the reclamation process (Figure 2).

Shrublands within the Restoration Area and associated with the nearby wetlands include wetland buffer habitat that is a mixture of native and non-native shrub species. Sequalitchew Creek, wetlands within the Restoration Area, and nearby wetlands are described in Section 2.1.3, Aquatic Resources.

2.1.3 Aquatic Resources

Aquatic resources include Sequalitchew Creek, Puget Sound shoreline nearshore springs, and eight wetland communities. No aquatic resources are located within the Re-Mine Area. One aquatic resource, the Kettle Wetland, is located within the Expansion Area (Figure 2). Sequalitchew Creek and the East Edmond Marsh, West Edmond Marsh, Sequalitchew Creek Riparian Wetlands, and the Brackish Marsh wetland systems are located outside of the mine footprint but within the Restoration Area and within the area where changes in groundwater levels are predicted. Three nearby wetlands located within the area that could potentially be affected by changes in groundwater levels are Sequalitchew Creek Ravine Seep Wetlands, Pond Lake, and Wetland 1D (Figure 3).

No change is predicted to groundwater quantity or quality that feeds the nearshore springs located along the Puget Sound shoreline, and no changes to the nearshore springs are identified (Aspect 2022).

2.1.3.1 Expansion Area Wetlands

2.1.3.1.1 Kettle Wetland

The 1.78-acre Kettle Wetland is located within the Expansion Area (Figure 2). This wetland would be removed by proposed mining on the South Parcel. It contains persistent emergent, non-persistent emergent, aquatic bed, and scrub-shrub wetland communities (City of DuPont 2007, 2013; Anchor QEA 2021c). The dominant hydrologic source for the wetland is the aquifer system. Water levels within the wetland are determined by the seasonal fluctuation in the elevation of the Vashon Aquifer.

The emergent communities consist of common mare's tail (*Hippuris vulgaris*), creeping spike rush (*Eleocharis palustris*), giant bur-reed (*Sparganium eurycarpum*), water parsnip (*Sium suave*), reed canarygrass (*Phalaris arundinacea*), water ladysthumb (*Polygonum amphibium*), mild waterpepper (*Polygonum hydropiperoides*), skunk cabbage (*Lysichiton americanus*), inflated sedge (*Carex vesicaria*), and northern bugleweed (*Lycopus uniflorus*). Aquatic species observed include pondweed

(*Potamogeton* sp.), lesser duckweed (*Lemna minor*), arrowleaf bur-reed (*Sparganium angustifolium*), and floating-leaved pondweed (*Potamogeton natans*).

Along the wetland boundary, the scrub-shrub community consists of Pacific willow (*Salix lasiandra*), Scouler's willow (*Salix scouleriana*), sitka willow (*Salix sitchensis*), red-osier dogwood (*Cornus sericea*), and hardhack (*Spiraea douglasii*). Other vegetation along the wetland boundary consists of stinging nettle (*Urtica dioica*), blue elderberry (*Sambucus caerulea*), beaked hazelnut, and Henderson sedge (*Carex hendersonii*).

Buffer vegetation bordering the Kettle Wetland includes tree, shrub, grass, and herbaceous species. Dominant tree species include big-leaf maple (*Acer macrophyla*), red alder, black cottonwood (*Populus trichocarpa*), western red cedar, bitter cherry (*Prunus emarginata*), Douglas hawthorne (*Crataegus Douglasii*), blue elderberry, and Pacific madrone. Dominant shrub species include trailing blackberry, salal, snowberry, Scot's broom, Oregon grape, bald-hip rose, ocean spray, sword fern, Saskatoon serviceberry (*Amelanchier alnifolia*), red huckleberry, and bracken fern. Herbaceous species include velvet grass, western wild-rye (*Elymus glaucus*), and colonial bentgrass (*Agrostis capillaris*). Vine species include manroot (*Marah oreganus*).

The Kettle Wetland is classified as a Category III wetland using the City's rating system (DMC 25.105.050) and the Ecology rating system (Anchor QEA 2021c; Hruby 2014). This wetland is not regulated by the U.S. Army Corps of Engineers because it lacks a surface water connection to waters of the U.S. (Corps 2019).

2.1.3.2 Restoration Area Wetlands

These resources are discussed generally here and will be evaluated fully in a separated environmental review. The following is intended to provide context of the effects of the related action (restoration) in comparison to the Proposed Action (mining).

2.1.3.2.1 West Edmond Marsh

West Edmond Marsh is the portion of Edmond Marsh located west of Robinson Trail, a former railroad grade that bisects Edmond Marsh and east of Center Drive (Figure 3). West Edmond Marsh occupies approximately 80 acres. It has a hydrologic regime dominated by surface water inputs entering East Edmond Marsh to the east and smaller inputs from stormwater infiltration ponds along the north and south. Sequalitchew Creek follows a relatively straight path near the northern boundary of the marsh that results from historical efforts to drain and channelize the marsh.

Water levels in West Edmond Marsh are controlled by multiple beaver dams, the most significant of which is a large beaver dam at the western boundary just upstream of the normally dry reach of Sequalitchew Creek under Center Drive.

Seasonal high water levels in West Edmond Marsh range from about 210 feet elevation in the westernmost portion to 211.8 feet elevation just downstream of Robinson Trail. The westernmost portion has seasonal variation in water levels of 4 to 5 feet and typically dries up in summer. The portion near Robinson Trail retains water year-round and typically experiences a seasonal range in water levels of 1 to 1.5 feet. Water levels in West Edmond Marsh exhibited an increasing trend from 2004 to 2014 and have since appeared to stabilize at the higher level.

Vegetative communities include scrub-shrub, emergent, and aquatic bed wetland types (City of DuPont 2007, 2013; Herrera Environmental Consultants 2005b; Wetland Science Applications and Anchor Environmental 2005). The eastern portion of the marsh is shallow to deeply inundated, due to impoundment by beaver dams. Dominant vegetation includes black cottonwood, willows (*Salix* sp.), spiraea (*Spirea douglasii*), water parsley (*Oenanthe sarmentosa*), yellow pond lily (*Nuphar luteum* var. *polysepala*), pond weed (*Lemna minor*), cattails (*Typha latifolia*), and reed canarygrass (*Phalaris arundinacea*). The area includes upland islands that are forested with mature Douglas-fir, black cottonwood, and other native species. The dense, layered vegetation within the marsh, upland islands, and patches of open water provide high-quality wildlife habitat and offer a substantial habitat base for native wetland plant and animal species.

West Edmond Marsh is classified as a Category II wetland using the City's rating system (DMC 25.105.050) and the Ecology rating system (Hruby 2014). Over time, the hydrology of West Edmond Marsh has been affected by various efforts to maintain an open water channel through dense scrub-shrub wetland. The construction and periodic maintenance of this channel through the marsh maintained water levels that were lower than currently exist. Subsequent impoundment of water by beaver dams across this channel and elsewhere in the marsh has resulted in water levels of the marsh steadily increasing in recent decades, as is evidenced by the drowning of some mature upland trees (Anchor QEA 2022 and aerial imagery).

2.1.3.2.2 East Edmond Marsh

East Edmond Marsh occupies approximately 55 acres (Figure 3) between the Robinson Trail on the west and DuPont-Steilacoom Road on the east. East Edmond Marsh continues to the east of DuPont-Steilacoom on Joint Base Lewis-McChord. This segment of the Marsh is not evaluated in this Report but will be evaluated as part of separate environmental review required for the Restoration Plan.

Historically, the primary source of water to East Edmond Marsh was the surface water of Sequalitchew Creek flowing out of Sequalitchew Lake. The creek followed a meandering channel through the marsh that was been excavated and cleared by human activity. However, beaver activity has resulted in water levels in East Edmond Marsh that are higher than in Sequalitchew Lake, and now the hydrology of East Edmond Marsh is dominated by groundwater inflows from multiple

sources including regional groundwater, shallow subsurface flow from nearby Bell, Hamer, and McKay marshes, and stormwater from nearby infiltration ponds.

The water level in East Edmond Marsh is controlled by a large beaver dam located just upstream of the primary culvert under Robinson Trail and is relatively uniform throughout the marsh segment. Seasonal high water levels are typically about 212.5 to 213 ft NGVD 29. East Edmond Marsh retains water year-round, with a typical water level fluctuation of 1 to 1.5 feet seasonally

Vegetative communities include forested, scrub-shrub, emergent, and aquatic bed wetland types. Dominant vegetation includes black cottonwood, red alder, Oregon ash (*Fraxinus latifolia*), willows, red-osier dogwood, spiraea, sedges (*Carex* spp.), bulrushes (*Scirpus* spp.), water smartweed (*Polygonum amphibium*), water parsley, cattails, and reed canarygrass. Floodwater storage, sediment sequestering, nutrient filtration, and biological support are strong functions of East Edmond Marsh. The area includes upland islands that are forested with mature Douglas-fir, black cottonwood, and other native species. The dense, layered vegetation within the marsh, upland islands, and patches of open water provide high-quality wildlife habitat and offer a habitat base for native wetland plant and animal species (City of DuPont 2007, 2013; Herrera Environmental Consultants 2005b; Wetland Science Applications and Anchor Environmental 2005).

East Edmond Marsh is classified as a Category II wetland using the City's rating system (DMC 25.105.050) and the Ecology rating system (Hruby 2014).

2.1.3.2.3 Sequalitchew Creek Ravine Riparian Wetlands

The riparian forest wetland that borders Sequalitchew Creek west of Center Drive (Figure 3) includes many areas of braided flow and side-channels, flood terraces, and well-established forested riparian wetland vegetation communities. The canopy species include red alder, big-leaf maple, and western red cedar. Common shrub species include vine maple (*Acer circinatum*), salmonberry (*Rubus spectabilis*), red elderberry (*Sambucus acemose*), black gooseberry (*Ribes lacustre*), and cascara (*Rhamnus purshiana*). Common herbaceous species include mannagrass (*Glyceria elata*), giant horsetail (*Equisetum telmatiea*), American brooklime (*Veronica americana*), slough sedge (*Carex obnupta*), stinging nettle, Cooley's hedge-nettle (*Stachys coolyeii*), and water parsley (City of DuPont 2007, 2013; Herrera Environmental Consultants 2005b; Wetland Science Applications and Anchor Environmental 2005).

The Sequalitchew Creek riparian forest wetlands are considered Category II wetlands using the City's rating system (DMC 25.105.050) and the Ecology rating system (Hruby 2014).

2.1.3.2.4 Brackish Marsh

Near its mouth, Sequalitchew Creek passes through a concrete box culvert (5 feet wide by 5 feet high and 240 feet long) under the BNSF Railway Company rail line before discharging into Puget Sound.

Upstream of this culvert is a brackish marsh (Figure 3). The brackish marsh occupies a series of terraces dissected by dendritic channels. Common species include Lyngby's sedge (*Carex lyngbeyi*), seacoast bulrush (*Scirpus maritimus*), seashore saltgrass (*Distichlis spicata*), marsh cinquefoil (*Potentilla anserina*), and gumweed (*Grindelia integrifolia*). Significant patches of colonial bentgrass occur along the margins of the brackish marsh (City of DuPont 2007, 2013; Herrera Environmental Consultants 2005b; Wetland Science Applications and Anchor Environmental 2005).

The Sequalitchew Creek brackish marsh is classified as a Category II wetland using the City's rating system (DMC 25.105.050) and the Ecology rating system (Hruby 2014).

2.1.3.3 Nearby Wetlands

2.1.3.3.1 Sequalitchew Creek Ravine Seep Wetlands

The ravine containing Sequalitchew Creek contains seeps and springs that surface from mid-slope to the toe of slope. These seeps and springs provide base flow to Sequalitchew Creek and contribute to species diversity within the area by supporting plant species that require more moisture than is available in surrounding upland areas. A 0.13-acre seep wetland complex consisting of two long, very narrow, and non-contiguous wetlands is located just above the trail along Sequalitchew Creek at about river mile 0.75 to 0.85. The wetland hydrology emanates from seep heads just above the trail and is dominated by groundwater. Dominant vegetation species include willow herb (*Epilobium ciliatum*) and lady fern (*Athyrium filix-femina*) (City of DuPont 2007), and the ravine includes plant species identified in Section 2.1.3.2.3.

These forested Seep Wetlands are classified as Category IV wetlands using the City's rating system (DMC 25.105.050) and the Ecology rating system (Hruby 2014).

2.1.3.3.2 Wetland 1D

Wetland 1D is located immediately north of West Edmond Marsh and south of Center Drive (Figure 3). The wetland covers approximately 2.1 acres and is dominated by scrub-shrub vegetation including Pacific willow, spiraea, western crabapple *(Malus fusca*), and red-osier dogwood. Wetland 1D is shallow and permanently inundated (City of DuPont 2007, 2013; Herrera Environmental Consultants 2005b; Wetland Science Applications and Anchor Environmental 2005).

Water levels in Wetland 1D range seasonally from 208.6 to 211 feet NGVD 29 and track closely with nearby groundwater levels.

Wetland 1D is considered a Category II wetland using the City's rating system (DMC 25.105.050) and the Ecology rating system (Hruby 2014).

2.1.3.3.3 Pond Lake

Pond Lake is located approximately 0.5 mile south of the proposed Expansion Area (Figure 3). The water level in Pond Lake typically exhibits a seasonal range of about 4 feet and tracks closely with nearby groundwater levels. It is a shallow pond dominated by herbaceous species, with a forested upland edge dominated by red alder and big-leaf maple. The dominant species in the wetland is reed canarygrass. Small pockets of native species including sedges and water-plantain (*Alisma plantago-aquatica*) occur in the wetland (City of DuPont 2007, 2013; Herrera Environmental Consultants 2005b; Wetland Science Applications and Anchor Environmental 2005).

Pond Lake is considered a Category III wetland using the City's rating system (DMC 25.105.050) and the Ecology rating system (Hruby 2014). Due to a lack of a surface water connection with other waters of the U.S., this wetland is not regulated by the Corps.

2.1.3.4 Nearshore Springs

Nearshore springs located on the forested hillside of Puget Sound flow directly into Puget Sound (Figure 3). These springs express from the hillside and there is no surface flow associated with these features within the South Parcel Project Area.

2.1.4 Rare Plants and Plant Communities

2.1.4.1 Washington Department of Fish and Wildlife Plants and Priority Habitats

No rare plants are identified by Washington Department of Fish and Wildlife (WDFW) in locations where mining could occur in the South Parcel Project Area or within the areas subject to changes in groundwater levels (WDFW 2022a). No populations of white-topped aster (*Sericocarpus rigidus*), a state sensitive species, have been documented within the limits of the South Parcel Project Area, although populations do occur in Pierce County (WDNR 2022) and in oak forests adjacent to the South Parcel Project Area (City of DuPont 2007; Herrera Environmental Consultants 2005b).

A patch of forested habitat at the south end of the Re-Mine Area where mining is proposed is mapped by WDFW as priority habitat biodiversity areas and corridor, but the physical characteristics within the small portion where mining is planned do not meet WDFW's stated criteria. Specifically, this area is flat, developable land and is not part of the steep, undevelopable ravine side slope. The forested riparian habitat of Sequalitchew Creek and the forested hillside of Puget Sound near where mining is proposed are also mapped as priority habitat biodiversity areas and corridor. The habitat of East and West Edmond Marsh are mapped by WDFW as waterfowl concentration areas (WDFW 2022a). The Priority Habitats and Species (PHS) database does not include any white oak woodlands in or around the Project area, or within the City of DuPont. Where white oak exist within the Project area, they are interspersed in a primarily coniferous forest within the Expansion Area and account for less than 5% of the canopy. WDFW defines priority Oregon white oak woodlands as

stands of pure oak or oak/conifer associations where canopy coverage of the oak component of the stand is 25%; or where total canopy coverage of the stand is less than 25%, but oak accounts for at least 50% of the canopy coverage present. The latter is often referred to as an oak savanna. In non-urbanized areas west of the Cascades, priority oak habitat consists of stands 0.4 hectare (1 acre) in size (Larsen and Morgan 1998). Therefore, the oak stand on the Project site does not meet WDFW criteria for priority habitat.

Important habitats in the larger vicinity of the South Parcel include the Nisqually Delta, a large, high-quality wetland complex with regionally rare intact estuarine functions and native plant populations, abundant wildlife habitat, and high utilization by wildlife.

2.1.4.2 Threatened and Endangered Plants

The U.S. Fish and Wildlife Service (USFWS) identifies Endangered Species Act (ESA)-listed plant species and critical habitats under USFWS jurisdiction that occur or may occur within a specific location where a project is proposed on the agency's website (USFWS 2021a). The status of federally listed plant species and critical habitats protected under the ESA that occur or may occur where mining could occur in the South Parcel or within the area subject to changes in groundwater levels is presented in Table 5.

Table 5
Federally Listed Plant Species that May Occur in the South Parcel or Areas Subject to Changes in Groundwater Levels, with Their Endangered Species Act and Critical Habitat Status

Species	Status	Critical Habitat
Golden paintbrush (*Castilleja levisecta*)	Threatened	None designated
Marsh sandwort (*Arenaria paludicola*)	Endangered	None designated

Potential habitat for the plant species golden paintbrush (*Castilleja levisecta*; USFWS 2021b) and marsh sandwort (*Arenaria paludicola*; USFWS 2021c) is not located in or within the vicinity of the South Parcel Project Area or within the area subject to changes in groundwater level.

2.2 Animals

Animal species are described based on the animal types: birds, mammals, and amphibians. Additional information on the wide variety of common species that use habitats within the Project vicinity is also described in the Pioneer Aggregates Draft EIS (City of DuPont 1992). Several federally and state-listed species occur within the Project vicinity. Their status and use of the Project vicinity are described in subsequent sections of this Report.

2.2.1 Birds

The South Parcel Project Area and Restoration Area provides a range of habitat features that can provide breeding, foraging, resting, and overwintering habitat to support a wide range of bird species (Johnson and O'Neil 2001; Hamer et al. 2018). Forested habitats provide foraging and nesting habitat for a wide variety of songbird species such as song sparrow (*Melospiza melodia*), bushtit (*Psaltriparus minimus*), Bewick's wren (*Thryomanes bewickii*), Steller's jay (*Cyanocitta stelleri*), spotted towhee (*Pipilo erythrophthalmus*), Swainson's thrush (*Catharus ustulatus*), winter wren (*Troglodytes hiemalis*), varied thrush (*Ixoreus naevius*), black-capped chickadee (*Parus atricapillus*), dark-eyed junco (*Junco hyemalis*), chestnut-backed chickadee (*Parus rufescens*), golden-crowned kinglet (*Regulus satrapa*), and red-breasted nuthatch (*Sitta canadensis*).

Upland shrublands and herbaceous habitats are used by species like barn swallow (*Hirundo rustica*), tree swallow (*Tachycineta bicolor*) and white-crowned sparrow (*Zonotrichia leucophrys*). Predatory birds like red-tailed hawk (*Buteo jamaicensis*) commonly hunt in these habitat types. Other raptors such as northern harrier (*Circus cyaneus*) and bald eagle (*Haliaeetus leucocephalus*) occur in forested areas near waterbodies. Snags and downed trees in forested habitat and along the forest edges also provide perch sites for these species. Snags in forested habitats also provide potential nest sites for cavity-nesting birds such as great horned owl (*Bubo virginianus*), and species of woodpeckers including downy woodpecker (*Picoides pubescens*), northern flicker (*Colaptes auratus*), and pileated woodpecker (*Dryocopus pileatus*).

Aquatic habitats and wetland habitats provide a variety of habitat for terrestrial birds, waterbirds, and waterfowl. Open water sections of wetlands can be expected to provide habitat for belted kingfisher (*Megaceryle alcyon*) and wintering and migratory waterfowl, including gadwall (*Anas strepera*), American widgeon (*Mareca americana*), mallard (*Anas platyrhynchos*), ring-necked duck (*Aythya collaris*), and American coot (*Fulica americana*). Wetland areas with grass and herbaceous vegetation provide habitat for red-winged blackbird (*Agelaius phoeniceus*), song sparrow, and marsh wren (*Cistothorus palustris*), among other species including waterfowl. Forested and scrub-shrub wetlands are commonly used by similar species as well as wood duck (*Aix sponsa*). Waterbird species such as great blue heron (*Ardea herodias*) also use many of these habitats.

2.2.2 Mammals

Small mammal species associated with forested habitats include shrew mole (*Neurotrichus gibbsii*), Townsend's vole (*Microtus townsendii*), masked shrew (*Sorex cinereus*), and striped skunk (*Mephitis mephitis*). Larger mammals such as black-tailed deer (*Odocoileus hemionus columbianus*) and coyote (*Canis latrans*) also occur throughout the site.

Wetlands and riparian areas provide habitat for North American beaver (*Castor canadensis*), water shrew (*Sorex palustris*), and raccoon (*Procyon lotor*). Beavers are well documented in the wetland

habitats of East and West Edmond Marsh. The non-native species Virginia opossum (*Didelphis virginiana*) also occurs in these habitat types. These and similar species depend on water for foraging, breeding, and sometimes, overwintering habitats.

2.2.3 Amphibians

Wetlands and streams provide habitat for amphibian species such as northern red-legged frog (*Rana aurora*), northwestern salamander (*Ambystoma gracile*), Pacific treefrog (*Pseudacris regilla*), roughskin newt (*Taricha granulosa*), and western red-backed salamander (*Plethodon vehiculum*).

2.2.4 Washington Department of Fish and Wildlife Priority Species

Three species are mapped by WDFW as occurring or habitat presence within the South Parcel Project Area and the area subject to changes in groundwater level: big brown bat (*Eptesicus fuscus*), little brown bat (*Myotis lucifugus*), and Yuma myotis bat (*Myotis yumanensis*). These bat species occur in forested habitats, typically occupying mature trees (WDFW 2022a). These bat species are not state or federally listed.

Western gray squirrel (*Sciurus griseus*), a state threatened species, is documented within the Project vicinity (Herrera Environmental Consultants 2005b) but is not currently identified by WDFW as occurring within the South Parcel Project Area and the area subject to changes in groundwater level. This species favors Garry oak (*Quercus garryana*) woodlands as prime habitat. This habitat occurs within areas adjacent to the South Parcel Project Area, in patches throughout the City of DuPont, and also within the Fort Lewis Military Reservation. This species also forages within coniferous forests that occur near Garry oak woodlands.

The western gray squirrel was listed as threatened in Washington State in 1993 (WAC 323.12.011). There are three known populations in Washington: the southern Puget Trough, north-central Washington, and south-central Washington (Vander Haegen and Orth 2011). Typical western gray squirrel habitat in the Puget Trough includes a Douglas-fir-Oregon white oak woodland with an understory dominated by snowberry (*Symphoricarpos albus*), California hazelnut (*Corylus cornuta* var. *californica*), Indian plum (*Oemleria cerasiformis*), and sword fern (*Polystichum munitum*) (Ryan and Carey 1995). Ryan and Carey continue to describe the typical characteristics of oak woodlands that are important to western gray squirrels as consisting of a mix of Douglas-fir (53% on average) with oaks comprising 34% on average. These characteristics were not observed within the South Parcel Project Area.

One of the primary limiting factors in western gray squirrel success in the Puget Trough is the lack of genetic diversity through habitat fragmentation (Linders and Stinson 2007). The South Parcel is separated from the primary western gray squirrel population at Joint Base Lewis-McChord (JBLM) by Interstate 5, as well as several other heavily used roadways. While a small amount of canopy

connectivity to JBLM property exists across the Puget Sound Bluff and up Sequalitchew Creek ravine, the lack of connectivity to confirmed squirrel-populated sites contributes to the overall lack of habitat potential on the South Parcel for gray squirrels.

Based on the above discussion, the South Parcel does not provide primary (nesting, breeding) habitat for western gray squirrel. While the site does possess marginal characteristics of secondary squirrel habitat (conifer-dominated, moderate canopy and shrub coverage), several identified factors make the possibility of use of the South Parcel by western gray squirrel remote.

2.2.5 Threatened and Endangered Species

USFWS identifies ESA-listed species and critical habitats under USFWS jurisdiction that occur or may occur within a specific location where a project is proposed on the agency's website (USFWS 2021a). The status of federally listed species and critical habitats protected under the ESA that USFWS identify as occurring or may occur in the South Parcel or within the area subject to changes in groundwater level is presented in Table 6. None of the species listed in Table 6 have been identified to be present within the Project area during field studies or database review conducted by Anchor QEA.

Table 6
Federally Listed Species that May Occur in the South Parcel or Areas Subject to Changes in Groundwater Level, with Their Endangered Species Act and Critical Habitat Status

Species	Status	Critical Habitat
Birds		
Northern spotted owl (*Strix occidentalis caurina*)	Threatened	Designated (not present)[1]
Marbled murrelet (*Brachyramphus marmoratus*)	Threatened	Designated (not present)[1]
Streaked horned lark (*Eremophila alpestris strigata)*	Threatened	Designated (not present)[1]
Yellow-billed Cuckoo (*Coccyzus americanus)*	Threatened	Designated (not present)[1]
Mammals		
Roy Prairie Pocket Gopher (*Thomomys mazama glacialis*)	Threatened	Designated (not present)[1]
Amphibians		
Oregon spotted frog (*Rana pretiosa*)	Threatened	Designated (not present)[1]

Note:

1. No records of the observed presence of this species utilizing the Project area have been found, and no observations have been made during field studies of the Project area.

Potential habitat for northern spotted owl (*Strix occidentalis caurina*) and marbled murrelet (*Brachyramphus marmoratus*), mature and old growth forest communities, is not located in or within the vicinity of the South Parcel or within the areas subject to changes in groundwater level. The WDFW PHS database records no species occurrence for northern spotted owl or marbled murrelets in or near the Project area (WDFW 2022a).

The species streaked horned lark (*Eremophila alpestris strigata*) and yellow-billed cuckoo (*Coccyzus americanus*) are generally considered to have a low tolerance to human activity. Potential habitat for streaked horned lark, yellow-billed cuckoo, and Roy prairie pocket gopher (*Thomomys mazama glacialis*) is not located within or near the South Parcel or the areas subject to changes in groundwater level. The WDFW PHS database records no species occurrence for these species in or near the Project area (WDFW 2022a).

Oregon spotted frog (*Rana pretiosa*) is highly aquatic and rarely found away from water. Within a watershed, most breeding populations are small, and many are isolated from other breeding populations. They require breeding sites in shallow water with short vegetation and full sun exposure. Only six watersheds are currently known to be occupied in Washington: Sumas River, South Fork Nooksack River, Samish River, upper Black River, lower Trout Lake Creek, and at Conboy Lake and Camas Prairie in the Outlet Creek drainage. The WDFW PHS database records no species occurrence for this species in or near the Project area (WDFW 2022a).

There are no state or federally listed fish species documented to occur in Sequalitchew Creek (WDFW 2022b; Anchor QEA 2022). The estuary and marine nearshore are potentially used by federally listed Chinook salmon and bull trout.

3 Impacts of the Proposed Action and No Action Alternative

This section describes the potential direct, indirect, and cumulative impacts to plants and habitat and animals from the Proposed Action (in Sections 3.1, 3.2, and 3.3, respectively). The direct and indirect impacts of the No Action Alternative are discussed in Sections 3.4 and 3.5, respectively). Section 3.6 identifies monitoring and mitigation measures that could avoid, minimize, or reduce potential impacts. Significant unavoidable adverse impacts are identified in Section 3.7.

Potential impacts to plants and habitat and animals from the proposed South Parcel Project include the following:

- Direct impacts related to logging, land clearing, mining activities, and reclamation in the proposed Re-Mine Area and the Expansion Area. Direct impacts include proposed activities within the South Parcel Project Area.
- Indirect impacts related to project-related changes in groundwater levels and restoration activities that could occur outside the South Parcel Project Area.
- Cumulative impacts include those resulting from South Parcel mining and additional actions implemented within the watershed pursuant to the Restoration Plan, including beaver management in Edmond Marsh and flow restoration in Sequalitchew Creek. Cumulative impacts are described in Section 4.

3.1 Direct Impacts of the Proposed Action on Plants and Habitat

3.1.1 Conifer Forests

All existing coniferous forests within the South Parcel Project Area would be logged prior to initiating mining. The total area of coniferous forest within the Re-Mine Area is approximately 15 acres, and the Expansion Area is approximately 135 acres. Revegetation would occur throughout the South Parcel Project Area according to the details of the reclamation plan developed for both the existing and proposed mining areas. Reclamation would include the establishment of mixed species and conifer dominant forests along the slopes of the mine.

3.1.2 Landmark Trees

Ninety landmark trees have been identified as being located within the areas that would be cleared under the proposed Project including Douglas-fir (74), Garry oak (13), Pacific madrone (1), Pacific yew (1), and western red cedar (1) (Anchor QEA 2021a).

3.1.3 Shrublands and Grasslands

All shrublands and grasslands within the South Parcel Project Area would be cleared in conjunction with logging activities. The total area of shrublands and grasslands within the Re-Mine Area is

approximately 60 acres, with most of that area comprised of grassland habitat associated with hydroseeding during reclamation activities. The total area of shrublands and grasslands within the Expansion Area is approximately 42 acres. The dominant shrublands species is the non-native invasive species Scot's broom. Scot's broom has been controlled in the Re-Mine Area during reclamation activities and would likewise be controlled throughout the site during mining and reclamation. This would benefit the existing adjacent native habitats and the riparian corridor of North Sequalitchew Creek by reducing invasive species pressure.

3.1.4 Aquatic Resources

The 1.8-acre Kettle Wetland is the only aquatic resource located within the South Parcel Project Area and is therefore the only aquatic resource that would potentially be disturbed by direct impacts associated with the proposed Project.

3.1.4.1 Kettle Wetland

The Kettle Wetland and its buffer would be cleared as part of the surface vegetation clearing. Thus, the entire wetland area (1.8 acres) would be eliminated. The Kettle Wetland relies on groundwater to sustain wetland vegetation so even if the Kettle Wetland were left in place within the Project area, the change in groundwater levels would eventually alter the hydrology of the Kettle Wetland, converting the wetland vegetation to upland plant species. Proposed mitigation for these wetland impacts is discussed in Section 3.4.

3.1.5 Rare Plants and Plant Communities

The Project would not directly impact rare plants or rare plant communities.

3.2 Animals

3.2.1 Birds

The Proposed Action could reduce and degrade existing foraging and breeding habitat for some bird species that use habitats within the South Parcel Project Area. The clearing of vegetation would increase the fragmentation and isolation of remaining habitats. The Project components with the greatest potential impact on bird habitats are the clearing of vegetation from the South Parcel Project Area.

The clearing of currently vegetated areas would eliminate the existing foraging and breeding habitats for birds. In addition to direct loss of habitats, the clearing of vegetation could increase the fragmentation and isolation of remaining habitats. Reclamation of the mine slopes will continue to progress. The proposed Project will increase the acreage of reclaimed and reforested areas on the mine slopes by 177 acres.

The removal of the Kettle Wetland could disrupt bird habitat and reduce breeding, wintering, and migration habitat for bird species until habitat in the mitigation wetland is fully functional. Restored forests on reclaimed slopes are already maturing and would continue to provide new habitat to offset this impact.

3.2.2 Mammals

The proposed Project could alter habitat for mammal species within the Project area for reasons similar to those described for impacts to birds. The majority of species would disperse into adjoining habitats. The proximity of the Project area to similar intact habitats will provide dispersal routes as construction begins.

3.2.3 Amphibians and Reptiles

Within the Kettle Wetland, any existing amphibians would perish during the clearing of the surface vegetation and soils. New habitat with similar hydrology would be created in the mitigation wetland to compensate for these impacts.

3.2.4 Washington Department of Fish and Wildlife Priority Species

Removal of mature trees in the coniferous forest could reduce habitat for big brown bat, little brown bat, and Yuma myotis bat species. Clearing of forested areas within the South Parcel Project Area would reduce habitat that is thought to have once been within the historical range of gray squirrels but is unlikely to be occupied by the current population.

3.2.5 Threatened and Endangered Species

No ESA-listed species habitat would be altered directly as a result of the Proposed Action. See Anchor 2022 for more detailed analysis of the potential effects on fish species.

3.3 Indirect Impacts of the Proposed Action on Plants and Habitat

3.3.1 Conifer Forests

No potential indirect impacts to coniferous forest habitats outside the South Parcel Project Area associated with the proposed Project are anticipated.

3.3.2 Shrublands and Grasslands

No potential indirect impacts to shrublands and grasslands habitats outside the South Parcel Project Area associated with the proposed Project are anticipated.

3.3.3 Aquatic Resources

The aquatic resources of Sequalitchew Creek and the four wetland systems within the Restoration Area: East Edmond Marsh, West Edmond Marsh, and the Sequalitchew Creek Riparian Wetlands are within the area where wetland hydrology could be affected by changes in groundwater levels. The wetland hydrology of aquatic resources identified as Nearby Wetlands with the exception of the Seep Wetlands (Sequalitchew Creek Ravine Pond Lake, and Wetland 1D) could also be affected by changes in groundwater levels, but any effects are anticipated to be minor. The indirect effects of the Project on the Seep Wetlands are anticipated to be more severe. Groundwater seeps that support the hydrology of these wetlands would be reduced, resulting in a reduction or loss of wetland hydrology. The brackish marsh would not be affected by changes in groundwater levels due the dominance of tidal hydrology on that resource.

3.3.3.1 West Edmond Marsh and Wetland 1D

West Edmond Marsh and Wetland 1D are the two resources that are most likely to be affected by the proposed groundwater drawdown without implementation of the Restoration Plan. Due to the greater magnitude of the change in groundwater levels in these areas and the degree of connectivity between ground and surface water within these wetlands (City of DuPont 2007; Herrera Environmental Consultants 2005b; Aspect 2022). An analysis of the effects on these wetlands without mitigation indicates that the average water level in West Edmond Marsh would be 1.9 feet lower than under existing conditions. In wetter years, West Edmond Marsh would refill in the fall to similar elevations as under existing conditions but would dry up a month or two earlier in spring (see Figure F-6 in Appendix F of Aspect 2022). In drier years, the wetland seasonal high water levels would be 2 to 3 feet lower than under existing conditions, and in the driest years (e.g., 2005) the West Edmond Marsh is predicted to remain dry year-round. Earlier drying of saturated and inundated areas could have detrimental effects on the existing plant community. Wetland plant communities (and soils) are shaped by saturated and inundated conditions during the growing season (averages from March 1 to October 31) (Ecology 1997). Exotic plant invasion (particularly reed canarygrass) favors this type of alteration when winter saturation and inundation are not sufficient to maintain existing plant communities or preclude noxious weed invasion.

Change of wetland areas along the margins of both wetlands (now saturated in the early spring) is unlikely. The jurisdictional wetland boundary is indicated by the presence of subsurface (within 12 inches below the soil surface) saturated conditions for 12.5% (approximately 30 or more consecutive days) of the growing season, as well as wetland soils and wetland plants (Ecology 1997). The high water levels in the marsh are currently controlled by the beaver dams in the system. Changes in groundwater elevation without mitigation would result in changes to surface water levels, which vary from year to year. In the wettest years, the wetland would still refill but would go dry one or two months earlier than under existing conditions. In drier years, the wetland would only partially

refill, and the dry season would be extended. In the driest years, the wetland could remain dry year-round. These changes in reaching peak water levels are not anticipated to result in a loss of subsurface saturation for 30 days of the growing season within the current wetland boundary. The result of these hydrology changes to West Edmond Marsh during the spring would be changes in vegetation: Reed canarygrass would be expected to encroach farther into the wetland, whereas now it is limited to the wetland edge. Wetland shrubs would also be expected to advance toward slightly deeper areas of the wetland. The wetland boundary may or may not change, but in most areas the slopes are relatively steep, and any change would be relatively minimal. In a few areas where the wetland boundary is on flatter terrain it is possible that upland species could establish, thus reducing the size of the wetland in those locations. Typically, the wetland would still fill sufficiently to maintain hydrophytic vegetation at around the same elevation and meet the wetland hydrology criteria (Ecology 1997). It is more likely that a slow conversion of wetland habitats would occur; the changes could result in some conversion of aquatic wetland habitat to emergent wetland habitat and emergent wetland habitat to shrub-scrub wetland habitat.

3.3.3.2 East Edmond Marsh

An analysis of the drawdown effects on East Edmond Marsh indicates that there would be an average decrease in water level of 1.2 inches (Aspect 2022). The decrease would be greatest in June at about 1.5 inches and lowest in February at less than 0.1 inch. East Edmond Marsh would continue to follow the same seasonal pattern of fluctuation with the highest water levels in January through March and seasonal lows in August and September. It is unlikely that this change will have any measurable effect on the wetland given that this decrease would occur within a seasonal fluctuation in water level of more than 20 inches. Ultimately, continued beaver activity would have a far greater impact on water levels in the marsh.

3.3.3.3 Pond Lake

Pond Lake is an isolated water body, hydrologically connected to groundwater with little surface water inflow and no outflows. With the Proposed Action, the surface water level in Pond Lake is conservatively projected to decrease by about 2 feet, the amount of groundwater drawdown in its vicinity. The surface water level in Pond Lake currently varies seasonally by up to 8 feet but more typically around 4 feet. Pond Lake goes dry in summer. With the Proposed Action, the seasonal variation would be 2 feet, and it would go dry a month earlier and rewet slightly later. Herbaceous vegetation in Pond Lake varies from year to year depending on when the water levels recede. With the Proposed Action the conditions observed during driest years would become common, with more emergent vegetation and less aquatic vegetation establishing. A sustained reduction in peak water levels could allow establishment of scrub-shrub wetland species along the wetland boundary and greater cover of reed canarygrass within the higher parts of the wetland. The relatively steep slopes around the wetland would prevent the wetland size from changing significantly.

3.3.3.4 Sequalitchew Creek and Riparian Forest Wetlands

Without restoration, Sequalitchew Creek west of Center Drive would experience reduced base flows as a result of reduction in seep and spring discharge caused by the drawdown of the Vashon Aquifer. A reduction of aquatic life would be expected to occur in the upper ravine without implementation of the Restoration Plan activities. More information on these effects is included in the *Fisheries Technical Report* (Anchor QEA 2022).

Without implementation of the Restoration Plan activities, the change in groundwater levels would eliminate the hydrologic support provided to the Sequalitchew Creek riparian forest wetlands, and some loss of the existing wetland vegetation would occur.

With implementation of the Restoration Plan activities, increased flows within Sequalitchew Creek are likely to cause changes to the existing stream morphology as a result of more energetic channel-forming processes more consistent with natural historical conditions. Current annual average flow rates in Sequalitchew Creek in the middle of the ravine are 1.0 to 1.6 cubic feet per second (cfs), with peaks near 5 cfs. Predicted flow rates of Sequalitchew Creek following implementation of the Restoration Plan are expected to average 11.2 cfs with peak flow during storm events that could reach near 60 cfs. These effects may cause some areas of existing wetland to be altered, although a net gain in water discharged to the riparian forest wetland is predicted to maintain or increase the total existing wetland area and increase hydrologic support throughout the growing season. The potential wetland alterations include conversion of wetland areas on the floodplain to active stream channels, loss of wetland vegetation nearer the existing channel and new wetland vegetation establishing farther from the existing channel. Some trees at the margins of the floodplain could fall due to increased inundation and the undermining of root systems, although fallen trees are also likely to contribute to large woody material in the stream which serves multiple ecological functions.

3.3.3.5 Sequalitchew Creek Ravine Seep Wetlands

With or without implementation of the Restoration Plan activities, dewatering of the aquifer is likely to indirectly impact the Seep Wetlands along the Sequalitchew Creek trail by disrupting the hydrology of these wetlands. These indirect impacts would result in the loss of wetland vegetation and function of the wetlands. The resulting loss in wetland area could be up to 0.13 acre of wetland habitat being converted to upland habitat due to insufficient saturation during the growing season.

Indirect impacts from changes in the aquifer would also affect the springs in the Sequalitchew Creek bed. These impacts could be mitigated by restoration. The effects on Sequalitchew Creek flow are described in Aspect 2022.

3.3.3.6 Brackish Marsh

The reduction in flows in Sequalitchew Creek resulting from dewatering of the Vashon Aquifer without implementation of the Restoration Plan are estimated at 1.3 cfs (Aspect 2022). While this is a significant fraction of the freshwater in the marsh, it would have little impact to the Brackish Marsh. The reduction in freshwater input would result in only a negligible increase in salinity in the marsh during high tides. Saltwater is denser than freshwater and the spatial extent of tidal flooding by saltwater would not be affected. Less freshwater input could result in changes in vegetation near the primary stream channel to more salt tolerant species. These changes would be subtle and may be difficult to detect. Alterations to the salinity elsewhere within the brackish marsh are predicted to be minor and would result in salinity values that are within the tolerance ranges for the existing plant communities documented in Anchor Environmental 2004a. No effect on the existing wetland is anticipated as a result of salinity alterations.

Increased flows associated with the implementation of the Restoration Plan would increase the rate of sediment transport to the lower ravine and brackish marsh. Historical alterations to the marsh including channelization of the stream and installation of a box culvert under the railway would direct sediment toward Puget Sound. Some fine sediment would continue to accumulate in the upper elevations of the intertidal marsh, which is part of the natural process of marsh formation and provides resiliency to sea level rise and episodic erosion.

3.3.3.7 Nearshore Springs

The springs that flow directly into Puget Sound express from the hillside near the toe of slope at the beach and there is no surface flow associated with these features within the South Parcel Project Area. No measurable change in groundwater flow from these springs is expected, and no impacts to these springs are expected as a result of the Proposed Action.

3.3.4 Animals

3.3.4.1 Birds

The alteration of wetland systems within the area subject to changes in groundwater level without restoration, particularly East and West Edmond Marsh, could disrupt bird habitat and reduce breeding, wintering, and migration habitat for bird species. These areas are documented to regularly attract concentrations of waterfowl (WDFW 2022a). However, the potential impacts to wetland area associated where changes in groundwater level is expected to be minor relative to the size of the wetland systems and in combination with the Restoration Plan activities.

3.3.4.2 Mammals

The alteration of Edmond Marsh and other wetland systems that could be modified by the changes in groundwater without mitigation could disrupt the existing wetland mammal habitat by removing

existing water and food sources and sheltering vegetation, thereby reducing the available breeding and foraging habitat for aquatic habitat dependent mammal species (beaver). However, the potential reduction in wetland areas where changes in groundwater level are expected to be minor relative to the size of the wetland systems and in combination with the Restoration Plan activities. Use of the Seep Wetlands by mammals is unlikely, and a reduction in the size or the loss of the Seep Wetlands would have minimal effect due to the proximity of the much larger Sequalitchew Creek and its associated riparian areas, which provide superior mammalian habitat.

3.3.4.3 Amphibians and Reptiles

Loss of wetland area, alterations to seasonal inundation patterns, and subsequent changes in plant communities would reduce the area of habitats that support amphibians. These changes could indirectly disrupt amphibian habitat and reduce breeding, wintering, and foraging habitat for amphibian species.

The early drying of normally inundated areas could adversely affect amphibian breeding by lowering surface water levels during the breeding and rearing seasons. This could result in the loss of available habitat, leading to exposure of egg masses and rearing juveniles from reduced water levels. Tadpoles, juveniles, and adults may disperse to areas that remain inundated during early drying periods. However, the existing amphibian population likely uses all available habitats. Thus, unoccupied amphibian habitats are likely to be unavailable to individuals dispersing from drying portions of the wetlands. However, the potential reduction in wetland area associated with the changes in groundwater level is expected to be minor relative to the size of the wetland systems and in combination with the proposed Restoration Plan activities.

Proposed Restoration Plan activities would improve aquatic resource habitats within the Restoration Area compared to existing conditions that provide habitat for amphibian species.

3.4 Impacts of the No Action Alternative

3.4.1 Direct Impacts of the No Action Alternative to Plants and Habitat

Under the No Action Alternative, the South Parcel would not be mined and the property could be developed for manufacturing and research and residential uses under existing land use and zoning designations. The extent of development under the No Action Alternative projected is based on current zoning. The ultimate density of development would be controlled by Project-specific and regulatory elements such as setbacks, open space, and critical areas.

Under the No Action Alternative, development would occur consistent with the DMC Critical Areas chapter (DMC 25.105), which could allow for development withing 50 feet of the top of the Sequalitchew Creek ravine. Existing coniferous forest within the Expansion Area could be cleared

under future development with landmark trees retained in accord with DMC requirements. There would be no changes in the use of the areas of the South Parcel zoned for Open Space; these areas currently include the naturally vegetated slope of the Sequalitchew Creek ravine and the Sequalitchew Creek pedestrian trail.

There would be no change in use of the areas within the existing mine. However, once the Re-Mine Area is reclaimed, it would likely be redeveloped according to its underlying zoning, similar to the South Parcel. The Kettle Wetland is within the existing mine and would remain intact, the buffers would remain vegetated, and mining operations would continue in other portions of the existing mine. The Kettle Wetland, its buffer, and other mine-related buffers could be reduced to the minimum width in the DMC.

3.4.2 Indirect Impacts of the No Action Alternative to Plants and Habitat

The Restoration Plan would not receive funding without the proposed Project and would not occur as part of the No Action Alternative. Under the No Action Alternative, the improvements and benefits to aquatic resource habitat proposed in the Restoration Area would not occur. Similarly, the impacts to groundwater associated with the Proposed Action would not occur.

3.4.3 Direct Impacts of the No Action Alternative to Animals

As described in Section 3.3.1, under the No Action Alternative, development could occur in the South Parcel Project Area resulting in clearing of forested and shrub habitat, reducing habitat for wildlife species that use these habitats. Direct impacts to animals would be similar to those described under Section 3.1.2.

3.4.4 Indirect Impacts of the No Action Alternative to Animals

Within the Restoration Area, wildlife species would not benefit from improved aquatic resource habitat conditions proposed under the Restoration Plan. The South Parcel would not undergo remediation from Tacoma Smelter Plume impacts leaving high concentrations of lead and arsenic in the soils.

3.5 Monitoring and Mitigation Measures

The Project proposes to mitigate for potential impacts to plants and animals and to monitor effects on surface water features and vegetation in areas that could potentially be affected. The Restoration Plan will be permitted and implemented contemporaneously with mining of the South Parcel. Among other things, the Restoration Plan will mitigate for the impacts of the mine. Monitoring and mitigation measures, including specific timeframes for monitoring and mitigation efforts, are defined in the Restoration Plan. The goal of the Restoration Plan is to offset potential impacts to aquatic resources within the area subject to changes in groundwater level.

Mitigation for impacts for the removal of the Kettle Wetland are identified in the Project *Wetland Mitigation Plan* (Anchor QEA 2021c). The design of the mitigation wetland complex is intended to create aquatic, wetland, riparian, and upland forest habitat by using groundwater intercepted within the mine. Specific Kettle Wetland mitigation goals include the following:

- Create a constructed palustrine depressional wetland complex consisting of forested, scrub-shrub, emergent, and aquatic bed wetland areas at least 3.4 acres in size.
- Provide adequate wetland acreage, functions, and values to mitigate all Project-related wetland impacts to the Kettle Wetland.
- Construct a vegetated buffer at least 100 feet around the boundary of the wetland.

Hydrologic changes will indirectly impact the Seep Wetlands; however, there will be no direct impacts (clearing, cut, or fill) to the wetland or its buffer. These changes will also not impact groundwater quality. The mitigation plan addresses these impacts through the creation of a larger complex of seep wetlands and springs within the mine. Springs and seeps will generally emanate on the eastern and southeastern slopes of the proposed mine in the South Parcel. Generally, seeps and springs will form within the lower one-third of the mine slope, approximately 20 to 30 vertical feet above the Olympia Beds.

Groundwater discharge will be greatest along the central and southern portion of the eastern slope and northeastern portions of the benches and will taper off to the north as the mine area approaches the Olympia Bed cutoff and to the south as the benches in the southeast corner get closer to the Sequalitchew Creek ravine. The specific locations of seeps and springs will depend on local variations in the outwash deposits related to silt content or areas of coarser materials. We can expect that there will be localized areas of greater discharge and other areas with more distributed seepage or even little to no discharge.

This new seep wetland complex will be supported by approximately 7 cfs of groundwater expression through the slope. Quantitatively this is well over an order of magnitude more water than supports the ravine seeps. Within 1 year after active dewatering ends, the areas of the mine face that meet the criteria for wetland hydrology will be delineated. These areas will be colonized or planted with pioneer wetland species, such as horsetail *(Equisetum* sp.), buttercup (*Ranunculus* sp.), and miner's lettuce (*Montia fontana*). Additional species would be introduced later, once the soils have developed sufficiently to support seral grasses such as foxtails, rushes, sedges etc.

The buffers around these new seeps will be subject to the City of DuPont's Critical Areas Ordinance (DMC 25.105.050) and protected. The minimum buffer size is 50 feet. These buffers would be planted in accordance with the mine reclamation plan and monitored in accordance with the Wetland Mitigation Plan. Control of Scot's broom, reed canarygrass, Himalayan blackberry (*Rubus*

armeniacus), and other noxious weeds within areas affected by the proposed Project would also be included as part of the Project mitigation activities.

3.6 Significant Unavoidable Adverse Impacts

3.6.1 Proposed Action

3.6.1.1 Direct Impacts

Significant unavoidable adverse direct impacts associated with the proposed South Parcel Project would be associated with the following Project elements:

- Drawdown of the Vashon Aquifer
- Clearing of vegetation from the proposed Re-Mine Area and Mine Expansion Area, including the removal of the Kettle Wetland and its buffer, and the removal of coniferous forest vegetation communities
- The clearing of currently vegetated areas would eliminate the existing foraging and breeding habitats for birds, mammals, and amphibian species. In addition to direct loss of habitats, the clearing of vegetation could increase the fragmentation and isolation of remaining habitats.

3.6.1.2 Indirect Impacts

Significant unavoidable adverse indirect impacts associated with the proposed South Parcel Project would be associated with the following Project elements:

- Drawdown of the Vashon Aquifer
- Loss of existing Seep Wetlands

Without restoration, drawing down the aquifer would reduce flows in Sequalitchew Creek to the extent that some flow would be subsurface. Changes in groundwater level could indirectly reduce the wetland area in Sequalitchew Creek riparian forest wetlands, West Edmond Marsh and Wetland 1D, and degrade wetland habitat in these wetlands due to early season loss of surface inundation and saturation in the early growing and breeding season. Aggradation of the brackish marsh could reduce the size and function of this wetland. The goal of the Restoration Plan is to offset potential impacts to these aquatic resources within the area subject to changes in groundwater level.

3.6.2 No Action Alternative

Future development consistent with underlying zoning could occur in the South Parcel Project Area resulting in clearing of coniferous forested and wetland habitat and reducing habitat for wildlife species that use these habitats. The clearing of currently vegetated areas could eliminate the existing foraging and breeding habitats for birds, mammals, and amphibian species. In addition to direct loss

of habitats, the clearing of vegetation could increase the fragmentation and isolation of remaining habitats.

The Restoration Plan would not occur as part of the No Action Alternative. Under the No Action Alternative, the improvements and benefits to aquatic resource habitat proposed in the Restoration Area would not occur.

Drawdown of the Vashon Aquifer would not occur as part of the No Action Alternative. Under the No Action Alternative, the loss of the 0.15 acre of Seep Wetlands would not occur.

3.6.3 Monitoring of Dewatering Operations

A Monitoring Plan (Aspect 2017) has been prepared to observe and respond to changes in groundwater levels. The goals of that plan include the following:

1. Maintain groundwater at or above predicted levels beneath Edmond Marsh and Sequalitchew Creek.
2. Maintain groundwater conditions conducive to safe and efficient mining and processing of the South Parcel aggregates.

The document also includes a detailed adaptive management plan and a description of the relationship to the Adaptive Management Process for the Restoration Plan.

3.6.4 Monitoring of the Restoration Plan

Monitoring and adaptive management of the Restoration Plan are described within the plan (Aspect 2018). This plan includes performance thresholds that are tied to specific goals and objectives. The goals of that plan include the following:

1. Restore year-round flows in Sequalitchew Creek from Sequalitchew Lake to the mouth to support natural life history stages of native salmonid species that use the system.
2. Improve habitat conditions for native salmonid populations in the Sequalitchew Creek watershed.

Potential response actions are called out if specific performance thresholds are not met. In addition, there are aspirational thresholds identified that, if achieved, would indicate the plan's continued success.

4 Cumulative Effects of the Proposed Action and Restoration Plan

The South Parcel Project, described in Section 1.1, assumes implementation of the Restoration Plan, developed by CalPortland and Environmental Caucus, as a separate but related action. This Plan seeks to restore and enhance streamflow and ecological functions from Sequalitchew Lake through Edmond Marsh into Sequalitchew Creek ravine. The Restoration Plan is intended to sequentially restore diverted flows back to the creek, improve the sustainability of flows through the system, and restore aquatic habitat by removing flow-related fish passage barriers and increasing the habitat available to aquatic species.

Predicted water surface elevations and flows have been prepared to understand the specific cumulative impacts of mining and restoration. A thorough discussion of this analysis can be found in the Earth and Water Resources Report (Aspect 2022). The effect of these predicted changes on plants and animals is discussed below.

4.1 Restoration Plan Benefits

The restoration is a separate but related action, and its benefits and impacts will be evaluated comprehensively in a separate environmental review document. The assessment here is preliminary and provided to give context to the cumulative effects to the watershed. The mining and restoration projects would reverse many of the adverse impacts related to diversion of water from the Sequalitchew Creek watershed and creek that have occurred over many decades. The benefits would be noticeable over a large portion of the stream and wetland habitats in the basin and would largely restore lost and reduced ecosystem functions including the movement of water, sediment, nutrients, biota, and dissolved gasses through the watershed from the headwater springs on Sequalitchew Lake to Puget Sound. The reconnection of Sequalitchew Creek to its historical primary source of flow, Sequalitchew Lake, would address the root cause of the primary historical impacts to the system.

These projects have the potential to restore an annual average of 12.6 cfs to a 1,200-foot reach of Sequalitchew Creek that currently experiences little to no consistent flow (Aspect 2022). Seasonally, the flows in this reach are predicted to be between 2.5 cfs in August up to just over 25.7 cfs in March. Flows of this magnitude would re-establish a functioning stream in the now frequently dry channel, providing new aquatic and riparian habitat and a connection between the Sequalitchew Creek ravine and the marshes. This would provide a corridor for both aquatic and terrestrial species and would provide new opportunities for species expansion and recovery.

In the Sequalitchew Creek ravine, the restoration and mining projects would result in a seven-fold increase in flow on an annual average basis, from the current 1.6 cfs up to 12.9 cfs. Peak flows could reach up to 65 cfs, sufficient to restore the natural channel-forming processes necessary to improve

habitat conditions in the ravine. Currently, the flows in the ravine are inadequate to move sediment effectively, create pools, or scour finer-grained materials from the substrate to create conditions suitable for spawning. Peak flows could be adaptively managed by adjusting the weir at the Diversion Canal and limiting flow through Edmond Marsh to prevent flooding or detrimental effects to the wetlands or the stream channel.

The restoration project would also have some direct benefits to the wetlands. Specifically, it would raise the water level in Hamer Marsh, expanding its size; remove fill and improve aquatic habitat conditions at the Lake Outlet Area; and reconnect East and West Edmond marshes by replacing a portion of the Robinson Trail separating the marshes with a bridge. Conditions in much of the marsh today favor a scrub-shrub plant community. Restoration would also reduce fluctuation in water surface through the growing season near the railroad grade allowing enlargement of the forested wetland community. Restoration would affect the conditions sufficiently to allow establishment of emergent vegetation in the western extent of the complex where inundation will persist through more of the growing season and could result in the formation of forested wetlands in East Edmond Marsh where water levels would be reduced and fluctuate less throughout the year. These effects would increase the diversity and complexity of habitats.

The greatly increased flow through Edmond Marsh would also improve water quality conditions by increasing dissolved oxygen concentrations and diluting and flushing an area of elevated iron concentrations in the center of the marsh.

4.2 Impacts of Restoration

Restoring the natural flow regime to the Sequalitchew Creek watershed, in combination with lower groundwater levels resulting from mining, would result in several impacts: a reduction in wetland area, increase in summer stream temperatures, and increased frequency of periods of high flow in winter and spring.

Water levels in Eastern East Edmond Marsh and Edmond Marsh would return to water levels more consistent with recent history but would result in a loss of current wetland area. At present the East Edmond Marsh wetlands are larger and deeper than they have been in the past several decades as a result of beaver activity and the secondary outlet for flow provided by the Diversion Canal. Water surface elevations in East Edmond Marsh are currently higher than in Sequalitchew Creek. Lowering the water levels in some areas of the marshes is necessary to restore flow from Sequalitchew Lake, as the marsh water levels are currently higher than the lake forcing water to flow into the Diversion Canal instead of Sequalitchew Creek.

The flow from Sequalitchew Lake is also warmer in summer than the current flow in the ravine. The Project would represent a return to a more natural, surface-flow-dominated condition, but one with

warmer stream temperatures that could approach or exceed biological criteria for coho salmon (*Oncorhynchus* kisutch) during much of the spring and summer months. Water originating from Sequalitchew Lake is warmer than groundwater because it is warmed by the sun in the lake and this water would be further warmed as it slowly flows through the marshes.

Finally, there are predicted to be infrequent periods when the mining and restoration projects would result in streamflows that are lower than currently occur. This condition would occur during extended dry periods, when outflow from Sequalitchew Lake is naturally low or non-existent. Streamflows would be lower than existing conditions about 10% of the time, typically in August and September of particularly dry years. Existing flows during these periods currently average 0.83 cfs and do not provide aquatic habitat for anadromous fish; mining and restoration would further reduce these flows by more than half during these periods (to 0.44 cfs).

4.3 Cumulative Effects

This section identifies cumulative effects on biological resources for the Proposed Action and implementation of the Restoration Plan. Cumulative effects analysis is an evaluation of the combined effects on biological resources for the Proposed Action and present and reasonable and foreseeable projects in the vicinity of the study area. This analysis is focused on Sequalitchew Creek and the wetlands. Potential restoration activities of stream and wetland habitats in the Sequalitchew Creek watershed upstream of the Restoration Plan area at the JBLM would not occur without the proposed Restoration Plan activities downstream of the JBLM. Upland areas would be only minimally affected by restoration. Each section is organized to discuss aquatic habitat first, followed by water quantity, then water quality.

4.3.1 Sequalitchew Creek

The combined effects of proposed mining and restoration plan projects on stream habitat would include a re-establishment of flow from Sequalitchew Lake to flow through the marshes and into Sequalitchew Creek ravine. The projects would also result in re-establishing the ecosystem process, specifically, the movement of water, sediment, nutrients, biota, and dissolved gasses through the watershed from the headwater springs on Sequalitchew Lake to Puget Sound. The increase in hydrology and stream energy would increase aquatic ecosystem productivity and create and maintain habitat diversity.

Re-establishment of peak flows and the associated sediment movement is key to restarting the arrested habitat-forming processes downstream of Edmond Marsh and a key objective of the Restoration Plan. Currently, even where flows persist perennially, they are inadequate to move sediment effectively, create pools, or scour finer-grained materials from the substrate to create conditions suitable for spawning. The input of sediment and organic matter will stimulate biological productivity and develop greater resources at the lower trophic levels. Restoration would also result

in pool and riffle habitat formation over time. This habitat and development of lower trophic productivity are key to developing conditions sufficient to restore target species such as chum (*Oncorhynchus keta*) and cutthroat trout (*O. clarkii*) in the system. Chum will also benefit from the restoration of a more varied hydrograph. Puget Sound stocks typically spawn in freshwater systems in November and December as flows rise in response to winter rains. This effect has been limited in the system due to the current lack of surface water connectivity. The *Dupont Aggregates South Parcel Project Fisheries Technical Report* (Anchor QEA 2022) contains additional information and assessment of the impacts to fisheries from the Proposed Action and the No Action Alternative.

4.3.1.1 Flow

The cumulative effect of the mining and restoration projects on streamflow was evaluated by predicting streamflows at two locations: in the dry reach between West Edmond Marsh and Sequalitchew Creek ravine, and in Sequalitchew Creek at the mid-ravine gage.

4.3.1.1.1 Dry Reach

Under existing conditions, the dry reach currently experiences no consistent flow passing through the entire reach. The bottom of the dry reach is above the current groundwater levels, so ground infiltration in the dry reach would not be affected by lowering of groundwater with mining.

The mining and restoration projects are predicted to result in an average flow of 12.6 cfs in the dry reach. The flow would vary seasonally from a monthly average of 2.5 cfs in August to 25.7 cfs in March as shown in Figure 5. Peak flows could be as high as 65 cfs if all water is routed through the wetlands during peak flow events. To avoid flooding during peak flows, the highest flows could be directed to the Diversion Canal or detained in the marshes. The results presented here do not account for the diversion of peak flows or detention in the marshes.

Streamflow in the dry reach was calculated by adjusting the daily average outflows from Sequalitchew Lake from 2003 to 2021 by the estimates of the gains or losses that would occur in the wetlands based on the results of the water balance model summarized in the Section 4.3.2, Wetlands, and presented in detail by Aspect Consulting (Aspect 2022). The dry reach was assumed to have a sealed bed under restored conditions (either naturally or through contingent actions), so no gains or losses were assumed to occur in the dry reach.

Modeling indicates there would be periods when there would be no outflow from West Edmond Marsh, as thus no flow in the dry reach. Water balance model results, based on hydrologic conditions observed over the 19-year period of record, indicate that water would not flow through the dry reach due to dry conditions on 401 days (or 7.7% of the time). These dry periods were predicted to last for multiple weeks to several months and occurred in five of the 19 years simulated by the model (2004, 2005, 2015, 2017, and 2018). The occurrence of these dry periods could be reduced or eliminated if

beaver management structures are built to store water and release it slowly and consistently during periods when there is no flow from Sequalitchew Lake.

4.3.1.1.2 Sequalitchew Creek at Mid-Ravine Gage

After passing through the dry reach, streamflows would enter the Sequalitchew Creek ravine. The vast majority of flow would originate from Sequalitchew Lake, but there would be contribution from springs within the ravine. Spring contribution related solely to the Vashon Aquifer would be reduced by approximately 79% (Aspect 2022). This flow would be augmented by the addition of new hyporheic input from streamflow restoration in the dry reach. Aquitards at the existing springs would force both sources of water in the aquifer to the existing springs.

Streamflows in Sequalitchew Creek ravine were predicted at the mid-ravine gage location (formerly known as the "upper gage") for comparison with the existing gage record. Streamflows were predicted by starting with the flows predicted for the dry reach, as described above, and adding in spring flow occurring in the upper portion of the Sequalitchew Creek ravine.

Spring flow in the upper reaches of the Sequalitchew Creek ravine would be affected by the lowered groundwater levels associated with mining. The groundwater model results for Step 4 of dewatering, the long-term condition that would persist after active dewatering has ceased, predict a reduction in spring flow of 79%, varying from 73% in January to 86% in summer. The reduction in spring flow was accounted for by scaling the average daily flow records from the mid-ravine gage record by the corresponding monthly percent reductions in spring flow. The scaled-down spring flow was then added to the predicted dry reach flow to create the predicted flow at the upper gage with mining and restoration.

On average, flow in Sequalitchew Creek at the mid-ravine gage would generally be similar to but slightly higher than the flows in the dry reach (i.e., 0.4 cfs greater), reflecting the input of spring flow. The annual average flow at the upper gage would be 12.9 cfs. Monthly average flows would range from 2.5 cfs in August to 26.3 cfs in March as shown in Figure 5. Peak flows would be generally the same magnitude (approximately 60 cfs) as in the dry reach.

There would be periods when the cumulative effects of the mining and restoration projects would result in a reduction in flows at the mid-ravine gage when compared with the existing condition. Of the 19 years evaluated, flows would be lower with the projects during 45 periods, lasting a total of 475 days, or about 10% of the time. Included in this tally are 24 additional days when there would be no flow at the mid-ravine gage. Under existing conditions, there were 7 days with no measurable flow at the gage. As noted above, these effects could be mitigated in part or in whole by careful implementation of the beaver management actions called for in the Restoration Plan

The median duration of a period when flows would be lower with mining and restoration (hereafter referred to as a "lower flow event") was 3 days, but there were seven lower flow events lasting more than 2 weeks long. The longer events occurred in 6 of the 19 years simulated (2004, 2005, 2015, 2016, 2017, and 2018). The longest single lower event was 98 days ending in October 2017. However, lower flow events dominated the summer and fall of 2005, when there were four lower flow events between July 20 and December 23 lasting a total of 134 days. Lower flow events occurred most commonly in July, August and September, but occasionally occurred all months except March. The average streamflow during lower flow events was 0.83 cfs under existing conditions and would be 0.44 cfs with mining and restoration. The decrease in streamflow during lower flow events ranged from 0.1 cfs up to 1.6 cfs. Again, these effects could be mitigated in part or in whole by careful implementation of the beaver management actions called for in the Restoration Plan.

4.3.1.2 Sequalitchew Creek Temperature

The mining and restoration projects would affect stream temperature in the Sequalitchew Creek ravine by introducing a large quantity of water from a source with a different temperature. The effects would vary seasonally as the volume of water from Sequalitchew Lake and its associated temperature varies. In summer, the outflow from Sequalitchew Lake is warmer than Sequalitchew Creek; in winter, it is colder.

Sequalitchew Creek would experience warm temperatures in June, July and August, with temperatures reaching up to 21°C (70°F) and cool temperatures in winter, down to 5°C to 6°C (41°F to 43°F) as shown in Figure 6. The predicted stream temperatures would be considerably warmer than the current spring discharge in the creek for most of the year. The surface water quality criterion for temperature applicable to Sequalitchew Creek is 16°C for the 7-day average of daily maximums. The analysis based on grab samples suggests that this threshold may be exceed from May to September.

Historically, the stream temperatures in Sequalitchew Creek were likely closer to those observed today in the lake outflow, and the steady, cool temperatures currently observed in the ravine reflect the proportionally greater input of groundwater resulting from diversion of the lake outflow from the system.

The change in stream temperature was evaluated quantitatively on a monthly basis by using a linear mixing equation with the observed temperatures for Sequalitchew Lake (with 1°C added to account for warming in the marshes) and Sequalitchew Creek, and the estimated future flow rates from each source. A discussion of the impacts of these changes in stream temperature on fisheries can be found in the *Dupont Aggregates South Parcel Project Fisheries Technical Report* (Anchor QEA 2022).

4.3.2 Wetlands

The Sequalitchew Marsh wetland complex has increased in size by more than 30 acres since the late 1990s when efforts to maintain a channel through the system were abandoned, and beaver dams began to raise water levels, preventing flow from reaching the ravine and redirecting nearly all flow to the Diversion Canal (Figure 3). A fundamental goal of the Restoration Plan is to direct flows from the Diversion Canal back down Sequalitchew Creek. This requires restoring the historical gradient from the outlet of Sequalitchew Lake to the top of the ravine. This will necessarily require a lowering of water levels in some parts of the wetland complex resulting in a reduction of wetland acreage.

During the Restoration Plan stakeholder process, the tradeoff between wetland impacts and creek flow was considered, and the stakeholders recommended an aggressive approach to increasing gradient to improve creek flows over a less aggressive approach to maintain wetland acreage and potentially sacrifice some creek flow (SPSSEG 2014). The restoration of flow using flexible levelers in beaver dams would limit the losses of wetland area and wetland function relative to the approach used in the 1980s when an open channel was maintained through the system. Wetland conditions in the 1980s are representative of a more aggressive approach to maintain the gradient and flow through the system. Aerial imagery and wetland delineations from around that period are useful in understanding the habitat conditions at the extreme of effects that could occur as a result of the restoration project. Flexible levelers can also be designed in such a way as to limit high flows by storing water behind beaver dams and release more water during periods when flows from upstream (Sequalitchew Lake) are low.

Some wetland and lake fringe habitats would be gained. Raising water levels in Hamer Marsh would compensate for some wetland loss. Removing fill from Edmond Marsh would compensate for some wetland loss and more importantly improve connectivity and function in the wetland.

Wetland functions and values have been quantified using metrics developed by Ecology. These include wetland rating scores and a hydrogeomorphic assessment methodology. Predictions of the effects on habitat, water quality, and hydrology were reviewed against the scoring criteria. In general, the changes related to the cumulative effects of mining and restoration were not sufficient to change scores. Of note is that the restoration of flow between Edmond Marsh and the ravine provides the opportunity to improve wetland functions and values to existing habitats in the ravine, brackish marsh and stream delta.

Cumulatively, the wetland restoration project and mine project would result in a significant but unavoidable loss of wetland acreage. Comparing existing wetland acreage to conditions in the 1980s, when every effort was made to channelize the wetlands to improve flows and no effort was made to maintain wetland acreage in the system, likely provides a conservative estimate of potential wetland loss that could result from the projects. Careful management of flexible levelers would minimize the

lost wetland acreage, allow for a greater diversity of wetland habitats in the complex, and most importantly develop greater ecosystem connectivity.

4.3.2.1 Marsh Water Levels

As outlined in the Restoration Plan, reconnecting flow from Sequalitchew Lake to the Sequalitchew Creek ravine will require lowering water levels in some areas of the marshes in order to establish a consistent downhill gradient. Currently, the water levels in Eastern East Edmond Marsh and East Edmond Marsh are higher than the typical lake level of about 211.5 feet, preventing any outflow from the lake from reaching the marshes. Restoration would create a gradient in Eastern East Edmond Marsh and in Edmond Marsh from elevation 2010.5 to 206.5 feet (North American Vertical Datum of 1988).

These target elevations are significantly lower than the current water levels in these marshes. A comparison of the existing and future marsh water levels is shown in Figure 5. The target water levels of the mining and restoration scenario achieve a difference in water surface elevations of 5 feet between the lake (typically 211.5 feet) and West Edmond Marsh (target elevation 206.5 feet). Over the 8,700-foot flow path through the marshes, these water levels would result in a hydraulic gradient of 0.0006%. This is a very low gradient, and streams in systems with similar gradients are often characterized by containing broad shallow channels, or multiple threaded channels. One or more broad (more than 20 feet), shallow (less than 2 feet) channels at this gradient would have sufficient capacity to convey the peak outflows from Sequalitchew Lake. Peak flow velocities in this system would be low (less than 1 foot per second).

The results of a water balance model, developed for the marshes to evaluate the combined effects of the restoration and mining projects, was developed based on an assumption that there would be little variation in wetland water levels with the projects, as there would almost always be more than enough flow from Sequalitchew Lake to keep the wetlands full to their target elevations. However, there are several summers during the simulation period when water levels in Eastern East Edmond Marsh would dip below the target elevations for a month or more. East and West Edmond Marshes would also experience occasional dips below the target elevation, but of lesser magnitude and much less frequently. These impacts could be reduced or eliminated by managing water level behind the beaver dams to store water and release it slowly during periods of low flow. The hydraulic gradient through the marshes would always be maintained, however, as the water level in Eastern East Edmond Marsh never dips below the water level in East Edmond Marsh allowing water stored in the marsh to flow downstream to the ravine.

A second key output of the water balance model is an understanding of the gains or losses in flow that would occur as it passes through the marshes. As water travels through the marshes, it would

still be subject to potential gains from precipitation, stormwater inflows, or discharge from groundwater, and losses to evapotranspiration or infiltration.

Model results indicate that most months of the year (March through October), the wetland system would experience the loss of a small amount of the flow from Sequalitchew Lake, ranging from a 1% loss in October up to 24% in loss in July. However, in the wetter months (November through February) some flow would be gained in the wetlands from surface water and groundwater inflows. Gains range from 2% in February up to 9% in December. These monthly average losses were used in the predictions of streamflow in the dry reach and Sequalitchew Creek ravine described above. The water balance model simulates the individual hydrologic processes that effect the wetlands, including precipitation, evaporation, surface inflows and outflows, subsurface flows, and groundwater recharge and discharge. The model predicts water level conditions on a monthly basis from 2004 to 2021, representing a range of climate conditions. The model was calibrated to observed water levels over that period and was able to closely reproduce the water levels, typically matching the observed water levels within 2 to 3 inches. For all wetlands, the model was able to reproduce the seasonal pattern of water levels and capture differences between wetter and drier years (e.g., the model accurately simulated years where West Edmond Marsh was completely dry in summer versus years where some water remained). Generally, the model fit is best for Hamer, East and West Edmond Marshes and weakest for Eastern East Edmond Marsh. Additional details about the development and use of the water balance model are presented in Aspect Consulting (Aspect 2022).

4.3.2.2 Wetland Water Quality

The proposed mining and restoration projects would benefit the water quality in Eastern East Edmond Marsh and Edmond Marsh by providing a high volume of high-quality water. The anticipated changes were evaluated qualitatively by comparing the water quality conditions in the outflow from Sequalitchew Lake with water quality conditions in the marshes.

With the mining and restoration projects, the residence time in the wetlands would reduce significantly, decreasing from weeks or months to days. Water quality in the wetlands would be dominated by the input from Sequalitchew Lake. As a result, dissolved oxygen would be higher, and the pH would be slightly more neutral. Temperature and turbidity have been about the same in the lake and marshes, so little change would be anticipated.

It is anticipated that the elevated iron concentrations observed in the center of Edmond Marsh would be resolved through flushing and dilution with Sequalitchew Lake water. The iron concentration in the outflow from Sequalitchew Lake has been measured on only one occasion (at 0.13 milligrams per liter [mg/L]), at a concentration below the elevated levels of 3 to 5 mg/L observed in Edmond Marsh near the railroad trail bridge and related seeps. While there is no state water quality criterion for iron in surface waters, British Columbia has established a water quality guideline for total iron of 1 mg/L

in surface water (Phippen et al. 2008). The marshes receiving flow from Sequalitchew Lake could be expected to have future iron concentrations near, but slightly above, the concentration in the lake, which based on the single observation, would be below 1 mg/L.

4.4 Cumulative Impacts to Specific Resources

The Restoration Plan, developed by CalPortland and the Environmental Caucus, seeks to restore and enhance streamflow and ecological functions from Sequalitchew Lake through Edmond Marsh into Sequalitchew Creek ravine. Restoration of Sequalitchew Creek seeks to address almost two centuries of human manipulation. The principal goals of the Restoration Plan are to restore flows in Sequalitchew Creek, portions of which are now dry. This goal will be achieved by implementing a series of actions in a coordinated and adaptively managed project. The Restoration Plan is intended to sequentially restore diverted flows back to the creek, improve the sustainability of flows through the system, and restore aquatic habitat by removing flow-related fish passage barriers and increasing the habitat available to aquatic species.

4.4.1 Cumulative Impacts to Conifer Forests

The restoration of the watershed would allow the re-establishment of conifer forests around the perimeter of Edmond Marsh. These forests have been recently lost to raising water levels, particularly on the northern boundary of East Edmond Marsh. Other impacts would be similar to those described in Sections 3.1.1 and 3.3.1.

4.4.2 Cumulative Impacts to Landmark Trees, Shrublands, and Grasslands

The implementation of the Restoration Plan would not further affect landmark trees, shrublands, or grasslands in the Project area or Project vicinity.

4.4.3 Cumulative Impacts to Aquatic Resources

The four Restoration Area Wetlands would be affected by implementation of the Restoration Plan. West Edmond Marsh and East Edmond Marsh would both experience changes in wetland hydrology. As the hydraulic gradient between Sequalitchew Lake and the west end of West Edmond Marsh is restored, the area of jurisdictional wetland and seasonal inundation will decrease in most locations. This is necessary to restore flows and reverse the effects of water diversion and beaver activity that has occurred since the 1990s. The creation of a gradient will allow flows out of Edmond Marsh, provide fish passage through the majority of the watershed, and improve water quality in the system.

4.4.3.1 West Edmond Marsh

West Edmond Marsh will be more frequently and continuously inundated in the deeper areas of the wetland, and seasonal fluctuations in water levels will decrease. This will occur as a lower and more

stable outlet hydrology is established in place of the existing beaver dam. The beaver dam currently prevents flow out of West Edmond Marsh, but it is occasionally breached.

Reducing or eliminating these rapid changes in hydrology will help to stabilize the vegetation communities which are currently susceptible to hydrologic fluctuations. Currently scrub-shrub wetland vegetation establishes in the marsh over several years only to be killed off when water levels rise. Emergent vegetation is not able to establish under the dead woody material before changes in water levels once again favor a scrub-shrub community.

4.4.3.2 East Edmond Marsh

Water levels in East Edmond Marsh are currently higher than in Eastern East Edmond Marsh and West Edmond Marsh. This reverses the gradient of Sequalitchew Creek preventing surface flow to the ravine from West Edmond Marsh. The restoration will lower water levels in East Edmond Marsh to restore a gradient from Lake Sequalitchew to the ravine. This will impact habitats, particularly along fringes of the wetland where forested areas will be able to re-establish. Forested wetland and wetland buffer has been lost over the past decades as water levels have risen. Rising water levels have also been responsible for the loss of scrub-shrub vegetation and detritus from those communities has prevented establishment of an emergent vegetation community.

4.4.3.3 Sequalitchew Creek Ravine Wetlands

The Sequalitchew Creek Ravine Wetlands will be affected as flows in the creek are restored. This will cause a change in the bankfull width of Sequalitchew Creek as well as the sediment load being actively transported downstream. Over the subsequent several decades the riparian and floodplain wetland communities will be affected by deposition of new floodplain terraces, channel migration, increased wet season flows and other natural stream processes.

4.4.3.4 Brackish Marsh

Due to the increased base and peak flows in Sequalitchew Creek, the brackish marsh at the mouth of Sequalitchew Creek are likely to be affected by increased sediment inputs and decreased salinity due to increased volumes of fresh water discharging into the wetland.

Increased sediment inputs into the brackish marsh due to increased flows in Sequalitchew Creek could modify the existing wetland topography, and as a result, the existing vegetation. Sedimentation would be minimized by controlling the discharge into Sequalitchew Creek during implementation of the Restoration Plan to prevent a rapid mobilization of sediments in the stream reaches upstream of the brackish marsh. Water discharge would be slowly increased to allow the channel and stream bank vegetation to adapt to the increased flow rates. The existing condition of sediments in the brackish marsh (dominance of cobbles and gravels in the channels) indicate that the existing input of fine-textured sediments is flushed during ebb tides. With appropriate upstream

mitigation, changes in sediment loading to the brackish marsh are expected to be minimal and would be further minimized by tidal flushing.

Salinity in the marsh will continue to be driven by tidal inflows and decreases in salinity associated with freshwater flows would only be expected during high flow events in winter months. Increased flow in Sequalitchew Creek with the Restoration Plan activities is not expected to affect existing brackish marsh vegetation or functions.

4.4.3.5 Other Wetlands

Restoration is not expected to have significant effects on the Nearshore Springs or Nearby Wetlands.

4.4.4 Cumulative Impacts to Birds

Implementation of the Restoration Plan will reverse the changes in bird habitat in East and West Edmond Marsh that have occurred over the last three decades. This will include a reorganization of some specific habitats include scrub-shrub wetlands and forested wetlands. It will increase the area of forested wetland buffer as water levels in some areas of East Edmond Marsh drop and increase the amount of and persistence of emergent wetland habitat in the west end of West Edmond Marsh.

4.4.5 Cumulative Impacts to Mammals

Beaver in the Edmond Marsh complex will be actively managed as part of the Restoration Plan. The intent is to maintain the beaver population while managing water levels to restore flow. Other mammal species are expected to see increases in available habitat, particularly where water levels drop providing additional denning opportunities in the wetland banks and increasing the size of upland islands within the wetland complex.

4.4.6 Cumulative Impacts to Amphibians and Reptiles

Amphibian reproduction can be adversely affected by sudden, non-seasonal changes in water levels. This occurs in West Edmond Marsh when the large beaver dam above the dry reach is breached. Amphibian eggs attached to the stalks of emergent vegetation will suddenly be above water, causing complete mortality. Areas of reduced wetland area in the Edmond Marsh complex could reduce the area of habitat for some amphibian species, while others would benefit from the re-establishment of the forested riparian buffer.

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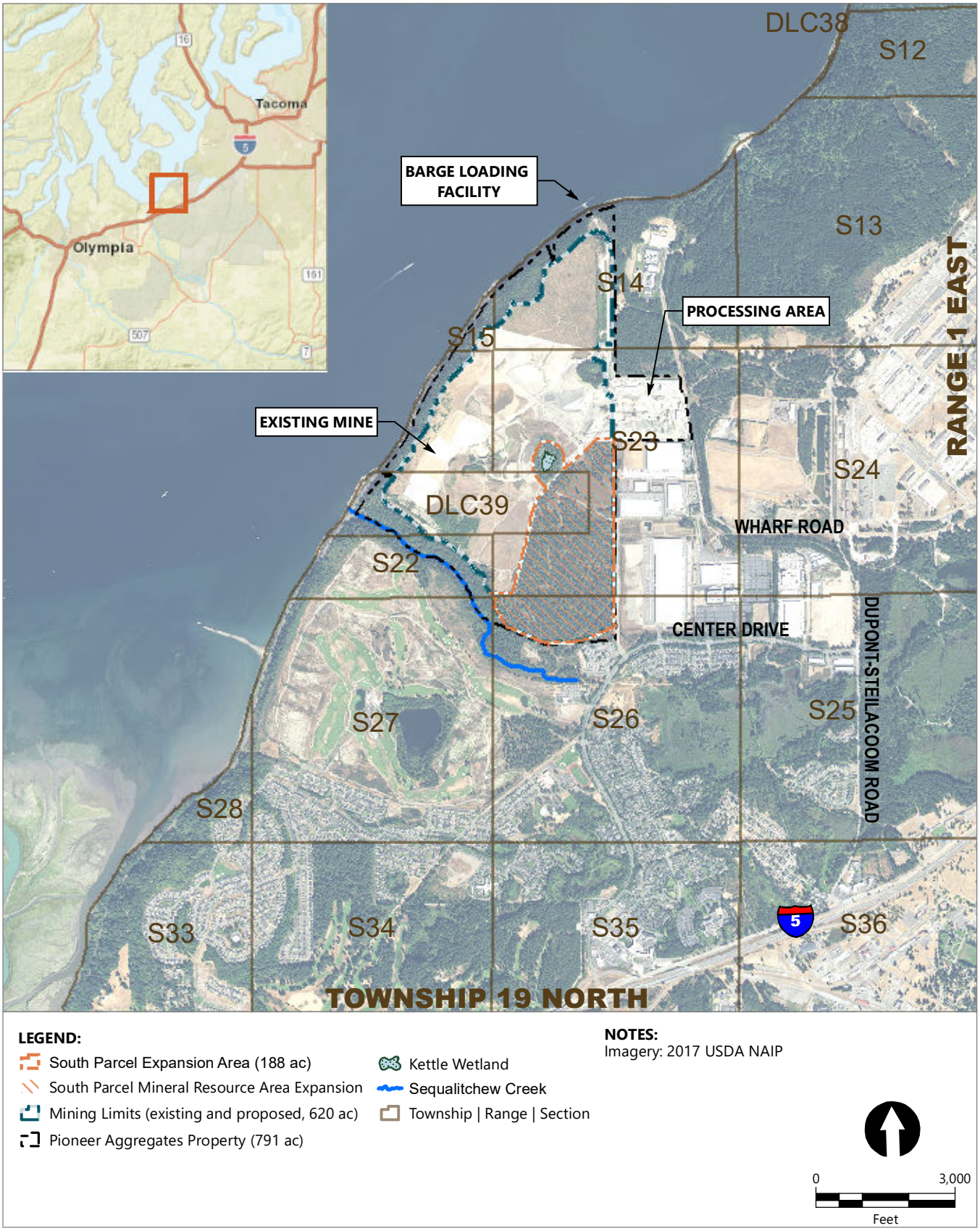
Figures



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ANCHOR QEA

Figure 1
Vicinity Map
Plants and Animals Technical Report
Pioneer Aggregates South Parcel Project

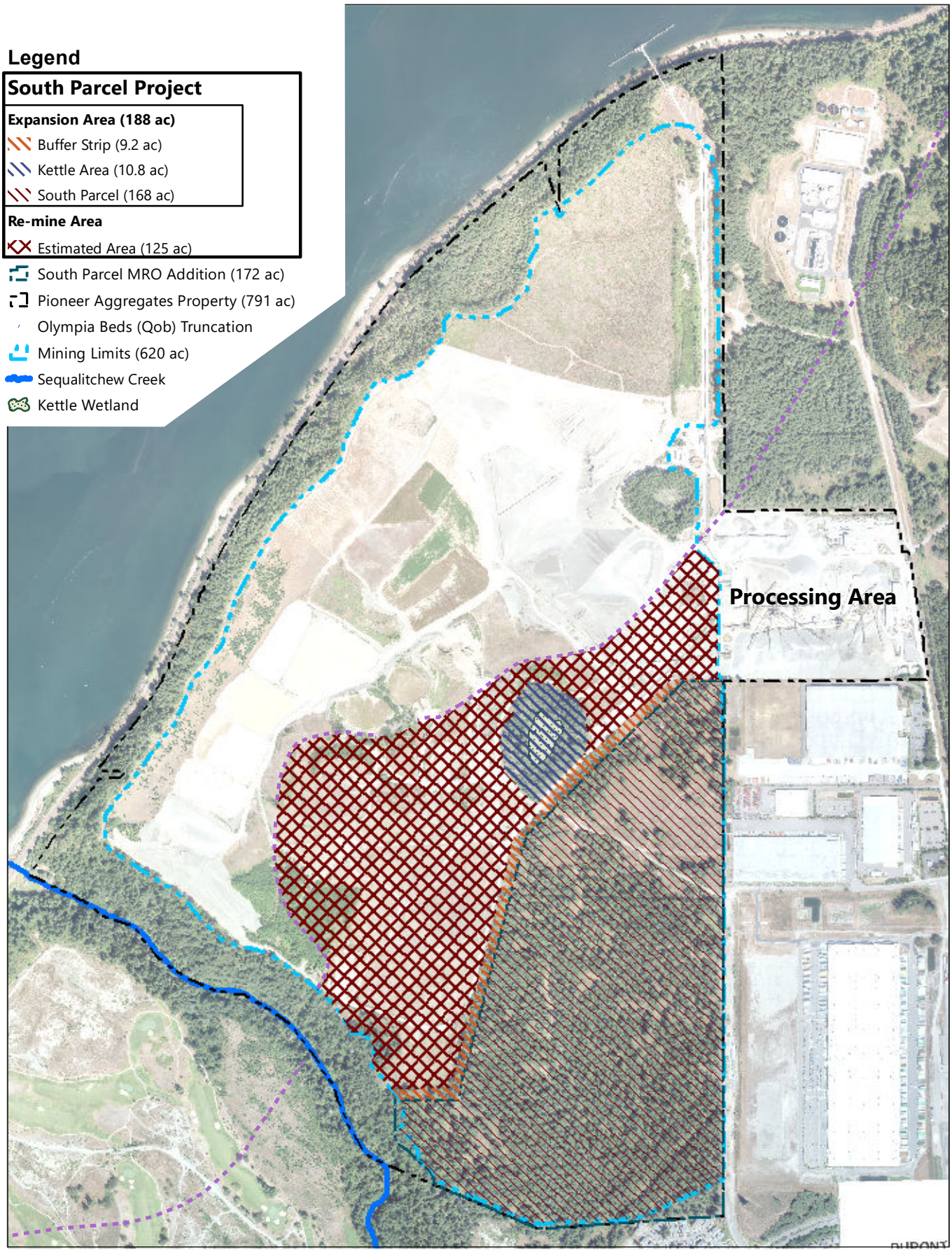

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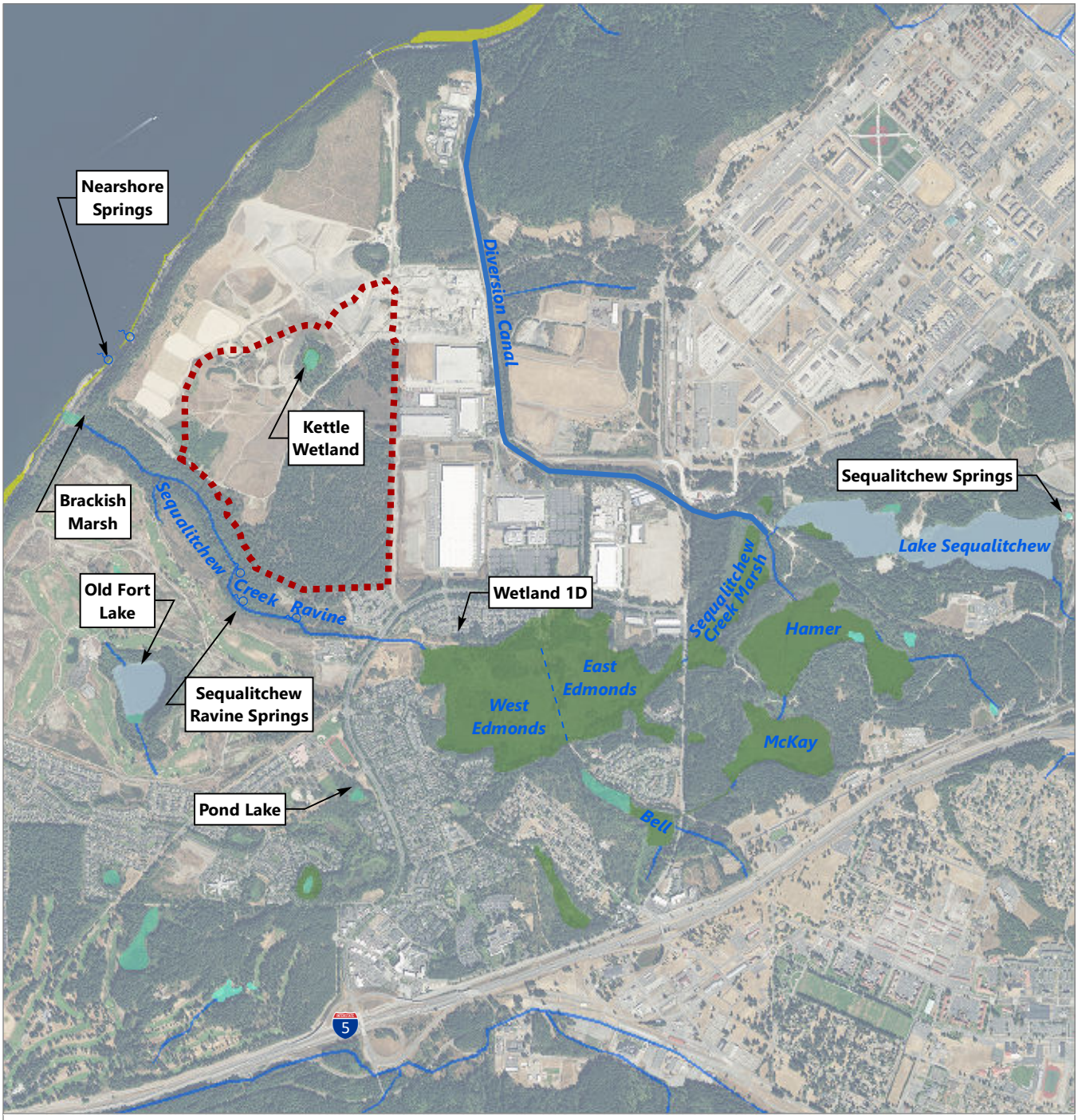
Figure 2
Project Components
Plants and Animals Technical Report
Pioneer Aggregates South Parcel Project



LEGEND:

- South Parcel Project

Aquatic Resources

- Stream/ Canal
- Freshwater Pond
- Spring
- Lake
- Estuarine and Marine Wetland
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland

NOTES:
This map was created by modifying the USFWS National Wetland Inventory to correct inaccuracies and add additional detail

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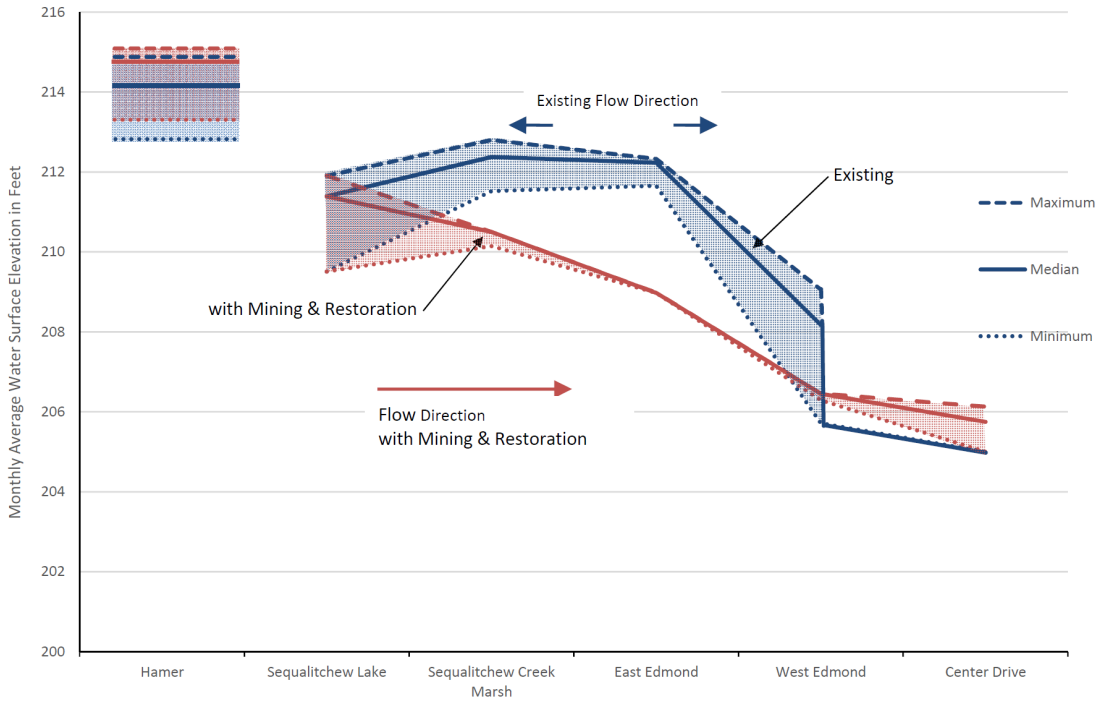
Figure 3
Aquatic Resources
Plants and Animals Technical Report
Pioneer Aggregates South Parcel Project

Predicted Surface Elevations in the Sequalitchew Creek Watershed



Predicted Annual Average Hydrograph in Sequalitchew Creek

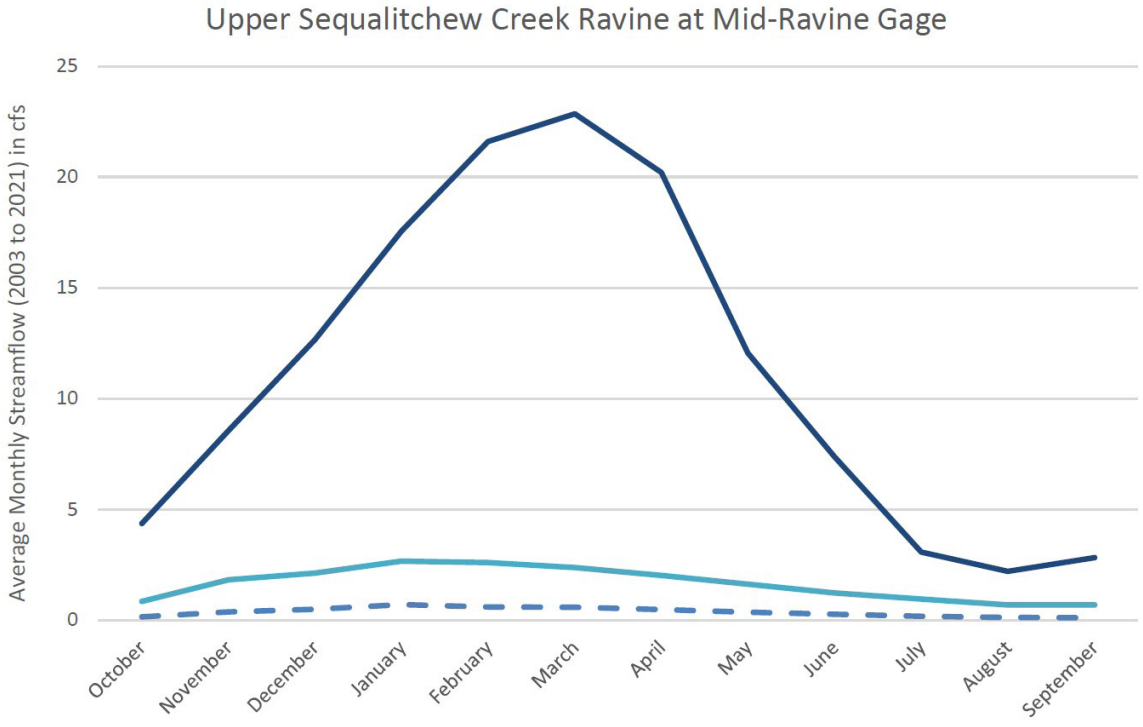


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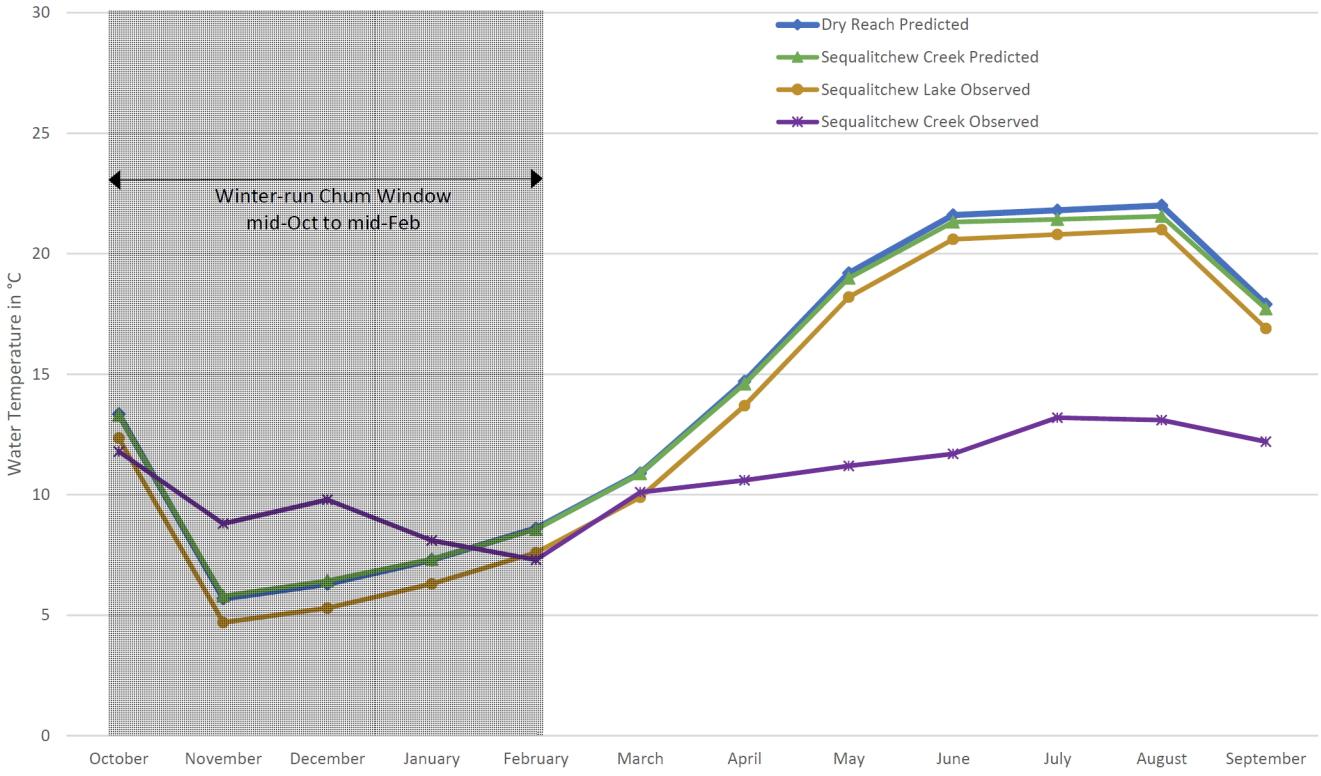
Figure 4
Predicted Water Surface Elevations and Flows
Plants and Animals Technical Report
Pioneer Aggregates South Parcel Project

Predicted Effects on Stream Temperature in Sequalitchew Creek Before and After Mining and Restoration



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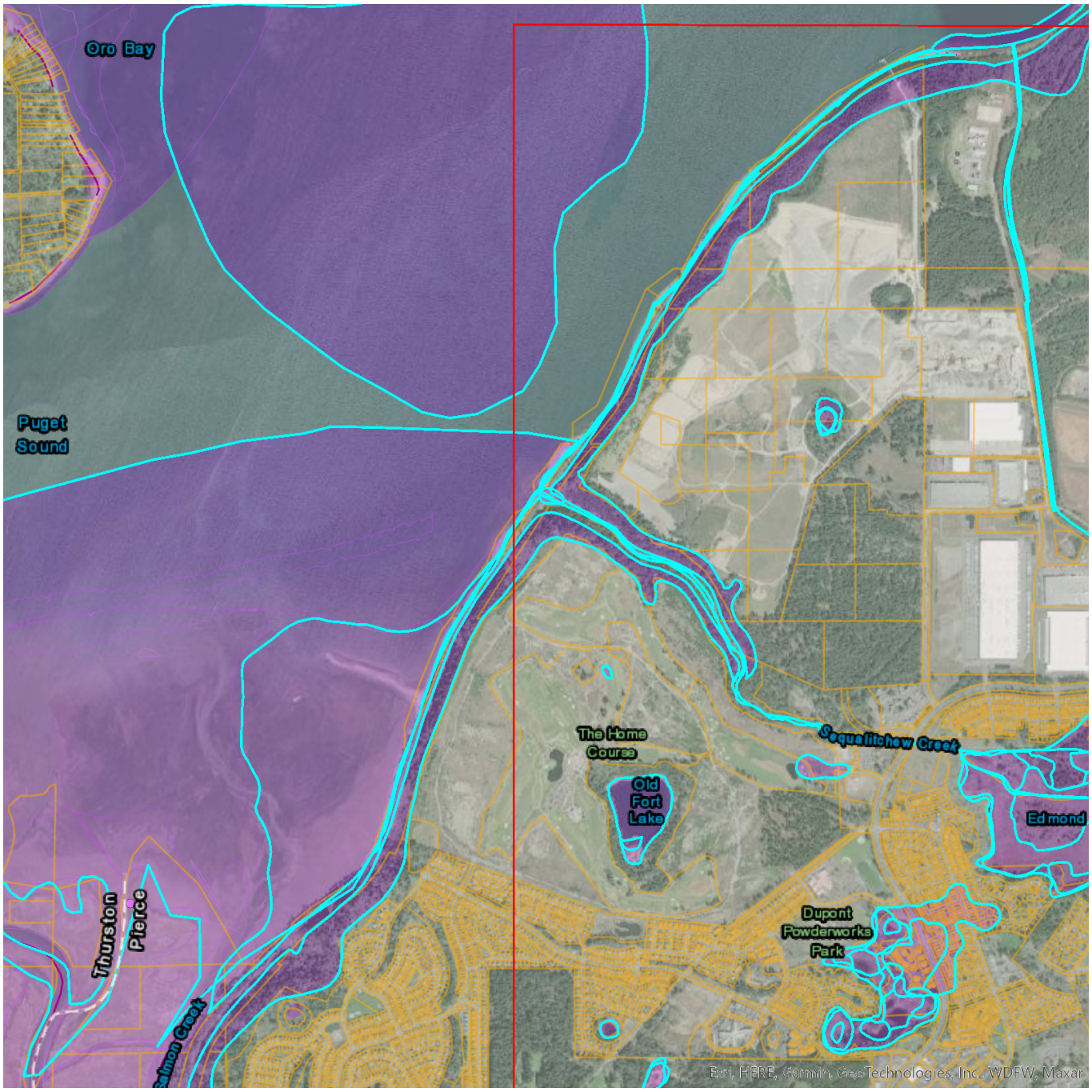
Appendix A
Washington Department of Fish and Wildlife Priority Habitats and Species in the Project Area

Priority Habitats and Species on the Web



Report Date: 09/19/2022

User Comments/Notes:

WDFW Priority Habitats and Species in the Vicinity of the Project Area.

PHS Species/Habitats Overview:

Occurence Name	Federal Status	State Status	Sensitive Location
Western gray squirrel	N/A	Threatened	No
Coho	N/A	N/A	No
Surf Smelt	N/A	N/A	No
Resident Coastal Cutthroat	N/A	N/A	No
Summer Chum	N/A	N/A	No
Pacific Sand Lance	N/A	N/A	No
Cutthroat	Not Warranted	N/A	No
Pandalid Shrimp	N/A	N/A	No
Dungeness crab	N/A	N/A	No
Wetlands	N/A	N/A	No
Biodiversity Areas And Corridor	N/A	N/A	No
Waterfowl Concentrations	N/A	N/A	No
Estuarine and Marine Wetland	N/A	N/A	No
Freshwater Emergent Wetland	N/A	N/A	No
Lake	N/A	N/A	No
Freshwater Forested/Shrub Wetland	N/A	N/A	No
Big brown bat	N/A	N/A	Yes
Little Brown Bat	N/A	N/A	Yes
Yuma myotis	N/A	N/A	Yes

PHS Species/Habitats Details:

Western gray squirrel	
Scientific Name	*Sciurus griseus*
Priority Area	Occurrence
Site Name	JBLM
Accuracy	GPS
Notes	WESTERN GRAY SQUIRREL NEST IN PIPO
Source Record	113567
Source Dataset	WS_OccurPoint
Source Date	WS_OccurPoint
Source Name	UNKNOWN/WDFW
Source Entity	WA Dept. of Fish and Wildlife
Federal Status	N/A
State Status	Threatened
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	Y
Display Resolution	AS MAPPED
ManagementRecommendations	http://wdfw.wa.gov/publications/pub.php?id=00027
Geometry Type	Points

Coho	
Scientific Name	*Oncorhynchus kisutch*
Priority Area	Occurrence/Migration
Site Name	Sequalitchew Creek
Accuracy	NA
Notes	LLID: 1226656471169, Fish Name: Coho Salmon, Run Time: Unknown or not Applicable, Life History: Anadromous
Source Record	50424
Source Dataset	SWIFD
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
More Info	http://wdfw.wa.gov/wlm/diversty/soc/soc.htm
Geometry Type	Lines

Surf Smelt	
Scientific Name	*Hypomesus pretiosus*
Priority Area	Breeding Area
Site Name	Station Number: 7
Accuracy	NA
Source Record	20585
Source Dataset	Forage_Fish_Survey
Source Date	Forage_Fish_Survey
Source Name	Not Given
Source Entity	WDFW
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Species or Habitat
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
Geometry Type	Lines

Resident Coastal Cutthroat	
Scientific Name	*Oncorhynchus clarki*
Priority Area	Occurrence/Migration
Accuracy	NA
Notes	LLID: 1226135471088, Fish Name: Cutthroat Trout, Run Time: Unknown or not Applicable, Life History: Unknown
Source Record	49272
Source Dataset	SWIFD
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
More Info	http://wdfw.wa.gov/wlm/diversty/soc/soc.htm
Geometry Type	Lines

Coho	
Scientific Name	*Oncorhynchus kisutch*
Priority Area	Occurrence/Migration
Accuracy	NA
Notes	LLID: 1226157471128, Fish Name: Coho Salmon, Run Time: Unknown or not Applicable, Life History: Anadromous
Source Record	49328
Source Dataset	SWIFD
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
More Info	http://wdfw.wa.gov/wlm/diversty/soc/soc.htm
Geometry Type	Lines

Resident Coastal Cutthroat	
Scientific Name	*Oncorhynchus clarki*
Priority Area	Occurrence/Migration
Accuracy	NA
Notes	LLID: 1226220470981, Fish Name: Cutthroat Trout, Run Time: Unknown or not Applicable, Life History: Unknown
Source Record	49447
Source Dataset	SWIFD
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
More Info	http://wdfw.wa.gov/wlm/diversty/soc/soc.htm
Geometry Type	Lines

Resident Coastal Cutthroat	
Scientific Name	*Oncorhynchus clarki*
Priority Area	Occurrence/Migration
Site Name	Sequalitchew Creek
Accuracy	NA
Notes	LLID: 1226656471169, Fish Name: Cutthroat Trout, Run Time: Unknown or not Applicable, Life History: Unknown
Source Record	50422
Source Dataset	SWIFD
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
More Info	http://wdfw.wa.gov/wlm/diversty/soc/soc.htm
Geometry Type	Lines

Resident Coastal Cutthroat	
Scientific Name	*Oncorhynchus clarki*
Priority Area	Occurrence/Migration
Accuracy	NA
Notes	LLID: 1226157471121, Fish Name: Cutthroat Trout, Run Time: Unknown or not Applicable, Life History: Unknown
Source Record	49326
Source Dataset	SWIFD
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
More Info	http://wdfw.wa.gov/wlm/diversty/soc/soc.htm
Geometry Type	Lines

Summer Chum	
Scientific Name	*Oncorhynchus keta*
Priority Area	Occurrence/Migration
Site Name	Sequalitchew Creek
Accuracy	NA
Notes	LLID: 1226656471169, Fish Name: Chum Salmon, Run Time: Summer, Life History: Anadromous
Source Record	50423
Source Dataset	SWIFD
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
More Info	http://wdfw.wa.gov/wlm/diversty/soc/soc.htm
Geometry Type	Lines

Pacific Sand Lance	
Scientific Name	*Ammodytes hexapterus*
Priority Area	Breeding Area
Site Name	Station Number: 5
Accuracy	NA
Source Record	20583
Source Dataset	Forage_Fish_Survey
Source Date	Forage_Fish_Survey
Source Name	Not Given
Source Entity	WDFW
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Species or Habitat
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
Geometry Type	Lines

Cutthroat	
Scientific Name	*Oncorhynchus clarki*
Priority Area	Occurrence
Site Name	Sequalitchew Creek
Accuracy	NA
Notes	LLID: 1226656471169, Stock Name: West South Sound Coastal Cutthroat, Run: Unspecified, Status: Unknown
Source Record	7020
Source Dataset	SASI
Source Name	Not Given
Source Entity	WDFW Fish Program
Federal Status	Not Warranted
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
More Info	http://wdfw.wa.gov/wlm/diversty/soc/soc.htm
Geometry Type	Lines

Resident Coastal Cutthroat	
Scientific Name	*Oncorhynchus clarki*
Priority Area	Occurrence/Migration
Accuracy	NA
Notes	LLID: 1226157471128, Fish Name: Cutthroat Trout, Run Time: Unknown or not Applicable, Life History: Unknown
Source Record	49327
Source Dataset	SWIFD
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
More Info	http://wdfw.wa.gov/wlm/diversty/soc/soc.htm
Geometry Type	Lines

Pacific Sand Lance	
Scientific Name	*Ammodytes hexapterus*
Priority Area	Breeding Area
Site Name	Station Number: 6
Accuracy	NA
Source Record	20584
Source Dataset	Forage_Fish_Survey
Source Date	Forage_Fish_Survey
Source Name	Not Given
Source Entity	WDFW
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Species or Habitat
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
Geometry Type	Lines

Pandalid Shrimp	
Priority Area	Presence
Site Name	Not Given
Accuracy	NA
Notes	Not Given
Source Dataset	Shellfish_Summary
Source Name	Not Given
Source Entity	WDFW
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
Geometry Type	Polygons

Dungeness crab	
Scientific Name	*Cancer magister*
Priority Area	Presence
Site Name	Not Given
Accuracy	NA
Notes	Not Given
Source Dataset	Shellfish_Summary
Source Name	Not Given
Source Entity	WDFW
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
Geometry Type	Polygons

Wetlands	
Priority Area	Aquatic Habitat
Site Name	SEQUALICHEW CREEK WETLANDS
Accuracy	1/4 mile (Quarter Section)
Notes	WETLANDS ASSOCIATED WITH SEQUALICHEW CREEK DRAINAGE WHICH PROVIDE SIGNIFICANT WINTERING WATERFOWL HABITAT AND GENERAL WILDLIFE HABITAT.
Source Record	902594
Source Dataset	PHSREGION
Source Name	NAUER, DON, WDW
Source Entity	WA Dept. of Fish and Wildlife
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Biodiversity Areas And Corridor	
Priority Area	Terrestrial Habitat
Site Name	PUYALLUP STEEP OPEN SPACES
Accuracy	1/4 mile (Quarter Section)
Notes	UNDEVELOPED STEEP SLOPES WITH NATIVE VEGETATION-UNSUITABLE FOR DEVELOPMENT BUT STILL PROVIDE WILDLIFE HABITAT.
Source Record	902552
Source Dataset	PHSREGION
Source Name	NAUER, DON WDW
Source Entity	WA Dept. of Fish and Wildlife
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://wdfw.wa.gov/publications/pub.php?id=00023
Geometry Type	Polygons

Waterfowl Concentrations	
Priority Area	Regular Concentration
Site Name	PIERCE COUNTY - NON FARM
Accuracy	1/4 mile (Quarter Section)
Notes	SMALL WATERFOWL CONCENTRATION AREAS, NON AGRICULTURAL.
Source Record	902564
Source Dataset	PHSREGION
Source Name	NAUER, DON WDW
Source Entity	WA Dept. of Fish and Wildlife
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS LISTED OCCURRENCE
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://wdfw.wa.gov/publications/pub.php?id=00026
Geometry Type	Polygons

Waterfowl Concentrations	
Priority Area	Regular Concentration
Site Name	PIERCE COUNTY - NON-AGRICULTURAL
Accuracy	1/4 mile (Quarter Section)
Notes	LARGE REGULAR WATERFOWL CONCENTRATION AREAS, NON AGRICULTURAL IN PIERCE COUNTY.
Source Record	902562
Source Dataset	PHSREGION
Source Name	NAUER, DON
Source Entity	WA Dept. of Fish and Wildlife
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS LISTED OCCURRENCE
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://wdfw.wa.gov/publications/pub.php?id=00026
Geometry Type	Polygons

Estuarine and Marine Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Estuarine and Marine Wetland - NWI Code: E2AB/USN
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Estuarine and Marine Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Estuarine and Marine Wetland - NWI Code: E2USN
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Emergent Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Emergent Wetland - NWI Code: PEM1C
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Emergent Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Emergent Wetland - NWI Code: PEM1/UBF
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Emergent Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Emergent Wetland - NWI Code: PEM1/UBF
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Emergent Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Emergent Wetland - NWI Code: PEM1/UBF
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Emergent Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Emergent Wetland - NWI Code: PEM1/UBF
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Emergent Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Emergent Wetland - NWI Code: PEM1A
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Emergent Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Emergent Wetland - NWI Code: PEM1A
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Emergent Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Emergent Wetland - NWI Code: PEM1A
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Lake	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Lake - NWI Code: L2ABH
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Emergent Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Emergent Wetland - NWI Code: PEM1/SSA
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Emergent Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Emergent Wetland - NWI Code: PEM1/SSF
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Emergent Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Emergent Wetland - NWI Code: PEM1Ch
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Emergent Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Emergent Wetland - NWI Code: PEM1F
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Emergent Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Emergent Wetland - NWI Code: PEM1F
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Emergent Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Emergent Wetland - NWI Code: PEM1F
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Emergent Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Emergent Wetland - NWI Code: PEM1F
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Emergent Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Emergent Wetland - NWI Code: PEM1Fx
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PFOC
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PFOC
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PFOC
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PFOC
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PFOC
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PFOA
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PFOA
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PFOA
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PFOA
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PFOF
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PSS/EM1C
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PSS/EM1F
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PSS/EM1F
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PSSC
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PSSC
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PSSC
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PSSC
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PSSC
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PSSC
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PSSF
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PSSF
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PSSF
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PSSF
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PSSF
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PSSF
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PFOA
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PSSC
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PSSC
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PSSC
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PSSA
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Freshwater Forested/Shrub Wetland	
Priority Area	Aquatic Habitat
Site Name	N/A
Accuracy	NA
Notes	Wetland System: Freshwater Forested/Shrub Wetland - NWI Code: PSSC
Source Dataset	NWIWetlands
Source Name	Not Given
Source Entity	US Fish and Wildlife Service
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	N
SGCN	N
Display Resolution	AS MAPPED
ManagementRecommendations	http://www.ecy.wa.gov/programs/sea/wetlands/bas/index.html
Geometry Type	Polygons

Big brown bat	
Scientific Name	*Eptesicus fuscus*
Notes	This polygon mask represents one or more records of the above species or habitat occurrence. Contact PHS Data Release (360-902-2543) for obtaining information about masked sensitive species and habitats.
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	Y
SGCN	N
Display Resolution	TOWNSHIP
ManagementRecommendations	http://wdfw.wa.gov/publications/pub.php?id=00605

Little Brown Bat	
Scientific Name	*Myotis lucifugus*
Notes	This polygon mask represents one or more records of the above species or habitat occurrence. Contact PHS Data Release (360-902-2543) for obtaining information about masked sensitive species and habitats.
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	Y
SGCN	N
Display Resolution	TOWNSHIP
ManagementRecommendations	http://wdfw.wa.gov/publications/pub.php?id=00605

Yuma myotis	
Scientific Name	*Myotis yumanensis*
Notes	This polygon mask represents one or more records of the above species or habitat occurrence. Contact PHS Data Release (360-902-2543) for obtaining information about masked sensitive species and habitats.
Federal Status	N/A
State Status	N/A
PHS Listing Status	PHS Listed Occurrence
Sensitive	Y
SGCN	N
Display Resolution	TOWNSHIP
ManagementRecommendations	http://wdfw.wa.gov/publications/pub.php?id=00605

DISCLAIMER. This report includes information that the Washington Department of Fish and Wildlife (WDFW) maintains in a central computer database. It is not an attempt to provide you with an official agency response as to the impacts of your project on fish and wildlife. This information only documents the location of fish and wildlife resources to the best of our knowledge. It is not a complete inventory and it is important to note that fish and wildlife resources may occur in areas not currently known to WDFW biologists, or in areas for which comprehensive surveys have not been conducted. Site specific surveys are frequently necesssary to rule out the presence of priority resources. Locations of fish and wildlife resources are subject to variation caused by disturbance, changes in season and weather, and other factors. WDFW does not recommend using reports more than six months old.

Appendix B
Tables of Plant and Animal Species Surveyed in the Project Area

Appendix B
Plants Identified In and Around the Proposed Action

Species	Common Name	Coniferous Forest	Kettle Wetland and Buffer	Disturbed Areas	Bluff	Open/ Grassland	Brackish Marsh
Plants							
Acer macrophyllum	bigleaf maple				x		
Toxicodendron diversilobum	Pacific poison oak				x		
Oenanthe sarmentosa	water parsley		x				
Perideridia sp.	yampah		x				
Apocyrum androsaemifolium	spreading dogbane	x			x		
Asarum caudatum	British Columbia wildginger	x					
Achillea millefolium	common yarrow				x	x	x
Nothocalais sp.	false-dandelion				x		
Anaphalis margaritacea	western pearly everlasting			x	x		
Artemisia californica	coastal sagebrush	x			x		
Artemisia sp.					x		
Symphyotrichum subspicatum	Douglas aster						x
Cirsium vulgare	bull thistle			x			
Cotula coronopifolla	common brassbuttons						x
Pseudognaphalium canescens ssp. *Microcephalum*	Wright's cudweed			x	x	x	
Grindelia sp.	gumweed						x
Leucanthemum vulgare	oxeye daisy			x			
Hieracium sp.	hawkweed			x	x	x	
Senecio jacobaea	tansy ragwort (stinking willie)				x		
Senecio sp.	senecio			x	x		
Solidago canadensis	Canadian goldenrod			x			
Achlys triphylla	vanilla-leaf	x					
Berberis aquifolium	hollyleaved barberry/Oregon grape	x		x	x		
Berberis nervosa	Cascade barberry				x		
Alnus rubra	red alder	x					
Corylus cornuta	beaked hazelnut/beaked hazel/western hazel	x			x		
Lepidium sp.	pepperweed				x		
Campanula scouleri	pale bellflower				x		
Linnaea borealis	twinflower	x		x		x	
Lonicera ciliosa	orange honeysuckle			x	x		
Sambucus nigra ssp. *cerulea*	blue elderberry			x	x	x	
Sambucus racemosa	red elderberry			x			
Symphoricarpos albus	common snowberry	x	x	x	x		
Moehringia macrophylla	largeleaf sandwort				x		
Cerastium sp.	chickweed			x			
Paxistima myrsinites	Oregon boxleaf			x			
Chenopodium album	fat hen/white goosefoot/common lambsquarters						x
Salicornia sp.	pickleweed						x
Cornus sericea	redtwig dogwood/redosier dogwood		x				
Marah oregana	Oregon bigroot/coastal manroot/western wildcucumber					x	
Carex deweyana	Dewey's sedge	x					
Carex lyngbyei	Lyngbye's sedge						x
Carex obnupta	slough sedge		x				
Carex inops	long-stolon sedge			x		x	
Luzula sp.	woodrush			x			
Arbutus menziesii	Pacific madrone			x	x		
Arctostaphylos uva-ursi	bearberry	x		x		x	
Gaultheria shallon	salal	x			x		
Vaccinium ovalifolium	oval-leaf huckleberry/oval-leaf blueberry/Alaska blueberry				x		
Vaccinium ovatum	evergreen huckleberry	x			x		
Vaccinium parvifolium	red huckleberry	x					
Cytisus scoparius	Scot's broom	x	x	x	x	x	x
Lupinus sp.	lupine				x		
Vicia sp.	vetch	x			x		

Appendix B
Plants Identified In and Around the Proposed Action

Species	Common Name	Coniferous Forest	Kettle Wetland and Buffer	Disturbed Areas	Bluff	Open/ Grassland	Brackish Marsh
Quercus garryana	Oregon white oak	x		x		x	
Centaurium erythraea	European centaury			x			
Ribes sanguineum	redflower currant			x	x		
Ribes watsonianum (?)	spring gooseberry					x	
Hypericum perforatum	common St. John's wort			x	x	x	
Hypericum sp.	St. John's wort	x			x	x	
Juncus bufonius	toad rush		x				
Juncus effusus	soft rush/lamp rush/common rush		x				x
Lycopus sp.	water horehound		x				
Mentha sp.	mint		x				
Micromeria douglasii	yerba buena				x		
Maianthemum stellatum	starry Solomon-plume/starry false lily of the valley/false Solomon's seal				x		
streptopus amplexifolius	clasping-leaved twisted-stalk/clasping twistedstalk/twisted stalk/claspleaf twistedstalk					x	
Nuphar polysepala	spatterdock/Rocky Mountain pond-lilly			x			
Chamerion sp.	fireweed				x		
Goodyera oblongifolia	rattlesnake-plantain					x	
Abies grandis	grand fir	x					
Pseudotsuga menziesii	Douglas-fir	x		x	x	x	
Tsuga heterophylla	western hemlock	x					
Plantago lanceolata	narrow-leaf plantain			x		x	x
Aira praecox	early hairgrass/yellow hairgrass			x			x
Elymus repens	quackgrass			x		x	x
Agrostis stolonifera	creeping bentgrass						x
Agrostis capillaris	colonial bentgrass		x	x		x	
Agrostis sp.	bentgrass						x
Dactylis glomerata	orchard grass					x	
Deschampsia cespitosa	tufted hairgrass						x
Schedonorus arundinaceus	tall fescue	x		x			
Festuca sp.	fescue			x			
Holcus lanatus	velvetgrass/common velvetgrass			x	x	x	x
Lolium sp.	ryegrass						x
Phalaris arundinacea	reed canarygrass		x				
Achnatherum sp.	needlegrass					x	
Polygonum sp.	knotweed		x				
Rumex acetosella	sheep sorrel			x	x		
Rumex occidentalis	western dock						x
Rumex stenophyllus	narrow-leaved dock						x
Athyrium felix-femina	lady fern		x				
Polystichum munitum	western swordfern	x		x	x	x	
Pteridium aquilinum	bracken fern	x			x	x	
Claytonia sibirica	Siberian miners'-lettuce	x					
Batis maritima	saltwort/turtleweed						x
Trientalis borealis	northern starflower	x			x		
Ceanothus velutinus var. veluntinus	tobacco bush				x		
Amelanchier alnifolia	western serviceberry	x		x		x	
Crataegus douglasii	black hawthorn		x		x		
Fragaria vesca	woodland strawberry			x			
Geum macrophyllum	large-leaf avens					x	
Rosa gymnocarpa	naked-hip rose/dwarf rose	x			x		
Holodiscus discolor	oceanspray	x			x	x	
Malus fusca	Oregon crab apple	x	x		x		
Oemleria cerasiformis	Indian plum	x					
Comarum palustre	marsh cinquefoil/purple marshlocks		x				x
Prunus emarginata	bitter cherry	x		x			

Appendix B
Plants Identified In and Around the Proposed Action

Species	Common Name	Coniferous Forest	Kettle Wetland and Buffer	Disturbed Areas	Bluff	Open/ Grassland	Brackish Marsh
Rosa nutkana	Nootka rose	x					
Rubus ulmifolius	Himalayan blackberry/elmleaf blackberry			x	x		
Rubus laciniatus	cut-leaf blackberry			x	x		
Rubus occidentalis	black raspberry			x	x		
Rubus parviflorus	thimbleberry				x		
Rubus spectabilis	salmonberry	x					
Rubus ursinus	Pacific blackberry/California blackberry	x		x	x	x	
Spiraea douglasii	hardhack/rose spirea	x		x			
Galium sp.	bedstraw	x					
Populus trichocarpa	black cottonwood	x		x			
Salix scouleriana	Scouler willow	x	x	x	x		
Salix sp.	willow			x			
Heuchera sanguinea	small-flower coral bells				x		
Digitalis purpurea	purple foxglove			x			
Solanum dulcamara	climbing nightshade		x				
Sparganium emersum	European bur-reed		x				
Taxus brevifolia	Pacific yew	x			x		
Typha latifolia	cat-tail			x			
Urtica dioca	stinging nettle	x					
Viola palmata	early blue violet					x	

Appendix B
Animals Identified In and Around the Proposed Action

Species	Common Name	Coniferous Forest	Oak-Grassland	Disturbed Areas	Palustrine Wetland	Brackish Marsh
Reptiles and Amphibians						
Taricha granulosa	Northern rough-skinned newt				x	
Plethodon cinereus	Western red-backed salamander	x			x	
Rana aurora	Northern red-legged frog	x			x	
Rana catesbeiana	Bullfrog				x	
Bufo boreas	Western toad				x	
Hyla regilla	Pacific tree frog	x			x	
Sceloporus occidentalis	Western fence lizard		x			
Gerrhonotus coeruleus	Northern alligator lizard		x			
Charina bottae	Rubber boa				x	x
Thamnophis sirtalis pickeringi	Puget Sound red-sided garter snake	x	x	x	x	x
Birds						
Loons and Grebes						
Gavia immer	Common loon					x
Aechmorphorus occidentalis	Western grebe					x
Podiceps gisegena	Red-necked grebe					x
Podiceps auritus	Horned grebe					x
Podilymbus podiceps	Pied-billed grebe					x
Waterfowl						
Anas platyrhynchos	Mallard				x	x
Anas acuta	Pintail				x	x
Anas strepera	Gadwall				x	x
Mareca american	American widgeon				x	x
Spatula clypeata	Northern shovelor				x	x
Anas discors	Blue-winged teal				x	x
Anas carolinensis	Green-winged teal				x	x
Aix sponsa	Wood duck				x	x
Aytha valisineria	Canvasback				x	x
Aytha collaris	Ring-necked duck				x	x
Aytha marila	Greater scaup				x	x
Aytha affinis	Lesser scaup				x	x
Bucephala clangula	Common goldeneye				x	x
Bucephala albeola	Bufflehead				x	x
Oxyura jamaicensis	Ruddy duck				x	x
Mergus serrator	Red-breasted merganser				x	x
Oidemia nigra	Common scoter				x	x
Melanitta deglandi	White-winged scoter				x	x
Melanitta perspicillata	Surf scoter				x	x
Raptors						
Cathartes aura	Turkey vulture	x	x	x		
Accipiter cooperii	Cooper's hawk		x			
Accipiter striatus	Sharp-shinned hawk	x	x	x		
Buteo jamaicensis	Red-tailed hawk *	x	x	x		
Haliaeetus leucocephalus	Bald eagle	x				x
Pandion haliaetus	Osprey	x			x	x
Falco sparverius	American kestrel		x	x		
Bubo virginianus	Great horned owl	x	x			
Asio flammeus	Short-eared owl				x	x
Tyto alba	Barn owl		x	x		
Upland Game Birds						
Dendragapus obscurus	Blue grouse	x				
Bonasa umbellus	Ruffed grouse *	x	x			
Lophortyx californicus	California quail	x	x			
Phasianus colchicus	Ring-necked pheasant		x	x		

Appendix B
Animals Identified In and Around the Proposed Action

Species	Common Name	Coniferous Forest	Oak-Grassland	Disturbed Areas	Palustrine Wetland	Brackish Marsh
Herons						
Ardea herodias	Great blue heron				x	x
Butorides virescens	Green heron				x	x
Rails and Coots						
Rallus limicola	Virginia rail				x	x
Fulica americana	American coot				x	x
Doves and Pigeons						
Columba fasciata	Band-tailed pigeon	x	x	x		
Zenaidora macroura	Mourning dove		x	x		
Shorebirds						
Charadrius vociferus	Killdeer			x		x
Capella gallinago	Common snipe				x	x
Uria aalge	Common mure					x
Cepphus columba	Pigeon guillemot					x
Cerorhinca monocerata	Rhinoceros auklet					x
Kingfishers						
Megaceryle alcyon	Belted kingfisher				x	
Hummingbirds						
Selasphorous rufus	Rufus hummingbird	x	x	x	x	
Woodpeckers						
Colaptes auratus	Common flicker *	x	x			
Dryocopus pileatus	Pileated woodpecker *	x				
Sphyrapicus varius	Red-breasted sapsucker *	x				
Dendrocopos villosus	Hairy woodpecker *	x				
Dendrocopos pubescens	Downy woodpecker	x				
Songbirds						
Empidonax trallii	Willow flycatcher		x	x		
Empidonax difficilis	Western flycatcher	x	x			
Contopus sordidula	Western wood pewee	x	x			
Nuitallornis borealis	Olive-sided flycatcher	x				
Hirundo rustica	Barn swallow				x	x
Petrochelidon pyrrhonota	Cliff swallow[1]					
Iridoprocne bicolor	Tree swallow				x	x
Cyancitta stelleri	Stellar's jay	x	x			
Corvus brachyrhynchos	Common crow *	x	x	x	x	x
Parus atricapillus	Black-capped chickadee	x				
Parus rufescens	Chestnut-backed chickadee *	x				
Psaltriparus minimus	Common bushtit		x	x		
Sitta canadensis	Red-breasted nuthatch *	x				
Certhia familiaris	Brown creeper	x				
Troglodytes troglodytes	Winter wren *	x	x			
Thryomanes bewickii	Bewick's wren				x	x
Telmatodytes palustris	Marsh wren				x	x
Turdus migratorius	American robin		x			
Ixoreus naveius	Varied thrush *	x	x			
Hylocichla ustulata	Swainson's thrush	x	x			
Regulus satrapa	Golden-crowned kinglet *	x				
Regulus calendula	Ruby-crowned kinglet	x				
Anthus spinoletta	Water pipit				x	x
Bombycilla cedrorum	Cedar waxwing		x			
Lanius excubitor	Northern shrike		x			
Sturnus vulgaris	European starling	x	x			
Vireo gilvus	Warbling vireo		x			
Dendroica petechia	Yellow warbler				x	
Dendroica coronata	Yellow-rumped warbler	x				
Geothlypis trichas	Common yellowthroat				x	
Oporornis tolmiei	MacGillivray's warbler		x	x		
Wilsonia pusilla	Wilson's warbler		x	x		
Sturnella neglecta	Western meadowlark		x	x		
Agelaius phoeiceus	Red-winged blackbird				x	
Molothrus ater	Brown-headed cowbird	x	x	x	x	

Appendix B
Animals Identified In and Around the Proposed Action

Species	Common Name	Coniferous Forest	Oak-Grassland	Disturbed Areas	Palustrine Wetland	Brackish Marsh
Piranga ludoviciana	Western tanager		x			
Hesperiphona vespertina	Evening grosbeak	x				
Carpodacus purpureus	Purple finch	x				
Carpodacus mexicanus	House finch	x				
Spinos pinus	Pine siskin	x				
Spinus tristis	American goldfinch		x	x		
Pipilo erthrophtalmus	Rufus-sided towhee	x	x	x		
Passersulus sandwichensis	Savannah sparrow		x	x		x
Pooecetes gramineus	Vesper sparrow		x	x		
Junco hyemalis	Dark-eyed junco		x	x		
Spizella passerina	Chipping sparrow		x	x		
Zonotrichia leucophrys	White-crowned sparrow		x	x		
Passerella iliace	Fox sparrow		x	x		
Melospiza melodia	Song sparrow		x	x		
Mammals						
Large and Medium Size						
Procyon lotor	Raccoon		x	x	x	x
Mustela frenata	Long-tailed weasel	x	x	x	x	x
Mephitis mephitis	Striped skunk	x	x	x	x	x
Canis latrans	Coyote *	x	x	x	x	x
Sciurus griseus	Western gray squirrel		x			
Tamiasciurus douglasi	Douglas squirrel *	x				
Erethizon dorsatum	Porcupine	x	x	x	x	x
Lepus americanus	Snowshoe hare		x	x	x	x
Sylvilagus floridanus	Eastern cottontail		x	x	x	x
Odocoileus hemionus	Black-tailed deer	x	x	x	x	x
Furbearers						
Mustela vison	Mink				x	x
Castor canadensis	Beaver				x	
Ondatra zibethica	Muskrat				x	
Small Mammals						
Sorex cinerus	Masked shrew	x	x		x	x
Sorex trowbridge	Trowbridge shrew	x	x			
Sorex vagrans	Vagrant shrew				x	x
Sorex obscurus	Dusky shrew	x	x	x	x	x
Sorex bendirei	Pacific water shrew				x	
Neurotrichus gibbsi	Shrew mole				x	x
Scapanus townsendi	Townsend mole	x			x	x
Scapanus orarius	Pacific mole		x			
Eutamias townsendi	Townsend chipmunk	x				
Peromyscus maniculatus	Deer mouse	x	x			
Microtus townsendi	Townsend vole		x		x	x
Microtus oregoni	Oregon vole	x	x	x		
Mus musculatus	House mouse		x			
Zapus trinolatus	Pacific jumping mouse	x	x		x	x

Notes:
1. along cliffs and bluffs
* staff observations

Appendix I

Landmarks Tree Inventory

August 2021
Pioneer Aggregates South Parcel Project

ANCHOR QEA

Landmark Tree Inventory Report

Prepared for CalPortland

Received 1-18-2023

August 2021
Pioneer Aggregates South Parcel Project

Landmark Tree Inventory Report

Prepared for
CalPortland – DuPont Plant
4301 Pioneer Avenue
DuPont, Washington 98327

Prepared by
Anchor QEA, LLC
1201 3rd Avenue, Suite 2600
Seattle, Washington 98101

Project Number: 190217-01.01
ND: 10552.09402 4843-8920-1864v1

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Figure 1 Vicinity Map

Figure 2 Landmark Trees Within South Parcel Project Area

APPENDICES

Appendix A Weyerhaeuser Pathologist Report

Appendix B Tree Survey Data

ABBREVIATIONS

City	City of DuPont
dbh	diameter at breast height
DMC	City of DuPont Municipal Code
MRO	Mineral Resource Overlay
Project	South Parcel Expansion Project

1 Introduction

CalPortland operates the Pioneer Aggregates Mine facility in DuPont, Washington (Figure 1). CalPortland is proposing an expansion of the mine to the south, known as the South Parcel Project (Project), within the City of DuPont's (City's) designated Mineral Resource Overlay (MRO) District.

The South Parcel Project includes mining within areas previously undisturbed by mining (termed the "Expansion Area") and mining deeper within a portion of the existing mine, referred to as the "Re-Mine Area." The Expansion Area is approximately 188 acres and is composed of three subareas (see Figure 2). The Kettle Area is a 10.8-acre previously undisturbed area. The 9.2-acre Buffer Strip is a strip of vegetation that was retained along the inside of the originally permitted mine bordering the South Parcel. The South Parcel is 168 acres located southeast of the original mine and inside the Mineral Resource Overlay area in the City of DuPont's adopted Comprehensive Plan. Approximately 126 acres within the 168-acre South Parcel are forested.

All areas to be cleared and mined are within the City's Comprehensive Plan MRO area. The purpose of an MRO designation is to implement the Growth Management Act, the Surface Mining Act, and the DuPont Comprehensive Plan by designating commercially viable mineral resources where they occur and allowing for extraction of resources from those areas (DMC 25.60.010).

This report is prepared to inform decisions made regarding tree retention requirements under DMC 25.120, to the extent DMC 25.120.030 is applicable to land and trees within the City's designated mineral Resource Overlay area.

Typical development projects are required to retain a certain number of trees within the tax parcel being developed. The proposed South Parcel Project includes activity on multiple tax parcels. For this report, landmark trees were inventoried within a study area that included all the tax parcels where work is proposed. For this reason landmark trees are counted that would be removed from the proposed Re-Mine Area and landmark trees in the buffer area adjacent to the Re-Mine Area are counted as retained. Similarly, landmark trees that would be removed from the proposed Expansion Area and landmark trees that would be retained within the buffer adjacent to the Expansion Area are inventoried.

Landmark trees in the Re-mine area and the expansion area are counted separately in this report because City permits for the existing mine authorize removal of trees from the Re-mine area and not the expansion area.

2 Tree Survey Methods

The City of DuPont Municipal Code (DMC) defines a "landmark tree" as "an existing healthy, well-formed tree which poses no safety hazard due to potential collapse," and that is of the following species, trunk type, and minimum diameter measured at breast height (dbh) (Table 1). See DMC 25.10.120.005.

Table 1
Landmark Tree Criteria

Trunk Type	Species	
	Oregon White Oak, Pacific Yew, or Madrone (dbh, inches)	**Douglas Fir, Western Red Cedar, Western Hemlock, or Bigleaf Maple (dbh, inches)**
Single Trunk	24	30
Multi-Trunk (sum of diameters)	30	45

A landmark tree inventory was conducted by a two-person team over 6 days in October 2019 and 1 day in September 2020. The team was led by Anchor QEA Biologist and Certified Arborist Joseph Pursley (International Society of Arboriculture PN-7486A). Trees meeting the species and stem size criteria for landmark trees (Table 1) were evaluated visually to determine if they met the health and form standard defined for landmark trees in the DMC.

Trees that did not exhibit apparent evidence of insect damage, woodpecker damage, rot, dwarf-mistletoe, or other similar tree ailments were considered healthy. Well-formed trees do not have broken leaders, significant wind damage, or exhibit irregular growth, including conifers with multiple stems.

All healthy and well-formed trees meeting the size criteria were marked with high-visibility spray paint, and a numbered aluminum tag was placed on the north side of the tree stem. For multi-trunk and multi-stemmed landmark trees, only one numbered tag was used. The location of each tagged and numbered tree was recorded using a Trimble differential global positioning system. Information collected at each tagged and numbered tree included the dbh of each stem, tag number, and species.

Available maps of Oak Management Units in the city and aerial photographs were also reviewed. Aerial photographs reveal that much of the Study Area was thinned and that many of the larger trees were removed between 1990 and 2002. Oak Management Unit (OMU) No. 14 lies within the Study Area, and one Oregon white oak that meets the City's Landmark tree criteria was found within OMU-14.

3 Health of Trees Observed

Poorly formed and unhealthy trees, including trees with damaged stems, broken leaders, insect damage, woodpecker damage, evidence of rot, dwarf-mistletoe, and other tree ailments, are prevalent in the study area. Most of the trees within the Study Area that met the landmark size criteria could not be deemed landmark trees because they are unhealthy, damaged, or otherwise poorly formed.

Historical aerial photographs suggest this is a naturally recruited, fairly even-aged stand established on previously logged property. The most common causes of poor health observed were insect damage, including bark beetle, and brown cubical rot. Most of the poorly formed trees appeared to have significant wind damage, resulting in loss of significant branches and lost leaders of conifers. Crowding under the closed canopy has also resulted in many specimens that are oddly formed in response to competition for sunlight.

4 Landmark Tree Inventory Results

The Study Area inventoried for landmark trees included the complete tax parcels that will be affected by mining of the Expansion Area and the Re-Mine Area. As summarized in Tables 2A and 2B and depicted in Figure 2, 141 trees within the Study Area met the landmark tree criteria of size, species, health, and form (Appendix B).

Table 2A
Summary of Landmark Trees Within the Expansion Area Tax Parcels

Common Name	Scientific Name	Total Trees	Trees in Expansion Area	Trees in Adjacent Buffer
Bigleaf maple	*Acer macrophyllum*	2	**-**	2
Douglas fir	*Pseudotsuga menziesii*	81	**73**	8
Pacific madrone	*Arbutus menziesii*	1	**1**	-
Pacific yew	*Taxus brevifolia*	1	**1**	-
Western red cedar	*Thuja plicata*	10	**1**	9
Total non-Oak		**95**	**-**	**-**
Oregon white oak	*Quercus garryana*	13	**13**	-
Total		**108**	**89**	**19**

Table 2B
Summary of Landmark Trees Within the Re-Mine Area Tax Parcels

Common Name	Scientific Name	Total Trees	Trees in Re-Mine Area	Trees in Adjacent Buffer
Bigleaf maple	*Acer macrophyllum*	-	-	-
Douglas fir	*Pseudotsuga menziesii*	15	1	14
Pacific madrone	*Arbutus menziesii*	1	-	1
Pacific yew	*Taxus brevifolia*	2	-	2
Western red cedar	*Thuja plicata*	8	1	7
Total non-Oak		**26**	**-**	**-**
Oregon white oak	*Quercus garryana*	7	2	5
Total		**33**	**4**	**29**

5 Landmark Tree Impacts

This evaluation of landmark tree impacts focuses on the landmark trees removed from the Expansion Area parcels because tree removal within the Re-Mine Area is authorized under existing permits. Table 3 lists the total number of landmark trees within the Expansion Area tax parcels that will be retained and the number that will be removed, by species.

Table 3
Summary of Impacts to Landmark Trees within Expansion Area Parcels

	Oregon white oak (*Quercus garryana*)	**Big Leaf Maple (*Acer macrophyllum)***	**Douglas fir (*Pseudotsuga menziesii*)**	**Pacific madrone (*Arbutus menziesii*)**	**Pacific yew (*Taxus brevifolia*)**	**Western red cedar (*Thuja plicata*)**	**Total Trees**
Trees Removed (under this request)	13	0	73	1	1	1	89
Trees Retained	0	2	8	0	0	9	19
Total Landmark Trees	**13**	**2**	**81**	**1**	**1**	**10**	108

Note: No western hemlock (*Tsuga heterophylla*) that meet landmark tree criteria are present on the Expansion Area parcels.

6 Landmark Tree Replacement Plan

The Surface Mine Reclamation Act (RCW 78.44) gives the Washington Department of Natural Resource (DNR) exclusive regulatory authority over surface mine reclamation in the state and requires miners to leave property in a condition suitable for its subsequent use following the completion of mining. The reclamation requirements are intended to address landscape concerns on the scope and scale appropriate for mining operations and are consistent with the purpose or intent of the City's landmark tree ordinance.

CalPortland successfully plants trees on the slopes of the existing mine as part of their ongoing mine reclamation program and in compliance with the Surface Mine Reclamation Act (RCW 78.44). Tree planting success (survival) is one component of the reclamation plan that is reviewed, approved, and inspected for compliance by the DNR. Implementation of the reclamation plan is assured by a financial guarantee provided to the DNR by the CalPortland in the form of a bond.

This practice will continue in the South Parcel and as mining progresses in other areas of the mine consistent with an updated mine reclamation plan reviewed, approved, and inspected by the DNR and required by the Surface Mine Reclamation Act (RCW 78.44).

Soil for future tree planting begins prior to mining when the site is cleared of stumps and debris, slash is ground to chips for later use as a soil amendment, and topsoil is mixed with wood chips and clean clay and silt washed from processed gravel (belt press fines) and stockpiled for later use in reclamation.

As extraction in each mine segment is completed, slopes are cut to final contours. In the South Parcel, slopes (approximately 3 feet horizontal to 1 foot vertical) will border the eastern and southwestern portions of the mine floor and join the existing mine area to the north.

The amended topsoil is then spread across the contoured slopes and cross tracked with a dozer to prevent erosion.

After topsoil placement, holes are dug in the slopes where trees are planted. Tree planting is proposed where new reclaimed slopes planted with trees and suitable to be designated as open space will remain after mining. Once final reclamation is complete, Sequalitchew Village will have approximately 180 acres of these slopes planted with a variety of trees including Douglas fir, red alder (*Alnus rubra*), and Oregon white oak, ranging in age from seedlings to nearly 40 years old.

Tree seedlings are generally planted during the fall and spring. Douglas fir, white oak, and other species are typically planted at an approximate spacing of 10- by 10-foot, establishing a stocking level of approximately 430 trees per acre on the reclaimed slopes. These plantings are

complemented by naturally recruited red alder, bigleaf maple, and Pacific madrone occurring in the buffers adjacent to the mined slopes.

CalPortland proposes removing 89 landmark trees in the Expansion Area. A typical tree mitigation plan might require a developer to replace removed Landmark trees at a ratio of 50:1 (Table 4). At a stocking ratio of 430 trees per acre, such a plan would require CalPortland to plant trees on only 10.9 acres to achieve a 50:1 replacement ratio for 89 trees. CalPortland expects to plant approximately 180 acres total on the slopes of the mine.

A typical mitigation plan might require a developer to plant trees for mitigation in a single season and monitor their success for 3 to 5 years. CalPortland will have planted a variety of trees on the reclaimed slopes of Sequalitchew Village over a period of at least three decades and will monitor and ensure their success with a reclamation bond held by DNR during that time.

In 2020 CalPortland began testing plantings of Oregon white oak and will continue to include Oregon white oak in the mix of trees planted in the future to ensure that at least 650 (50X13) white oaks are planted.

As the reclaimed areas mature, a native understory of herbaceous and woody species will also propagate from seed and rhizomes naturally occurring in the redistributed topsoil. Reclaimed slopes along the western boundary of the site are designed in a sinuous fashion to mimic and blend with the native topography that parallels Puget Sound.

Deleterious vegetation such as blackberry and Scotch broom will be removed mechanically, to allow tree establishment and release from shading and competition for nutrients and moisture.

Table 4
Tree Replacement Summary for All Trees

Type	Quantity to Be Removed	Mitigation Ratio	Approximate Number of Trees to Be Planted[1]
Landmark Trees	89	50:1	4,450

Note:

1. The total number of trees to be planted is limited by the areas suitable for planting prior to development of Sequalitchew Village, in accordance with the City of DuPont Comprehensive Plan.

Table 5 summarizes the proposed replacement tree planting. Tree seedlings will be planted during the dormant season. Douglas fir, white oak, and other species will be planted at 10- by 10-foot spacings, establishing a stocking level of approximately 430 trees per acre on the reclaimed slopes. These plantings are expected to be complemented by naturally recruited red alder, bigleaf maple, and Pacific madrone. Based on the success of the reforested slopes in the existing mine, Douglas fir

(1+1 seedling stock) and red alder (plug 1 or yearling pull-ups) are recommended. In 2020 CalPortland began testing plantings of Oregon white oak. If initial plantings are successful, then theses species will be added to the mix of trees planted. Based on existing reclamation at the site, volunteer seedlings are expected to propagate on the topsoiled slopes, in addition to the planting described above. The mature forests that buffer the western mine boundary provide an excellent seed source of other native deciduous and conifer species including Pacific madrone, bigleaf maple, western hemlock, and western red cedar.

Table 5
Revegetation Planting Plan

Common Name	Scientific Name	On Center Spacing (feet)	Planting Season
Douglas fir	*Pseudotsuga menziesii*	10	October 15 – March 15
Oregon white oak	*Quercus garryana*	10	October 15 – March 15
Red Alder	*Alnus rubra*	10	October 15 – March 15

Figures

LEGEND:

- Pioneer Aggregates Property (791 ac)
- South Parcel MRO Addition (172 ac)
- Mining Limits (620 ac)
- Sequalitchew Creek
- Kettle Wetland

South Parcel Project

- Expansion Area (188 ac)
- Re-mine Area (125 ac)

NOTES:
Imagery: 2017 USDA NAIP

0 3,000
Feet

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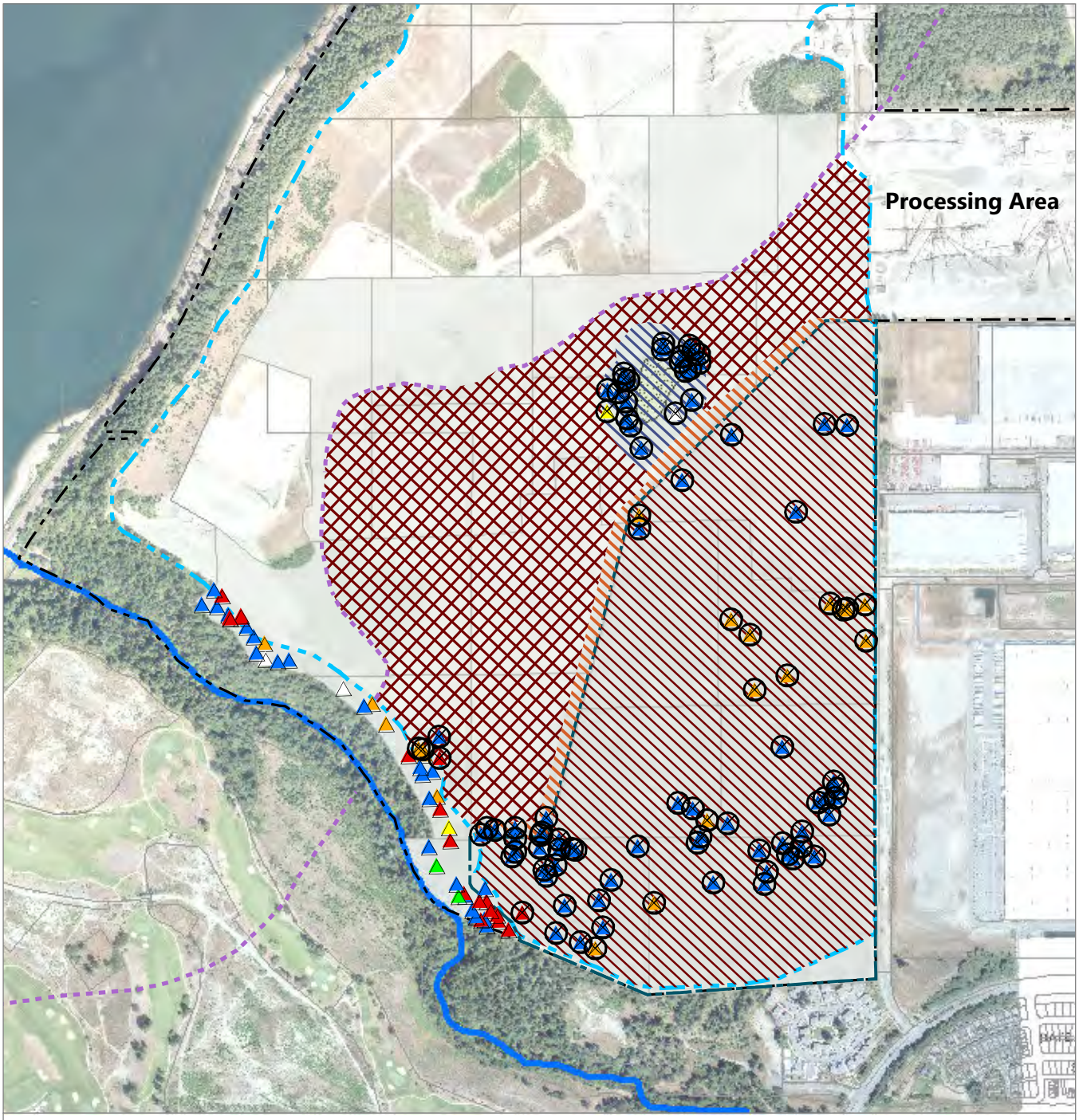
ANCHOR QEA

Figure 1
Vicinity Map
Landmark Tree Inventory Report
Pioneer Aggregates South Parcel Project



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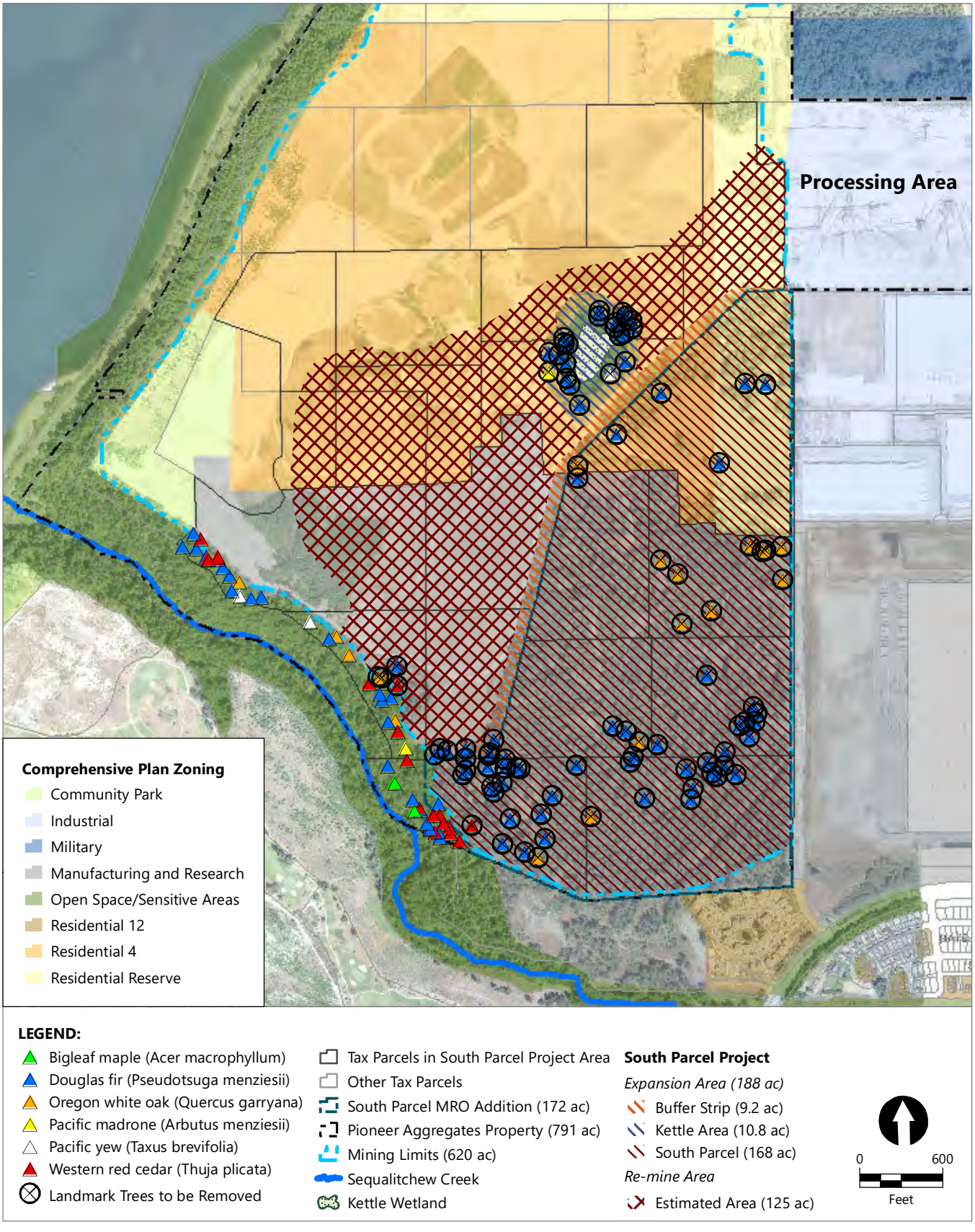
ANCHOR QEA

Figure 2
Landmark Trees Within South Parcel Project Area
Landmark Tree Inventory Report
Pioneer Aggregates South Parcel Project



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ANCHOR QEA

Figure 3
Landmark Trees and Comprehensive Plan Zoning
Landmark Tree Inventory Report
Pioneer Aggregates South Parcel Project

Appendix A
Weyerhaeuser Pathologist Report

Location • Weyerhaeuser Research
505 N Pearl St
Centralia, WA 98531

8/16/2019

Subject: Weyerhaeuser Dupont Mine Site “Landmark Trees” Recognizance

Author: John Browning (Weyerhaeuser Forest Pathologist)

Weyerhaeuser has a forested area adjacent to the Dupont CalPortland gravel mine. We are interested in removing these trees so the area can be mined for gravel. Most of the trees on this land are Douglas-fir. The city of Dupont has a “Landmark tree” statute as shown in Table 1. On 8/26/2019, Mary Castle (Weyerhaeuser Manager of Western Minerals) and myself walked this land to examine these trees and see if we thought they would qualify as “Landmark trees.”

Table 1. Dupont Landmark tree statute.

25.10.120.005 Landmark tree.

SHARE

“Landmark tree” means an existing healthy, well formed tree which poses no safety hazard due to potential collapse and that is of the following species, trunk type, and minimum diameter measured at breast height:

	Species	
Trunk type	Oregon white oak, Pacific yew, or madrona	Douglas fir, western red cedar, western hemlock, or big leaf maple
Single trunk	24 inches	30 inches
Multi-trunk (sum of diameters)	30 inches	45 inches

(Ord. 18-1045 § 2 (Exh. A))

Stand Composition:

This stand is primarily Douglas-fir mixed with some Oregon white oak. We also found a small amount of big leaf maple. The majority of the Douglas-fir is probably smaller than the 30" DBH requirement for Landmark Trees but there are still many big trees larger than 30". These are mostly open grown Douglas-fir with very large branches down to the ground. Photos 1-3 show examples of these "Woofy" Douglas-fir.

Damage and Hazards:

Mary and I thought most of the large Douglas-fir would be rejected from the Landmark Tree status due to form and possibly safety concerns. Most of these trees have major damage approximately 30 to 40 feet up the truck were the top had died or been broken out and side branches had taken over. Jim Tweedy (mine manager for Glacier NW) stated that this damage was likely due to a major ice storm back in the 50s. Many of these trees also have forked tops. In addition, quite of few of these trees also have considerable sweep at the base. Photos 4 through 12 show examples of the form issues with these Douglas-fir.

From a hazard tree standpoint there is always concern in large Douglas-fir when the top dies and laterals take over because this will develop a weak area and likely entry point for decay.

We looked for root disease and decay and found some evidence of brown cubical rot (possibly *Schweinitzii* although we did not find any fruiting bodies) decaying smaller Douglas-fir to the point that they were falling over (Photos 13 to 16). While I suspect that there is major decay is some of the larger Douglas-fir I did not find any that had fallen over. There are some with evidence of wounds near the base which could be entry points for decay (Photos 17 to 19). Weyerhaeuser Research does have a Resistograph drill which could be used to test these trees for decay without majorly damaging the trees.

There were Douglas-fir with evidence of woodpecker activity which usually indicates insect infestation (Photo 20). Photos 21 to 23 show large hole evidence of boring activity near the base of the trees. Some trees had lots of sap flow which probably indicates a bark beetle infestation (Photo 24).

Hardwoods.

Most of the hardwoods on this site were Oregon white oaks. We did not find any of these trees large enough to meet the Landmark tree definition of 24" (30" for multiple trunks). We did examine one large bigleaf maple which had lots of decay within 6' of the base (Photo 25).

Trees with good form.

We did find a few Douglas-fir large enough to be classified as "Landmark trees" with good form. Overall, we saw maybe six trees that would meet the "Landmark tree" definition as we interpreted it.

General Form Photos:

Photo 1. Open grown Douglas-fir with large branches down to the ground.

Photos 2 & 3. Open grown Douglas-fir with large branches.

Damage and hazards photos:

Photo 4. Trunk deformed 30’ up.

Photo 5. Douglas-fir with poor form

Photo 6. Douglas-fir with poor form

Photo 7. Douglas-fir with poor form

Photo 8. Douglas-fir with poor form

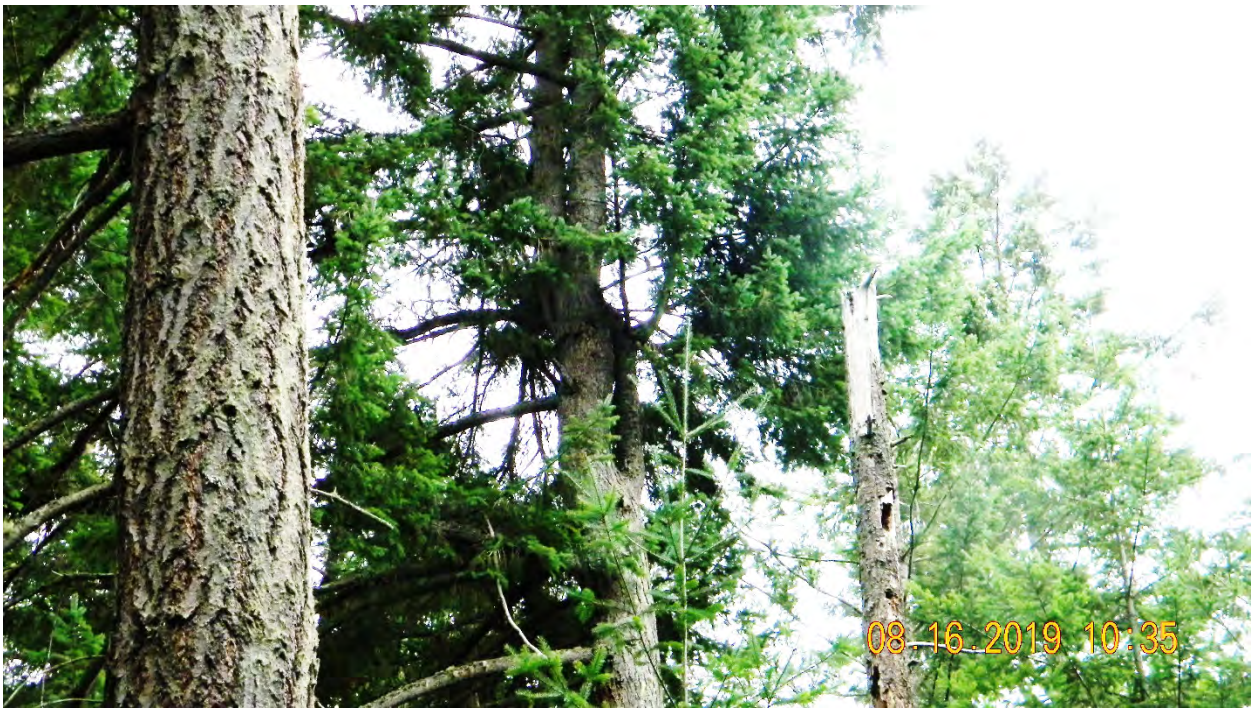

Photo 9. Douglas-fir with poor form

Photo 10. Douglas-fir with poor form

Photo 11. Douglas-fir with poor form

Photo 12. Douglas-fir with poor form

Fallen trees with decay photos:

Photos 13 and 14. Fallen tree with brown cubical rot, possibly *Schweinitzii*.

Photo 15. Fallen tree with brown cubical rot

Photo 16. Falling tree with brown cubical rot

Wound Photos:

Photo 17. Wound on Douglas-fir. Probably allowing decay to enter truck.

Photo 18. Wound on Douglas-fir. Probably allowing decay to enter truck.

Photo 19. Wound on Douglas-fir. Probably allowing decay to enter truck.

Woodpecker activity photos:

Photo 20. Woodpecker activity. Usually indicating tree infested with insects.

Photo 21. Holes near the base of the tree.

Photo 22. Holes near the base of the tree.

Photo 23. Holes near the base of the tree.

Sap flow photo:

Photo 24. Sap flow from truck. Indicating either insect attacks or fungal infections.

Hardwood with decay photo:

Photo 25. Large big leaf maple with evidence of considerable decay

Photos of large Douglas-fir with good form:

Photo 26. Large straight tree, possible “Landmark tree”

Photo 27. Large straight tree, possible “Landmark tree”

Photo 28. Possible “Landmark tree”

Appendix B
Tree Survey Data

Appendix B
Tree Survey Data

Common Name	Scientific Name	Tag Number	Number of Stems	Total dbh (inches)	Within Clearing Limits	City of Dupont Land Use
Douglas fir	*Pseudotsuga menziesii*	1104	1	43	Yes	Residential Reserve
Douglas fir	*Pseudotsuga menziesii*	1135	1	29	Yes	Residential Reserve
Douglas fir	*Pseudotsuga menziesii*	1155	1	29	Yes	Residential 4
Douglas fir	*Pseudotsuga menziesii*	1165	1	37	Yes	Residential 4
Douglas fir	*Pseudotsuga menziesii*	1176	1	29	Yes	Residential Reserve
Oregon white oak	*Quercus garryana*	1190	3	39	Yes	Residential 4
Douglas fir	*Pseudotsuga menziesii*	1192	1	34	Yes	Manufacturing and Research
Oregon white oak	*Quercus garryana*	1006	1	28	Yes	Manufacturing and Research
Oregon white oak	*Quercus garryana*	1007	1	22	Yes	Manufacturing and Research
Oregon white oak	*Quercus garryana*	1008	2	48	Yes	Manufacturing and Research
Oregon white oak	*Quercus garryana*	1014	2	30	Yes	Manufacturing and Research
Oregon white oak	*Quercus garryana*	1015	1	24	Yes	Manufacturing and Research
Oregon white oak	*Quercus garryana*	1041	3	31	Yes	Manufacturing and Research
Oregon white oak	*Quercus garryana*	1043	3	34	Yes	Manufacturing and Research
Oregon white oak	*Quercus garryana*	1052	4	48	Yes	Manufacturing and Research
Oregon white oak	*Quercus garryana*	1098	3	34	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1217	1	37	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1226	1	32	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1227	1	33	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1228	1	30	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1237	1	31	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1238	1	32	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1240	1	34	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1246	1	30	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1250	1	30	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1263	1	30	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1266	1	30	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1275	1	30	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1276	1	30	Yes	Manufacturing and Research
Oregon white oak	*Quercus garryana*	1278	3	39	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1279	1	33	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1280	1	30	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1285	1	32	Yes	Manufacturing and Research
Oregon white oak	*Quercus garryana*	1292	4	47	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1413	1	30	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1415	1	33	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1419	1	36	Yes	Manufacturing and Research

Appendix B
Tree Survey Data

Common Name	Scientific Name	Tag Number	Number of Stems	Total dbh (inches)	Within Clearing Limits	City of Dupont Land Use
Douglas fir	*Pseudotsuga menziesii*	1420	1	40	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1421	1	46	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1422	1	31	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1436	1	40	Yes	Manufacturing and Research
Oregon white oak	*Quercus garryana*	1493	1	30	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1496	1	31	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1301	1	33	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1304	1	30	Yes	Manufacturing and Research
Western red cedar	*Thuja plicata*	1309	1	41	Yes	Open Space/Sensitive Areas
Western red cedar	*Thuja plicata*	1317	1	33	No	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1323	1	31	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1329	1	32	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1341	1	38	Yes	Manufacturing and Research
Western red cedar	*Thuja plicata*	1356	1	38	No	Open Space/Sensitive Areas
Western red cedar	*Thuja plicata*	1357	1	32	No	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1359	1	30	No	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1360	1	30	No	Open Space/Sensitive Areas
Western red cedar	*Thuja plicata*	1393	1	35	No	Open Space/Sensitive Areas
Western red cedar	*Thuja plicata*	1394	1	33	No	Open Space/Sensitive Areas
Western red cedar	*Thuja plicata*	1395	1	32	No	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1501	1	30	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1502	1	31	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1503	1	36	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1505	1	30	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1506	1	34	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1511	1	30	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1512	1	31	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1513	1	31	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1515	1	31	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1516	1	30	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1521	1	30	No	Open Space/Sensitive Areas
Western red cedar	*Thuja plicata*	1529	1	40	No	Open Space/Sensitive Areas
Pacific madrone	*Arbutus menziesii*	1532	1	24	No	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1535	1	31	Yes	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1536	1	38	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1537	1	30	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1538	1	37	Yes	Manufacturing and Research

Appendix B
Tree Survey Data

Common Name	Scientific Name	Tag Number	Number of Stems	Total dbh (inches)	Within Clearing Limits	City of Dupont Land Use
Douglas fir	*Pseudotsuga menziesii*	1540	1	32	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1543	1	38	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1544	1	38	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1546	1	30	Yes	Manufacturing and Research
Douglas fir	*Pseudotsuga menziesii*	1573	1	32	Yes	Residential 4
Douglas fir	*Pseudotsuga menziesii*	1577	1	35	Yes	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1578	1	33	Yes	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1580	1	31	Yes	Open Space/Sensitive Areas
Pacific madrone	*Arbutus menziesii*	1583	1	24	Yes	Residential 4
Douglas fir	*Pseudotsuga menziesii*	1584	1	30	Yes	Residential 4
Douglas fir	*Pseudotsuga menziesii*	1585	1	33	Yes	Residential 4
Douglas fir	*Pseudotsuga menziesii*	1587	1	31	Yes	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1558	1	32	Yes	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1589	1	32	Yes	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1603	1	32	Yes	Residential 4
Douglas fir	*Pseudotsuga menziesii*	1604	1	34	Yes	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1609	1	31	Yes	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1610	1	30	Yes	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1612	1	35	Yes	Residential 4
Douglas fir	*Pseudotsuga menziesii*	1613	1	30	Yes	Residential 4
Douglas fir	*Pseudotsuga menziesii*	1615	1	33	Yes	Residential 4
Douglas fir	*Pseudotsuga menziesii*	1617	1	34	Yes	Residential 4
Douglas fir	*Pseudotsuga menziesii*	1621	1	30	Yes	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1622	1	30	Yes	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1625	1	40	Yes	Residential 4
Pacific yew	*Taxus brevifolia*	1627	1	24	Yes	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1636	1	32	Yes	Manufacturing and Research
Western red cedar	*Thuja plicata*	1639	1	42	No	Manufacturing and Research
Oregon white oak	*Quercus garryana*	1643	2	31	No	Open Space/Sensitive Areas
Western red cedar	*Thuja plicata*	1644	1	39	No	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1649	1	34	No	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1652	1	32	No	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1653	1	33	No	Open Space/Sensitive Areas
Oregon white oak	*Quercus garryana*	1654	3	57	No	Open Space/Sensitive Areas
Oregon white oak	*Quercus garryana*	1656	1	25	No	Open Space/Sensitive Areas
Oregon white oak	*Quercus garryana*	1657	1	27	No	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1659	1	32	No	Open Space/Sensitive Areas

Appendix B
Tree Survey Data

Common Name	Scientific Name	Tag Number	Number of Stems	Total dbh (inches)	Within Clearing Limits	City of Dupont Land Use
Western red cedar	*Thuja plicata*	1662	1	34	No	Open Space/Sensitive Areas
Oregon white oak	*Quercus garryana*	1667	3	34	No	Open Space/Sensitive Areas
Oregon white oak	*Quercus garryana*	1671	1	26	No	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1672	1	30	No	Open Space/Sensitive Areas
Pacific yew	*Taxus brevifolia*	1676	3	32	No	Open Space/Sensitive Areas
Western red cedar	*Thuja plicata*	1362	1	31	No	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1363	1	31	No	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1366	1	30	No	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1370	1	46	No	Open Space/Sensitive Areas
Western red cedar	*Thuja plicata*	1371	1	38	No	Open Space/Sensitive Areas
Bigleaf maple	*Acer macrophyllum*	1372	1	35	No	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1381	1	30	No	Open Space/Sensitive Areas
Bigleaf maple	*Acer macrophyllum*	1384	1	31	No	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1390	1	30	No	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1680	1	34	No	Open Space/Sensitive Areas
Oregon white oak	*Quercus garryana*	1681	1	28	No	Open Space/Sensitive Areas
Pacific yew	*Taxus brevifolia*	1683	1	24	No	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1684	1	33	No	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1685	1	33	No	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1686	1	30	No	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1694	1	34	No	Open Space/Sensitive Areas
Western red cedar	*Thuja plicata*	1695	1	45	No	Open Space/Sensitive Areas
Western red cedar	*Thuja plicata*	1696	1	42	No	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1699	1	38	No	Open Space/Sensitive Areas
Western red cedar	*Thuja plicata*	1700	1	39	No	Open Space/Sensitive Areas
Western red cedar	*Thuja plicata*	1701	1	42	No	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1705	1	32	No	Open Space/Sensitive Areas
Western red cedar	*Thuja plicata*	1707	1	43	No	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1708	1	30	No	Open Space/Sensitive Areas
Douglas fir	*Pseudotsuga menziesii*	1713	1	31	No	Open Space/Sensitive Areas

Appendix J

Floodplain Habitat Assessment and Mitigation Report

November 2020
DuPont Aggregates South Parcel Project

Floodplain Habitat Assessment and Mitigation Report

Prepared for
CalPortland
P.O. Box 1730
Seattle, Washington 98111

Prepared by
Anchor QEA, LLC
1201 3rd Avenue, Suite 2600
Seattle, Washington 98101

1 Introduction

Glacier Northwest, Inc., dba CalPortland, is seeking regulatory approvals for the Pioneer Aggregates South Parcel Project (Project), which proposes to extend sand and gravel mine operations to the southeast of existing activities at the Pioneer Aggregates Mine in DuPont, Washington. This Floodplain Habitat and Mitigation Report (Report) has been prepared per Federal Emergency Management Agency (FEMA) guidelines as defined in the FEMA guidance document *Regional Guidance for Floodplain Habitat and Assessment and Mitigation in the Puget Sound Basin* (FEMA 2013).

There is one waterbody in the Project Area, the 1.78-acre Kettle Wetland. Fish and wildlife habitat conservation areas located within the Project Area include the Kettle Wetland, the associated wetland bu

ffer, and upland vegetation communities. The following Project documents have been prepared describing the Kettle Wetland and vegetation communities and wildlife habitat conditions within the Project Area:

- *North Sequalitchew Creek Project Impact Area Wetland Delineation Report* (Anchor Environmental 2007)
- *Addendum to 2007 North Sequalitchew Creek Project Impact Area Wetland Delineation Report* (Anchor QEA 2018)
- *South Parcel Expansion Project Critical Areas Report* (Anchor QEA 2020a)

These other reports provide supporting information such as the Project description, Kettle Wetland delineation and rating, vegetation and wildlife habitat description, topography, soils, geologic conditions, Project impacts, proposed mitigation measures, and associated figures, all of which are included by reference in this Report. Per FEMA guidance, the term Project Area is used in this Report (FEMA 2013). In the *South Parcel Expansion Project Critical Areas Report and Habitat Management Plan* (Anchor QEA 2020a), the term Expansion Area is used to describe the Project Area.

2 Project Area

The proposed Project is located on privately owned property at 4301 Pioneer Avenue in the City of DuPont, Pierce County, Washington (Figure 1). The proposed Project covers portions of Sections 22, 23, 26, and 27 of Township 19 North, Range 1 East at 47.118213 N latitude / -122.661295 W longitude.

The Project will be located on the following privately owned tax parcels: 0119233011, 0119233014, 0119233015, 0119233016, 0119233017, 0119262015, 0119262016, 0119232011, 0119232012, and 0119224005. The Project is located in the Chambers-Clover Watershed, Water Resource Inventory Area (WRIA) 12 (Ecology 2020).

The Project Area is zoned as Mineral Resources overlay (City of DuPont 2015). Project Area features including parcel boundaries, the analysis area, the Kettle Wetland, topography, soils, geology, and aerial photographs displaying vegetation communities are shown in the figures in the *South Parcel Expansion Project Critical Areas Report and Habitat Management Plan* (Anchor QEA 2020a) and *North Sequalitchew Creek Project Impact Area Wetland Delineation Report* (Anchor Environmental 2007).

2.1 Fish and Wildlife Habitat

There is one waterbody in the Project Area, the Kettle Wetland. The Kettle Wetland is a 1.78-acre wetland located southwest of the existing processing plant. This wetland is classified as a Class II wetland by City of DuPont regulations and a Category III wetland using the Washington State Department of Ecology (Ecology) wetland rating system. Water levels within the wetland are determined by the seasonal fluctuation in the elevation of the Vashon aquifer, which is the dominant source of hydrology for the wetland. The Kettle Wetland is more than 1/2 mile from a water of the United States and sits in a closed depression, with no surface water connection to the larger watershed, substantially limiting the wetland's opportunity to provide hydrologic or water quality functions. The Kettle wetland is within a FEMA mapped Special Flood Hazard Area without base flood elevation (Zone A). A second FEMA mapped Special Flood Hazard Area (also Zone A) is approximately 0.3 miles southwest of the Kettle Wetland (Figure 2). This second feature is on dry, excessively drained soils (Soil Survey Staff 2020). The second feature has been previously disturbed and cleared of woody vegetation. It provides poor habitat conditions for the species described in this document. Neither of the two Flood Hazard Areas have any surface water connections, the only hydrologic connections are precipitation and in the case of the Kettle wetland, groundwater.

The original Kettle Wetland delineation was conducted in 2007 by Anchor Environmental staff. The Kettle Wetland was redelineated in December 2017 due to the length of time that transpired since the original delineation occurred. During this later delineation, the Kettle Wetland was rated under Ecology's *Washington State Wetland Rating System – Western Washington: 2014 Update* (Hruby 2014)

and the 2018 DuPont Municipal Code Sensitive Areas Regulations (City of DuPont 2018). On April 17, 2019, the U.S. Army Corps of Engineers issued a determination that the Kettle Wetland is not a water of the United States (USACE 2018).

A complete description of the Kettle Wetland and associated wetland buffer vegetation, soil, and hydrologic characteristics, wetland functions, wetland delineation data forms, and the Ecology and City of DuPont wetland rating forms are included in the *North Sequalitchew Creek Project Impact Area Wetland Delineation Report* (Anchor Environmental 2007) and *Addendum to 2007 North Sequalitchew Creek Project Impact Area Wetland Delineation Report* (Anchor QEA 2018).

The Kettle Wetland is identified on Washington Department of Fish and Wildlife (WDFW) Priority Habitats and Species (PHS) Maps (WDFW 2020a) and U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) Map Information (USFWS 2020a). The southwest portion of the Project Area is also mapped by WDFW PHS as a biodiversity area. The WDFW PHS identifies the Project Area as containing big brown bat (*Eptesicus fuscus*), little brown bat (*Myotis lucifugus*), and Yuma myotis bat *Myotis yumanensis*), which may breed in the area. No state or federally listed species are documented by WDFW within the Project Area (WDFW 2020a). Federally listed species are discussed in Section 2.1.1.

These reference maps should be included as figures.

2.1.1 Endangered Species Act-Listed Species and Critical Habitats

Endangered Species Act (ESA)-listed species and critical habitats under National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) jurisdiction in western Washington are referenced on the agencies' websites. The NMFS identifies ESA-listed species that occur or may occur within a broad geographic area, such as an evolutionarily significant unit (ESU) or a distinct population segment (DPS), rather than a project-specific location (NMFS 2020). The USFWS identifies ESA-listed species that occur or may occur within a specific location where a project is proposed (USFWS 2020b).

included the NMFS and USFWS species lists as appendices.

The October 2020 status and potential presence of federally listed species and critical habitats protected under the ESA that may occur within the Project Area are presented in Table 1. As shown in Table 1, 11 ESA-listed species are identified by NMFS and USFWS as having the potential to occur within the Project Area. Of these species, three are aquatic (fish); five are terrestrial (one amphibian, three birds, and one mammal), and three are plants. Designated critical habitat for several of these species is present within Pierce County; however, no designated critical habitat is present within the Project Area.

Table 1
Occurrence of Listed Species and Critical Habitat in or Near the Project Area

Common Name	Scientific Name	ESA Status	Jurisdiction	Species Present in Project Area	Critical Habitat Present in Project Area
Fish					
Puget Sound ESU Chinook Salmon	*Oncorhynchus tshawytscha*	Threatened	NMFS	No	No
Puget Sound DPS Steelhead	*Oncorhynchus mykiss*	Threatened	NMFS	No	No
Coastal-Puget Sound DPS Bull Trout	*Salvelinus confluentus*	Threatened	USFWS	No	No
Amphibians					
Oregon Spotted Frog	*Rana pretiosa*	Threatened	USFWS	No	No
Birds					
Marbled Murrelet	*Brachyramphus marmoratus*	Threatened	USFWS	No	No
Streaked Horned Lark	*Eremophila alpestris strigata*	Threatened	USFWS	No	No
Yellow-billed Cuckoo	*Coccyzus americanus*	Threatened	USFWS	No	No
Mammals					
Gray Wolf	*Canis lupus*	Proposed Endangered	USFWS	No	No
Plants					
Golden Paintbrush	*Castilleja levisecta*	Threatened	USFWS	No	No
Marsh Sandwort	*Arenaria paludicola*	Endangered	USFWS	No	No
Water Howellia	*Howellia aquatallis*	Threatened	USFWS	No	No

There are no federally listed species, designated critical habitats, or essential fish habitats in the Project Area. The ESA-listed or proposed terrestrial and plant species identified by the USFWS as potentially occurring in the Project Area do not occur in the vicinity of the Project Area based on the species' life history and habitat requirements. The Kettle Wetland does not provide wetland habitat features associated with Oregon spotted frog. Potential habitat for the four ESA-listed bird and mammal species identified in Table 1 (gray wolf, marbled murrelet, streaked horned lark, and yellow-billed cuckoo) is not located within many miles of the Project Area due to urban development. Additionally, these species are not typically associated with areas of human activity except in rare,

What about listed salmonid fish in the Sequalitchew Cr. system and marine shoreline, whose habitat may be affected by the Project and related restoration plan?

usually temporary, circumstances. Habitat features associated with the three plant species (golden paintbrush, marsh sandwort, and water howellia) are not present within the Project Area or vicinity.

3 Project Description, Environmental Effects, and Mitigation Measures

3.1 Project Description

The Project description is presented in the *South Parcel Expansion Project Critical Areas Report and Habitat Management Plan* (Anchor QEA 2020a).

3.2 Environmental Effects and Mitigation Measures

The following subsections provide a summary of environmental effects under the proposed Project. A complete description of potential Project impacts and Project mitigation measures is presented in the *South Parcel Expansion Project Critical Areas Report* (Anchor QEA 2020a).

3.2.1 Wetlands

Under the proposed Project, permanent impacts to the Kettle Wetland and its buffer would occur as a result of earthwork mining activities: the entire wetland would be excavated. The area of wetland disturbance is 1.78 acres, and the total buffer area of disturbance is 3.4 acres. All functions and values of the wetland will be mitigated for by constructing a larger wetland as described in the *South Parcel Expansion Project Wetland Mitigation Plan* (Anchor QEA 2020b).

3.2.2 ESA-Listed Species and Critical Habitats

Overall, the Project will not result in measurable potential impacts on ESA-listed species or critical habitats. There is no designated critical habitat located within the Project Area. Potentially suitable habitat for ESA-listed species identified by NMFS and USFWS as having the potential to occur within or near the Project Area is not present within the Project Area. Based on the proposed Project elements, if an ESA biological evaluation was performed for this Project, the effect determination for ESA-listed species and associated critical habitats would likely be no effect.

See comments on page 4.

4 Figures

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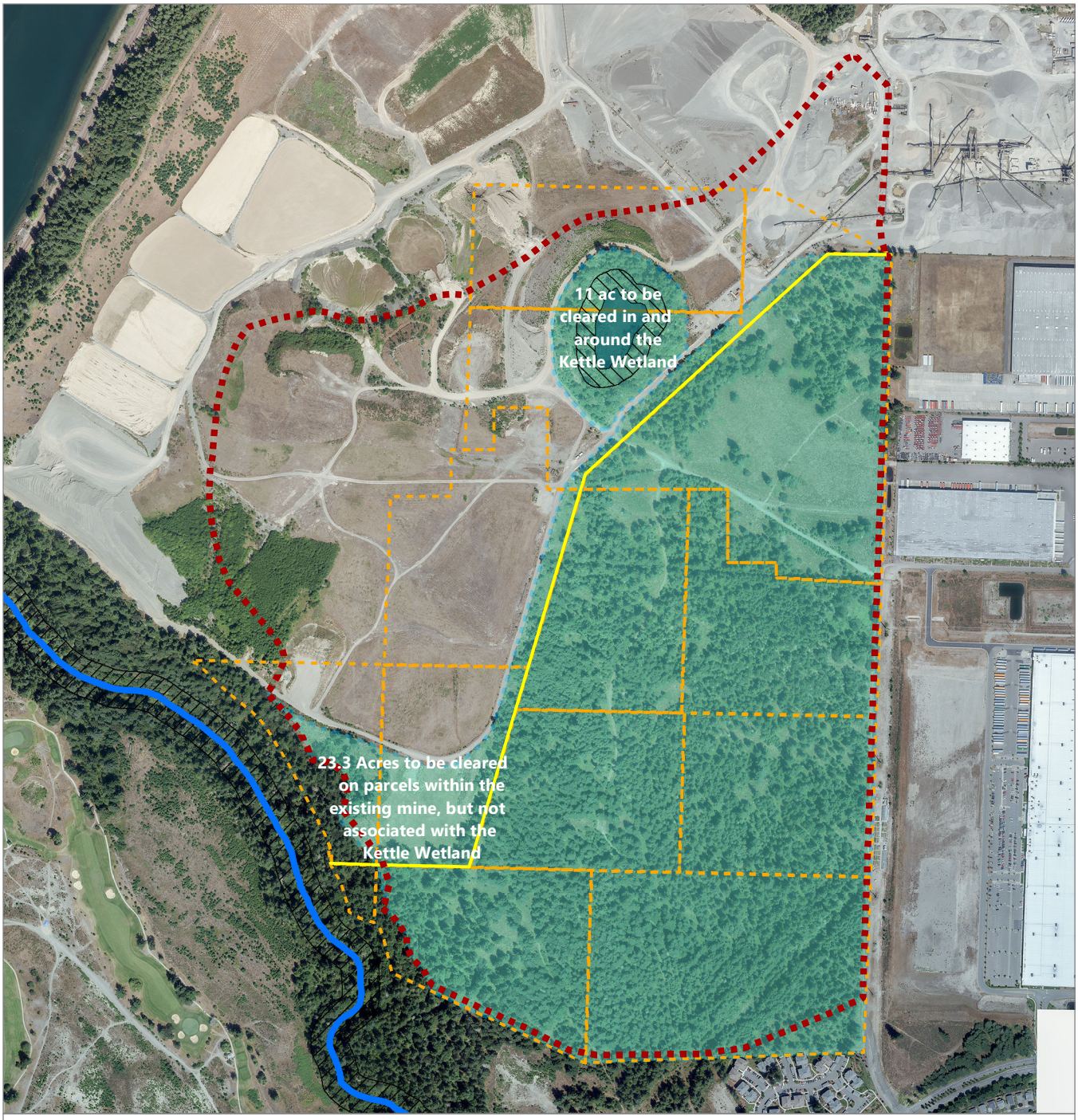

LEGEND:

- South Parcel Project
- Clearing Limits for Mine Expansion (201.6 ac)
- Boundary of Existing Mine
- Area Inside Existing Mine (100.7 ac)
- Kettle Wetland
- 100-ft Wetland Buffer
- Sequalitchew Creek
- 100-ft Stream Buffer

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Feet

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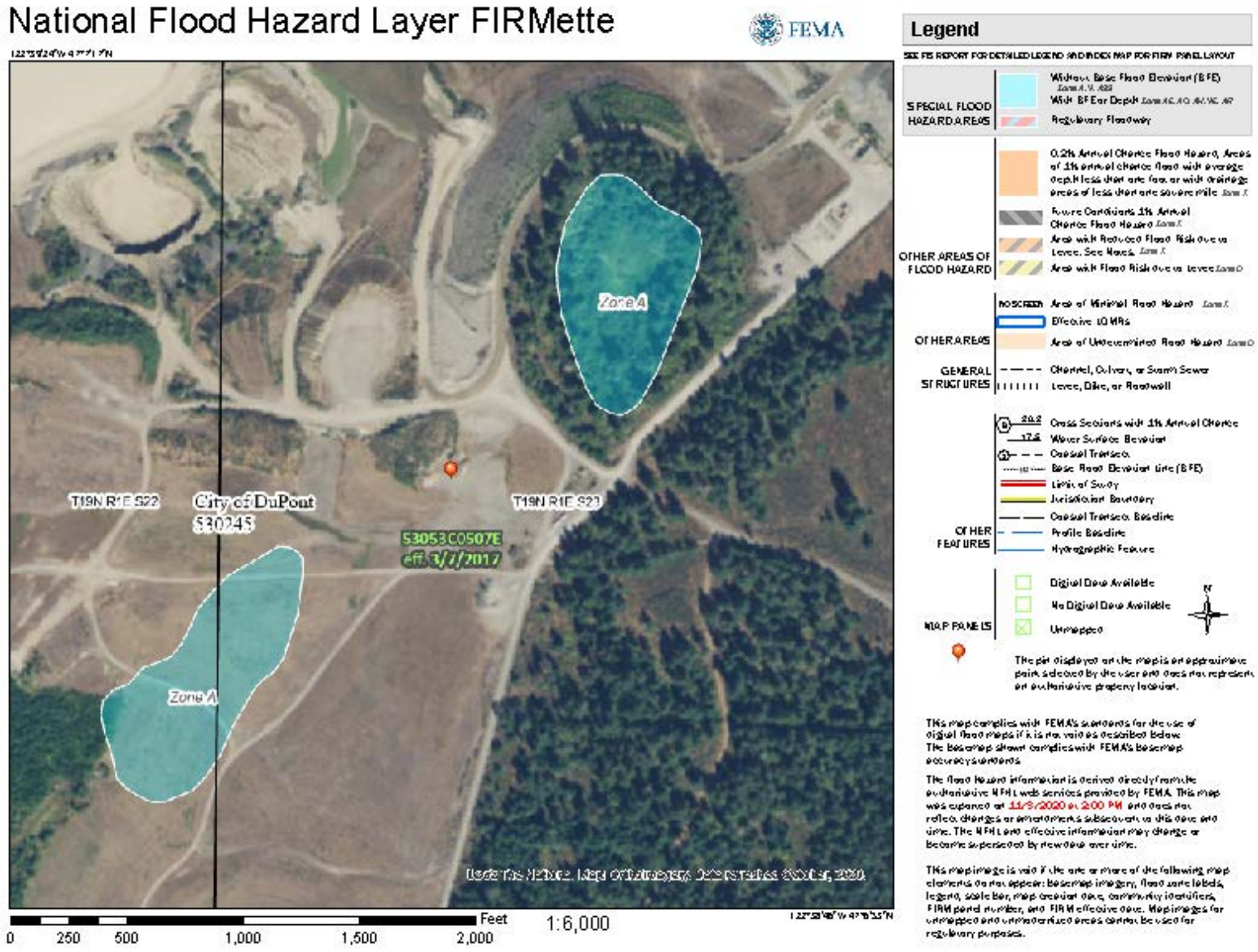
ANCHOR QEA

Figure #1
Project Area
FEMA Habitat Assessment
Pioneer Aggregates South Parcel Project



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ANCHOR QEA

Figure 2

Mapped Flood Hazards Within the Expansion Area

FEMA Habitat Assessment

Pioneer Aggregates South Parcel Project

Appendix K
Noise Study

Prepared for:

CalPortland

Prepared by:

Ramboll US Consulting

Lynnwood, Washington

Date

September 27, 2022

PIONEER AGGREGATES SOUTH PARCEL EXPANSION PROJECT

NOISE STUDY

RAMBOLL Bright ideas. Sustainable change.

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1. INTRODUCTION

The Pioneer Aggregates South Parcel Project ("South Parcel Project") includes horizontal expansion of mining into approximately 188 acres previously undisturbed by mining and vertical expansion of approximately 125 acres where mining will deepen a portion of the existing mine. The South Parcel Project would extend mining at the current rate for approximately 14 additional years.

Mining under the South Parcel Project will proceed slowly from the north to the south over a period of five to eight years. The method of mining will be identical to that currently used in the permitted mine area. A dozer would push excavated material from the top of the mine face to two front-end loaders working on the mine floor. The front-end loaders would scoop-up the sand and gravel and dump it into portable hoppers that feed conveyors leading to the processing area.

A conveyor will start at the north end of the Expansion Area and will be extended south as mining progresses. The conveyor is comprised of a 48-inch-wide rubberized belt that is supported by a series of rollers, called idlers, mounted on steel framed segments that support the conveyor about five feet off the ground.

A 20-foot-high noise berm will be constructed along the southern boundary of the South Parcel behind retained vegetation and will help reduce potential noise associated with mining for adjacent land uses. The berm will be constructed prior to clearing in the adjacent portionof the South Parcel.

This analysis considers potential noise impacts to residences and other sensitive receivers nearest the expansion area. The following report reviews noise terminology, regulatory criteria applicable to the project, and the methods and findings of the analysis

2. NOISE LEVEL TERMINOLOGY AND HUMAN HEARING

Noise is sometimes defined as unwanted sound; the terms noise and sound are used more or less synonymously in this report. The human ear responds to a very wide range of sound intensities. The decibel scale (dB) used to describe sound is a logarithmic rating system which accounts for the large differences in audible sound intensities. This scale accounts for the human perception of a doubling of loudness as an increase of 10 dB. Therefore, a 70-dB sound level will sound about twice as loud as a 60-dB sound level. People generally cannot detect differences of 1 dB; in ideal laboratory stuations, differences of 2 or 3 dB can be detected by people, but such a change probably would not be detectable in an average outdoor environment. A 5-dB change would probably be perceived under normal listening conditions.

When addressing the effects of noise on people, it is useful to consider the frequency response of the human ear. Sound-measuring instruments are therefore often programmed to weight measured sounds based on the way people hear. The frequency-weighting most often used is A-weighting because it approximates the frequency response of human hearing and is highly correlated to the effects of noise on people. Measurements from instruments using this system are reported in "A-weighted decibels" or dBA. All sound levels in this evaluation are reported in A-weighted decibels.

Distance from the source, the frequency of the sound, the absorbency of the intervening ground, obstructions, and duration of the noise-producing event all affect the transmission and perception of noise. The degree of this effect also depends on who is listening and on existing sound levels.

3. AFFECTED ENVIRONMENT

3.1 Regulatory Overview

The project site is located within the City of DuPont in Pierce County. Section 9.09.040 of the DuPont Municipal Code (DMC 9.09.040) specifies noise limits based on the limits set in the Washington Administrative Code (WAC 173-60). DMC 9.09.040 establishes limits on sounds crossing property boundaries based on the Environmental Designation for Noise Abatement (EDNA) of the sound source and the receiving properties. Section 9.09.040(b) of the DuPont City Code identifies Class A EDNAs as residential areas, Class B EDNAs as commercial areas, and Class C EDNAs as industrial areas. The allowable noise level limits are displayed in **Table 1**.

Table 1. DuPont Maximum Permissible Sound Levels (dBA)

EDNA of Source Property	EDNA of Receiving Property		
	Class A Day/Night [a]	Class B	Class C
Class A	55/45	57	60
Class B	57/47	60	65
Class C	60/50	65	70

[a] The limits for noise received in Class A EDNAs are reduced by 10 dBA during nighttime hours (10 PM to 7 AM).
Source: DMC 9.09.040.

The city noise rule allows the limits presented in **Table 1** to be exceeded for certain periods of time: 5 dBA for no more than 15 minutes in any hour, 10 dBA for no more than 5 minutes of any hour, or 15 dBA for no more than 1.5 minutes of any hour. These allowed increases can be described in terms of the percentage of time a certain level is exceeded, using statistical noise descriptors (L_{n}s). For example, L_{25} represents a sound level that is exceeded 25 percent of the time, or 15 minutes in an hour. Similarly, $L_{8.33}$ and $L_{2.5}$ are the sound levels that are exceeded 8.33 and 2.5 percent of the time, or 5 and 1.5 minutes in an hour, respectively. At no time can the allowable sound level be exceeded by more than 15 dBA, represented by the L_{max}.

DMC Section 9.09.040(c) identifies a map that specifically designates the EDNA's for various properties within the City (Appendix A of Ordinance 208). The EDNA boundaries shown in this map identify a small Class A (Residential) EDNA on both sides of Barksdale Avenue in the historic village of DuPont, a small Class B (Commercial) EDNA between the historic village and I-5, and the remainder of the DuPont area as a Class C (Industrial) EDNA. DuPont Ordinance 208 and the associated map in Appendix A were adopted in 1978; they are no longer representative of current zoning and comprehensive land use plan designations. Furthermore, the 1978 map of EDNA designations does not adequately represent the basic uses identified in 9.09.040(b) that define EDNAs. It is, therefore, unclear whether the EDNA designations shown in the 1978 map or the EDNA identifications based on land uses in 9.09.040(b) should apply.

For this noise analysis, land use zones (as identified in Dupont's Zoning Map) were used to determine the appropriate noise limits for the various receiving properties. This approach is consistent with the more modern language and identification of EDNA designations based on actual uses and represents a more accurate reflection of current and expected future conditions. But applying either method for

identifying the appropriate EDNAs, the South Parcel would be considered a Class C EDNA, and the applicable Ln noise limits for a Class C EDNA noise source affecting different types of receiving properties are displayed in **Table 2**.

Table 2. Applicable Ln Noise Limits for Class C EDNA Noise Sources

EDNA of Source Property	Ln Limits			
	L_{25}	$L_{8.3}$	$L_{2.5}$	L_{max}
Class A [a]	60/50	65/55	70/60	75/65
Class B	65	70	75	80
Class C	70	75	80	85

[a] The limits for noise received in Class A EDNAs are reduced by 10 dBA during nighttime hours (10 PM to 7 AM) and are shown for Day/Night.
Source: DMC 9.09.040 (d)

Because noise generated by South Parcel mining would typically be fairly consistent over an hourly period, the allowances for short-term increases in the noise level limits would rarely apply. Therefore, the most stringent/conservative noise limit for the proposed mining (a Class C source) would be an L_{25} of 70 dBA at nearby Class C EDNAs, an L_{25} of 65 dBA at nearby Class B EDNAs, or an L_{25} of 60 dBA between 7 AM and 10 PM and 50 dBA between 10 PM and 7 AM at nearby Class A EDNAs.

DMC 9.09.050 exempts the following sources from the above noise limits:

- Temporary construction noise, except when received in Class A EDNA properties between the hours of 10 PM and 7 AM;
- Sounds created by motor vehicles when regulated by the state noise limit (Chapter 173-62 WAC), adopted by reference in DMC 9.09.040; and
- Sounds created by motor vehicles, licensed or unlicensed, when operated off public highways, except when such sounds are received in Class A EDNAs.

3.2 Existing Sound Levels

Ramboll measured sound levels from October 31 – November 1, 2019 to characterize the existing sound levels in the project vicinity as part of a noise study for an earlier proposal to mine the south parcel. For the measurements, Ramboll used Larson Davis LxT Class 1 sound level meters and measured hourly sound levels for a minimum of 24-hours. The meters were field-calibrated prior to the measurements and had been factory certified within the previous 12 months. The microphones were placed on tripods about 5 feet above the ground.

The sound level measurements were taken at two locations, shown in **Figure 1**. SLM1 was chosen to represent the nearest residences south of the mine on the north side of the Creekside Apartment complex. SLM2 represents the residential community across Center Drive from the South Parcel. At both measurement locations, noise from the existing Pioneer Aggregates facility was not audible and did not substantively contribute to the measured levels. A summary of the sound level measurement results is displayed in **Table 3,** and detailed information regarding the measured levels is included in Attachment A.

Table 3. Range of Existing Measured Hourly Sound Levels (dBA)

Location	Time [a]	L_{eq} [b]	L_{max}	L_2	L_8	L_{25}	L_{90}	L_{dn} [b]
SLM1	Day	39-48	52-72	43-56	42-49	37-47	33-45	47
	Early Morning	42-44	56-58	46-47	45-46	43-45	40-43	
	Night	35-44	48-58	39-47	37-46	35-45	33-43	
SLM2	Day	49-54	61-83	55-61	53-57	50-56	41-51	56
	Early Morning	52-55	69-700	57-59	56-58	53-56	45-49	
	Night	42-55	57-70	48-59	45-58	41-56	38-49	

[a] Daytime hours are defined as between 7 AM and 10 PM, early morning hours are between 5 and 7 AM, and nighttime hours are between 10 PM and 7 AM.

[b] The Leq is an energy-average sound level defined over a specified period of time, often one hour. It is useful for representing the energy of a fluctuating sound with a single number. The Ldn is a similar to a 24-hour Leq, except the Ldn includes an additional 10 dBA added to sound levels in each hour between 10 PM and 7 AM to account for increased sensitivity to noise at night.

SLM1 – Located behind the Creekside Apartment complex. Noise sources included JBLM and civilian aircraft, including helicopters. The noise environment at the apartment complex was relatively quiet during deployment and retrieval of the meters.

SLM2 – Located at the Edmond Village Park to represent the residential setbacks from Center Drive. The primary noise source was traffic along Center Drive. Sporadic noise sources included aircraft noise, both military and civilian.

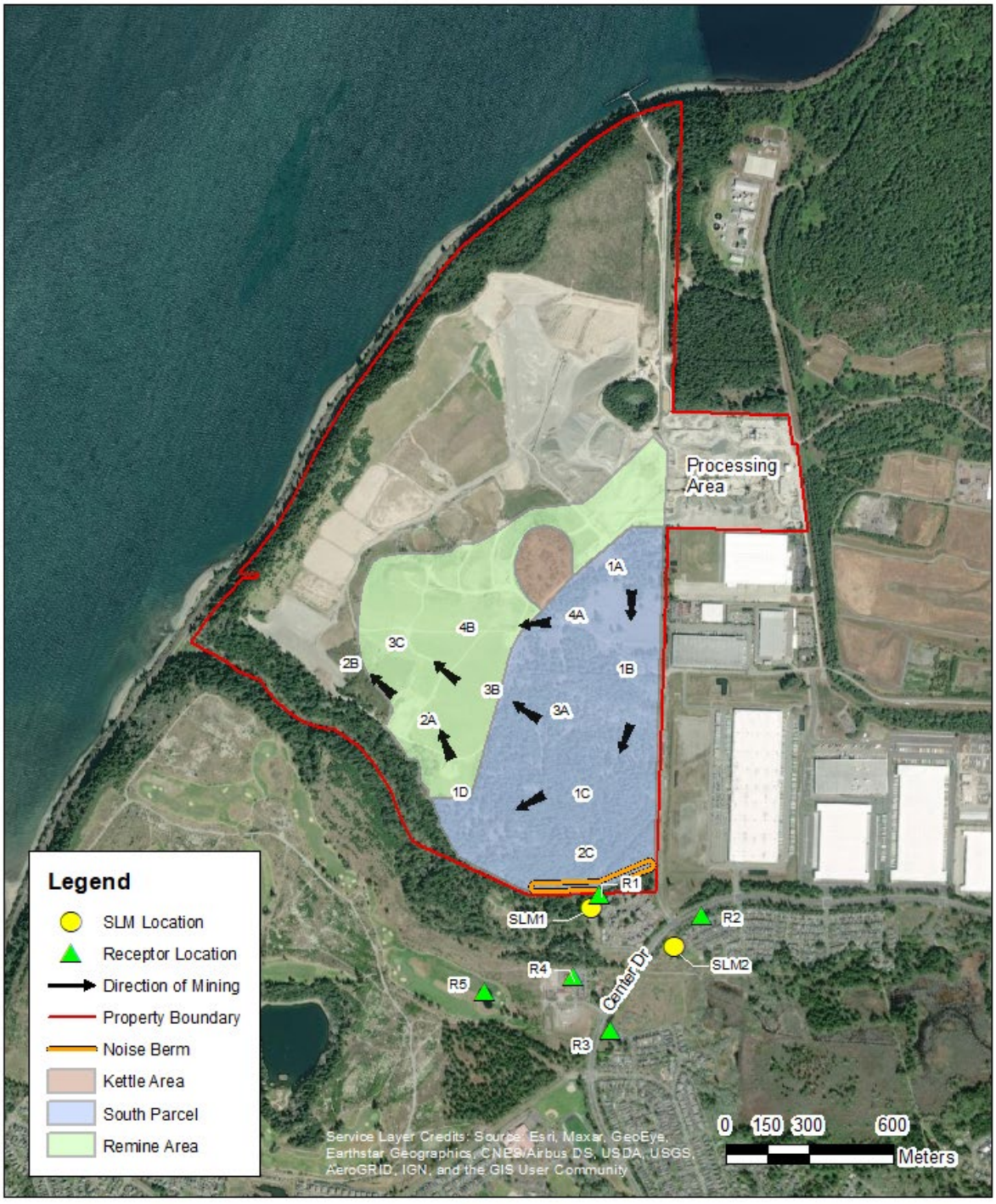

Figure 1. Sound Level Measurement and Model Receptor Locations

4. OPERATIONAL NOISE IMPACTS

The South Parcel Project will not substantially alter the majority of existing mining-related operations at the facility. The method of mining will be identical to that currently used in the permitted mine area. A dozer would push excavated material from the top of the mine face to two front-end loaders working on the mine floor. The front-end loaders would scoop-up the sand and gravel and dump it into portable hoppers that feed conveyors leading to the processing area. The material processing plants and barge-loading facilities would not change.

4.1 Noise Sources

Equipment required for mining the South Parcel includes two front-end loaders, a bulldozer, and conveyors and a electric conveyor drive motor. This equipment would work in tandem; the bulldozer would push material down the mining face to the loaders, which would load the material onto a conveyor going to the existing processing plant. The bulldozer and loaders would be the dominant noise sources at the nearest sensitive receivers to the South Parcel.

Noise from the excavation equipment was considered in noise modeling to estimate future noise associated with the facility. Noise from most equipment was characterized using measurements of equipment operating at the existing Pioneer Aggregates facility. The measurement of the electric conveyor drive motor was measured at a different facility and is from Ramboll's source sound level archives. The sound levels of the representative equipment are shown in **Table 4**.

Table 4. Mining Equipment Noise Levels (L_{25}/L_{eq}, dBA)

Equipment	Sound Level at 100 feet
Bulldozer	76
Front-End Loader	75
Electric conveyor drive motor	60
Conveyor	56
Source: Ramboll US Consulting	

Because the noise from a sand and gravel operation is typically fairly constant over the course of an hour, the noise standard that would be most limiting would be the hourly L_{25} limit. In order to more closely relate the calculated sound levels with the applicable noise limits, Ramboll used the measured L_{25} of each source when this information was available. However, not all of the equipment sound level information was available as an L_{25}. Because the noise generated by mining tends to be fairly continuous over the course of an hour, the sound levels of these operations described by the L_{eq} and L_{25} tend to be very similar. Therefore, in instances where L_{25} data were not available, Ramboll used the L_{eq} to represent an L_{25}.

4.2 Noise Model

Ramboll used the CadnaA noise model to estimate sound levels expected to be generated by the proposed mining expansion equipment. CadnaA is a computer program that calculates sound levels after considering the noise reductions or enhancements caused by distance, topography, ground surfaces, atmospheric absorption, and meteorological conditions in compliance with ISO 9613-2. The

modeling process included the following steps: (1) characterizing the noise sources based on frequency-specific measurements of representative equipment; (2) creating three-dimensional maps of the site and vicinity to enable the model to evaluate effects of distance and topography on noise attenuation, (3) assigning the equipment sound levels to the appropriate locations on the site, and (4) placing model "receptors" at several model receptor locations to represent places where the noise will be received.

4.3 Modeling Assumptions

The following assumptions were used in our assessment:

- The South Parcel will be mined in phases, beginning in the northeast section of the parcel and proceeding south and then west and northwest;
- The noise model evaluated mining activities in Phases 1B, 2C, and 3B to consider the range of sound levels that might occur from the South Parcel activities;
- For Phase 1B, much of the existing topography was assumed to be intact, providing some amount of intervening topography between the excavation equipment and the receivers to the south;
- For Phases 2C and 3B, most of the South Parcel was assumed to have been mined;
- For each phase considered, the noise model included one bulldozer pushing material down the mine slope, two front-end loader sat the toe of the slope loading material into a hopper, and a conveyor transporting material from the active mining area to the processing plant area;
- All equipment was assumed to operate concurrently and continuously;
- The South Parcel Expansion will not require increased capacity of the processing plants; and
- The site plan and noise model include a 20-foot high berm, constructed prior to mining of Phase 2C, located in the southeast corner of the site between the Creekside Apartments and the South Parcel. The berm will include trees and landscaping.

4.4 Noise Modeling Results

4.4.1 Compliance Assessment

As part of the noise assessment, Ramboll first compared the model-calculated sound levels with the applicable City noise limits to assess potential compliance with the limits. Sound levels from proposed excavation activities were modeled at six receptor locations representing three residential areas, a civic center, and a golf course nearest the South Parcel. The receptor locations are shown in **Figure 1**. The predicted future sound levels and detailed descriptions of each receptor location are provided in **Table 5**. Noise from the existing Pioneer Aggregates operations does not substantively contribute to the sound levels at the receptor locations considered in this assessment, and the predicted sound levels provided in **Table 5** can be considered representative of the entire operation with mining in the South Parcel.

As can be seen by the values in **Table 5,** sound levels from the proposed mine would easily comply with the applicable noise limits during daytime hours (i.e., 7 AM to 10 PM) at all locations. However, sound levels at the upper floors of the Creekside Apartments facing the site may exceed the noise limits if full mining activity occurs in Phase 2C during early morning hours (i.e., between 5 and 7 AM).

Because the dominant noise source at the Creekside Apartments during Phase 2C excavation is the bulldozer, Ramboll considered the noise benefits of restricting bulldozer use in this phase to daytime hours only. Prohibition of bulldozer use during the early morning hours results in modeled sound levels below the nighttime noise limits applied between 5 and 7 AM at all receptor locations.

Table 5. Model-Calculated Sound Levels (L_{eq}/L_{25}, dBA)

Model Receptor Location	Modeled Sound Level				Noise Limit [a]
	Phase 1B	Phase 2C	Phase 2C (No Bulldozer)	Phase 3B	
R1a	42	55	48	43	60/50
R1b	41	46	42	40	60/50
R2	40	45	43	37	60/50
R3	36	40	37	36	60/50
R4	37	39	36	38	65
R5	36	38	37	39	65

Receptor Locations:

R1a – Upper floor of the Creekside Apartments nearest the South Parcel

R1b – Ground floor of the Creekside Apartments nearest the South Parcel

R2 – Residences in Edmond Village

R3 – Residences in Palisade Village

R4 – Dupont Civic Center

R5 – The Home Course Golf Course

(a) The noise limits shown for residential locations are for daytime/nighttime hours, where daytime hours are from 7 AM to 10 PM and nighttime hours are from 10 PM to 7 AM.

Source: Ramboll US Corporation

4.4.2 Increases over Existing Sound Levels

In addition to evaluating the potential compliance of on-site sources associated with South Parcel activities, Ramboll considered potential noise impacts caused by project-related increases over existing baseline sound levels. This assessment was restricted to residential receptor locations potentially affected by project-related increases over existing levels.

For the project sound levels during daytime hours, we used the worst-case modeled levels expected during all phases of excavation. For the project sound levels during early morning hours, we used the worst-case modeled sound levels during all phases of excavation assuming *no bulldozer* in Phase 2C. Because mining activities in Phase 2C may exceed the nighttime noise limit of 50 dBA at the upper floors of the Creekside Apartments with all equipment in operation, use of the bulldozer in Phase 2C will be restricted to daytime hours only. The resulting increases over existing levels are displayed in **Table 6**.

Table 6. Calculated Increases Over Existing Sound Levels (Leq, dBA)

Model Receptor Location	Time of Day [a]	Measured Existing Levels	Level with South Parcel Expansion		
			Project Only [b]	Cumulative [c]	Increase [d]
R1a	Day	39-48	55	55-56	8-16
	Night	42-44	48	49-50	5-7
R1b	Day	39-48	46	46-50	2-8
	Night	42-44	42	45-46	2-3
R2	Day	49-54	45	51-55	0-1
	Night	52-55	43	52-55	0
R3	Day	49-54	40	50-55	0
	Night	52-55	37	52-55	0

Notes:

(a) Daytime hours are from 7 AM to 10 PM. Nighttime hours for the purpose of this evaluation are from 5 to 7 AM, when early morning excavation may occur.

(b) The daytime project levels shown are the highest modeled sound levels from all phases of South Parcel activities considered in this assessment. The nighttime levels shown are the highest levels from all modeled phases except 2C.

(c) Cumulative levels represent the existing measured sound levels + the modeled project-related sound levels.

(d) Apparent discrepancies in any calculated increases are artifacts of rounding the displayed sound levels to the nearest whole number.

Source: Ramboll US Corporation

As can be seen in **Table 4**, the sound levels when a bulldozer is working very near the project boundaries in Phase 2C are substantially higher than the baseline sound levels at the upper floors of the Creekside Apartments (R1a), resulting in potential increases of 8 to 16 dBA. If these sound levels were experienced throughout the life of the project, they would represent a substantial increase. However, the modeled levels at the Creekside Apartments are dominated by noise from a bulldozer working on the slope of 2C very near the southern project boundary. This worst-case condition would only occur during Phase 2C excavation. Even during Phase 2C excavation, the bulldozer would split its time between excavation in Phase 2C and excavation in the existing mining areas farther north and west, and sound levels much of the time would be substantially lower than the worst-case levels identified here. The variation in sound levels over the life of the mine and the variation in day-to-day bulldozer activities would reduce the potential noise impacts at the Creekside Apartments due to increases over baseline levels.

At the more distant residential locations (R2 and R3), increases over background sound levels are 1 dBA or less during even the worst-case Phase 2C activities. Such increases would not be discernable in an active outdoor environment and would result in no impact.

5. CONSTRUCTION

The material processing infrastructure that would be used to support South Parcel mining already exists. Construction directly related to the South Parcel would be limited to logging, preparation of new mining phases/segments for excavation, expansion of the on-site conveyor system to connect the

expanded mining area to the existing processing facility, and the construction of the berm on the south side of Phase 2C for noise attenuation.

Much of the construction activity would entail heavy equipment similar to, or the same as, the equipment required during excavation. Therefore, the sound levels of construction are expected to be similar to the modeled operational sound levels identified above. The exception would be sound levels associated with construction of the berm on the south side of Phase 2C. During construction of the berm, sound levels at nearby receivers may be noticeable and, at times, intrusive. This could result in temporary and short-term noise impacts at nearby properties. Construction activity is exempt from Dupont's noise regulations during daytime hours (7 AM to 10 PM).

6. MITIGATION

6.1 Operation

The plans for the site include construction of a 20-foot high berm on the south side of Phase 2C to reduce noise at off-site locations, especially at the Creekside Apartments. With such a berm, modeled sound levels of worst-case mining activities are well below the applicable daytime noise limits at all receptor locations.

Excavation in Phase 2C during early morning hours (i.e., between 5 and 7 AM) may exceed the stricter nighttime limit of 50 dBA applicable at the Creekside Apartments. The sound levels from Phase 2C activities affecting the Creekside Apartments is dominated by a bulldozer working at the top of the slope. Restriction of the bulldozer to daytime hours only within Phase 2C reduces the modeled sound levels at the Creekside Apartments to 48 dBA or less, which would comply with Dupont's nighttime noise limit.

6.2 Construction

Construction activities (i.e., logging and construction of the southern berm) would be conducted during daytime hours only (7 AM to 10 PM) to minimize noise impacts.

7. SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

With construction of the proposed berm as noted above and with restriction of hours of bulldozer operation in Phase 2C to daytime hours only, the project is expected to fully comply with the Dupont noise limits. Furthermore, potential noise impacts at the Creekside Apartments (R1) can be mitigated by the proposed mitigation measures, although short-term unavoidable noise impacts may be expected. Due to the short-term nature of the impacts at R1, any such impacts would not be characterized as significant.

APPENDIX A
SOUND LEVEL MEASUREMENT DETAIL

SLM1: Located behind the Creekside Apartment Complex October 31- November 1, 2019								
Date	**Time**	**Leq**	**Lmax**	**Lmin**	**L2**	**L8**	**L25**	**L90**
31-Oct	12:00:00	47.4	72.0	33.1	55.5	47.2	42.0	34.7
31-Oct	13:00:00	38.7	58.6	32.1	44.9	42.7	38.8	33.3
31-Oct	14:00:00	40.3	61.4	32.3	48.9	43.3	37.4	33.6
31-Oct	15:00:00	41.3	60.2	32.2	50.9	43.7	38.6	33.7
31-Oct	16:00:00	41.8	61.1	33.1	50.1	45.3	39.7	35.1
31-Oct	17:00:00	41.0	55.6	35.0	45.6	43.5	41.8	37.4
31-Oct	18:00:00	42.2	61.2	38.3	46.0	43.8	42.4	40.3
31-Oct	19:00:00	40.8	52.3	36.9	43.2	42.3	41.3	38.8
31-Oct	20:00:00	41.1	54.0	37.6	43.3	42.4	41.5	39.6
31-Oct	21:00:00	44.2	69.3	37.0	52.6	43.0	41.4	38.8
31-Oct	22:00:00	38.1	51.5	33.6	41.3	39.8	38.5	35.9
31-Oct	23:00:00	37.7	49.7	33.6	41.9	39.7	38.0	35.3
1-Nov	0:00:00	37.2	49.9	33.2	41.9	39.5	37.6	34.5
1-Nov	1:00:00	36.1	48.2	33.1	39.7	38.5	36.3	34.3
1-Nov	2:00:00	35.2	49.1	32.1	38.9	37.3	35.4	33.3
1-Nov	3:00:00	36.8	48.5	33.3	40.3	39.1	37.3	34.6
1-Nov	4:00:00	39.1	55.3	34.3	41.9	40.7	39.6	37.2
1-Nov	5:00:00	42.4	57.9	37.5	45.8	44.5	43.2	39.7
1-Nov	6:00:00	44.3	55.5	40.8	47.0	45.9	44.9	42.5
1-Nov	7:00:00	44.8	53.5	41.0	47.4	46.5	45.4	43.1
1-Nov	8:00:00	46.8	61.7	42.9	50.3	48.7	47.0	44.7
1-Nov	9:00:00	45.3	63.5	38.6	48.8	47.0	46.1	40.9
1-Nov	10:00:00	42.5	64.9	36.4	50.0	45.6	41.1	38.1
1-Nov	11:00:00	47.9	71.8	36.2	50.2	44.1	40.4	37.6
Ldn = 47.0								

SLM2: Located at the Edmond Village Park October 31- November 1, 2019								
Date	**Time**	**Leq**	**Lmax**	**Lmin**	**L2**	**L8**	**L25**	**L90**
31-Oct	12:00:00	53.5	68.4	38.4	59.6	56.9	53.9	46.2
31-Oct	13:00:00	49.9	63.4	35.0	56.5	54.3	50.4	41.3
31-Oct	14:00:00	49.8	67.1	35.2	55.7	53.5	50.6	41.3
31-Oct	15:00:00	50.7	67.3	34.3	56.6	53.9	51.4	42.4
31-Oct	16:00:00	52.3	68.0	35.9	56.8	55.3	53.4	46.7
31-Oct	17:00:00	52.5	61.3	40.0	57.2	55.8	53.6	46.5
31-Oct	18:00:00	53.3	72.2	41.2	57.5	56.3	54.7	46.5
31-Oct	19:00:00	50.2	65.3	40.5	55.8	54.1	51.3	43.4
31-Oct	20:00:00	50.8	65.5	40.6	56.3	54.6	52.1	43.3
31-Oct	21:00:00	54.1	83.5	41.5	57.5	54.9	51.5	43.5
31-Oct	22:00:00	46.9	62.2	38.4	53.5	51.1	47.2	40.6
31-Oct	23:00:00	46.2	61.2	38.1	53.1	50.6	45.5	40.5
1-Nov	0:00:00	45.1	60.3	36.5	52.6	49.0	44.2	39.8
1-Nov	1:00:00	42.8	60.0	37.1	48.4	44.5	42.6	39.8
1-Nov	2:00:00	42.1	63.8	35.1	49.7	44.7	40.6	37.6
1-Nov	3:00:00	42.9	56.6	37.4	50.3	46.8	41.7	39.0
1-Nov	4:00:00	45.4	57.9	39.5	52.2	49.7	44.5	41.3
1-Nov	5:00:00	51.7	69.2	41.2	57.4	55.6	52.8	44.7
1-Nov	6:00:00	54.6	69.7	43.8	59.4	57.9	55.7	49.2
1-Nov	7:00:00	54.5	68.9	46.6	58.7	57.3	55.6	49.6
1-Nov	8:00:00	54.5	69.2	47.5	58.3	56.9	55.3	50.7
1-Nov	9:00:00	51.9	63.4	43.1	55.7	54.5	53.0	47.7
1-Nov	10:00:00	49.4	74.2	40.7	54.8	52.8	50.3	43.3
1-Nov	11:00:00	53.8	76.0	40.3	60.5	55.7	51.8	44.4
Ldn = 55.8								

Appendix L

Visual Impact Analysis

CALPORTLAND DUPONT SOUTH PARCEL MINING AREA EXPANSION VISUAL IMPACT ANALYSIS

Project Description

CalPortland, a building materials company producing cement and construction material products, is applying to expand sand and gravel mining operations at their existing Pioneer Aggregates Mine site in the City of DuPont, Washington. The proposed project, referred to as the South Parcel Project, includes horizontal expansion of mining into approximately 188 acres previously undisturbed by mining (Expansion Area), and vertical expansion of approximately 125 acres where re-mining will deepen a portion of the existing Pioneer Aggregates Mine (Re-mining Area). See Attachment A for a more detailed project description.

The South Parcel Project site is located southeast of the existing Pioneer Aggregates Mine in the City of DuPont (known as "the City"). The site is within the City's designated Mineral Resource Overlay and is bordered to the north and west by the existing Pioneer Aggregates Mine, to the east by industrial/ distribution facilities, and to the south by Sequalitchew Creek and the Creekside Village residential development. See Attachment A, Figure 1 for a map of the project area.

This project is anticipated to extend the time allowance for mining at the current rate by approximately 14 years, subject to market conditions.

Affected Environment

The area affected by the proposed expansion includes a mixture of open grassland and mature, open prairie forest dominated primarily by Douglas fir. This forest cover varies in density throughout the site, typical for a south Puget Sound prairie landscape, but is comparatively dense on the eastern edge of the site, along Powerline Road and Center Drive. This forested evergreen buffer provides a measure of visual opaqueness to the site, such that passersby currently cannot view the existing mining operations.

Methodology

The visual impact methodology is intended to document the nature of the existing landscape, and to identify impacts to visual resources that would result from alteration of the landscape from mining and reclamation. This assessment relied on the preparation of computer-based visual simulations of the landscape that would result from mining of the expansion area. These simulations are a generally accepted means to evaluate the nature of proposed visual change. The landscape at the proposed mine site is uniform and lacking in defining features.

A number of key viewpoints were identified from a variety of locations around the site, in consultation with City of DuPont staff and their EIS consultant. The selected viewpoints are intended to be representative of viewpoints where public views toward the site are available, and to illustrate the significant visual impacts to the public from the Proposed Action (see discussion of Key Viewpoint Selection below). At each of these locations, existing conditions were photographed with a SonyA6300 camera at an equivalent focal length of 35mm and 50mm. These photographs were later used as a basis of comparison against simulated conditions at the same viewpoints.

Digital engineered survey drawings of both the existing landscape and the proposed final grading plans following mining and reclamation were provided by the applicant as AutoCAD Civil3D files. These digital grading plans were imported into Trimble SketchUp Pro software to create digital elevation models of the corresponding terrain. This terrain model was then imported to Lumion Pro software, where the site model was further developed with realistic textures and built features such as fencing, paving and utility poles being added in their proposed positions. Accurately detailed plant models were added to represent vegetative screening at various stages of growth — from new plantings up to mature growth. Within the environment of the site model, views were created to match the key viewpoint photographs.

The viewpoint perspectives were accurately generated by computer, which serves to limit human error and minimize artistic license in the simulation process. These perspective views began as 'wire-frame' views of the ground surface and were then imported to light and material rendering software Lumion Pro. The simulated viewpoints were accurately positioned using geolocation data noted onsite during the initial photography. For each of those locations, the view settings were adjusted to match the original camera setting for focal length in order to achieve the same field of view. The view was then aligned using reference objects between the simulated view and an overlay of the original photograph. Lighting conditions were also set within the model to match those of the respective existing conditions photograph. Ultimately, the rendered views of the proposed South Parcel Project conditions were compared with the original photographs to show the unaltered context around the simulated proposed conditions. Conclusions regarding relative degree of change or impact were then made on the basis of the final photo-realistic simulations.

Visual impact assessment is based on a combination of identifying potential for public view, evaluating existing visual quality, identifying viewer sensitivities, and evaluating degree of visual change resulting from a proposed project. For this analysis, levels of visual quality and viewer sensitivity are estimated based on criteria that establish ratings of "high," "medium," and "low." Visual change is qualitatively evaluated based on the visual simulations. By qualitatively combining rankings of visual quality, visual sensitivity, and the direct visual change identified in the simulations, an overall determination can then be made regarding the potential impact on a given viewpoint by the project. For example, mining-related actions at a

particular viewpoint may show a high level of impact in the simulations, but when combined with a low visual quality and sensitivity ranking, would be considered to have little overall impact to visual quality in that area.

Visual quality was evaluated using the following criteria:

- **Low**: Landscape is common to the region and exhibits few, if any, memorable features, or patterns that provide visual diversity. A prevalence of encroaching human elements or landscape modifications exists, which do not compatibly blend with the natural surroundings. Human alterations exhibit low maintenance, design quality, or siting sensitivity.

- **Medium or Moderate**: Landscape exhibits generally attractive natural and man-made features/patterns, although they are not visually distinctive or unusual within the region. The landscape integrity of the area provides some positive visual experiences such as natural open space with some existing disturbance or well-maintained development.

- **High**: Landscape exhibits distinctive and memorable visual features and patterns that are largely intact and undisturbed – usually a rural or open space setting. Development or visual disturbances, if present, are well planned to integrate with natural landscape materials or character.

Viewer sensitivity is dependent on viewer types and exposure to a proposed activity, number of viewers, availability of views to the proposed activity, view orientation and duration, and viewer expectation. Levels of viewer sensitivity were evaluated by the following criteria:

- **Low**: Viewer types represent viewers of low visual sensitivity including agricultural and industrial workers who are involved in their work and not focused on the landscape. Viewer numbers and view duration are low. Viewers have low expectations of experiencing high quality views and are not typically in search of a quality visual experience. Views are often screened or limited.

- **Medium or Moderate**: Viewer types represent viewers of medium visual sensitivity including recreationists and passing motorists. Viewer numbers and view duration are moderate in scope. Viewers have only a moderate expectation of experiencing high quality views and may or may not be engaged with the passing visual experience.

- **High**: Viewer types represent viewers of high visual sensitivity including tourists and homeowners. Viewer numbers and view duration are high, with views oriented towards a specific landscape or vista. Viewers have every expectation of experiencing high quality views and are often in search of a quality visual experience. Views are often wide and sweeping, or from a superior vantage point.

Key Viewpoint Selection

Due to existing topography and vegetation, there are very few locations outside the existing or proposed mining areas from which these operations are now visible or would be visible in the future. Natural topographic relief in the area is minimal, outside the Sequalitchew Creek Canyon, which is a relatively deep incision in the surrounding plateau. Although views into the site from outside the existing or proposed mining areas are minimal, proposed mining operations would remove some of the existing vegetation on

the project area, which would affect some off-site views. Therefore, a number of locations were considered as potential locations where simulations would be appropriate.

Key Viewpoints (KVPs) were selected to illustrate the greatest or "worst case" visual impact to the public from the Proposed Action. Analysts reviewed previous environmental analysis of the CalPortland Mining site including the Glacier Northwest DuPont Mining Area Expansion and North Sequalitchew Creek Project Draft and Final Supplemental EIS (City of Dupont, 2006 and 2007, respectively), CalPortland DuPont North Parcel Mining Final EIS, (City of Dupont 2013), and City of DuPont land use designations (City of Dupont, 2021). Analysts also made a site visit to familiarize themselves with the landscape context of mining operations during viewpoint selection and took photographs of the site from various locations near the site (ESA, 2022).

A viewshed analysis using Google Earth (2022) demonstrated that there are no surrounding areas of higher ground that afford views of the site (ESA, 2022). Aerial photos show that current mining operations have maintained vegetated buffers along the west and south sides of the mine. As a result, there are no views into the site from Puget Sound or the Sequalitchew Creek canyon. Views into the South Parcel Project site from the north are only available from the existing mine.

This preliminary information was presented to the City of Dupont, and viewpoints were selected in consultation with City of DuPont staff (EA Engineering 2022).

There are no public viewpoints of the project site to the west, due to presence of the vegetated bluff at the west perimeter of the mine along Puget Sound. No public viewpoints are available from the northwest; the only views are from the mining access road and the abandoned Fort Lewis landfill. Therefore, the viewpoints chosen for simulations are limited to locations to the south and east of the proposed mine.

Visual simulations were developed from the four KVPs around the proposed mine site where a view to the proposed mining activity is available (KVPs 1, 2, 3 and 4), as identified in **Figure 1-1**. A summary description and selection criteria for these four KVPs is provided in **Table 1-1**. These viewpoints were chosen to provide representative depictions of the future landscape that would best illustrate proposed project changes from a variety of viewpoints. To the degree possible, "sensitive" viewpoints were selected from locations accessible to the public; these were believed to potentially impact the greatest number of people.

The four other viewpoints (KVPs 5, 6, 7 and 8) were considered but simulations were not considered necessary because the project site is blocked from view by vegetation and/or topography and would remain so during and after mining at the project site. This included a view at the west end of Sequalitchew Drive (KVP 5); a public road that is expected to be eventually extended but currently serves as an access point to a public trailhead; a typical view looking northwest towards the project site along Sequalitchew Trail (KVP 6); and a view from a semi-public viewpoint – The Home Course golf course south of Sequalitchew Creek (KVP 7). For these viewpoints, photos are included showing the approximate location of the project site beyond the vegetation and topography that obstructs views of the site.

The information in the 'Selection Rationale' column in **Table 1-1** represents the result of both site visits and consultation with City of DuPont Staff. This information, along with additional knowledge gained from subsequent site visits and analysis, was used as input for the preparation of the visual simulations. All

simulations prepared for this analysis are included in Attachment B in full page layout, in addition to the images in this report.

Figure 1-1 South Parcel Project Key View Points

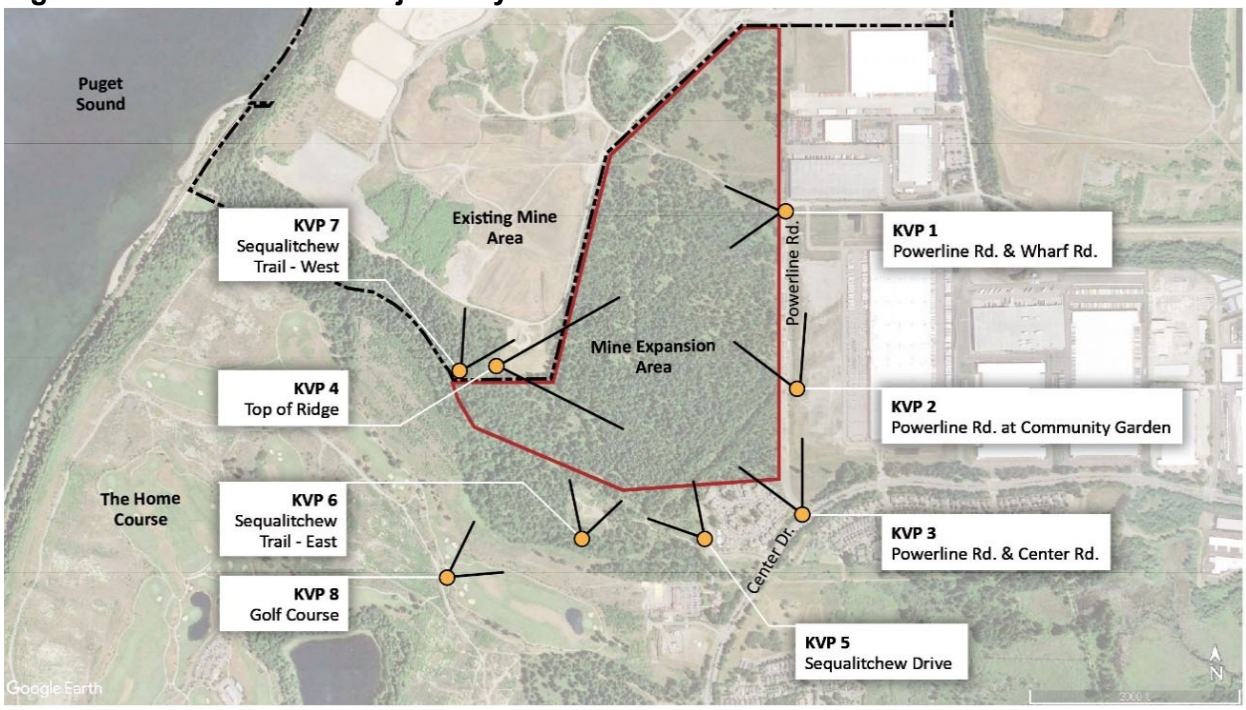

Table 1-1. Summary Description of Simulation Key Viewpoints (KVPs)

Key Viewpoint Description	Location and Viewers	Selection Rationale
1: Powerline Rd. at Wharf Rd. This viewpoint lies along Powerline Road at the point where there is a 90-degree bend in the road. The camera angle is looking in a westerly direction, down into the basin of the new creek bed.	Private Road: Vehicle passengers	Wharf Road is used primarily by trucks turning around for the adjacent warehouses, but Wharf Road is open to the public. Pedestrians and cyclists using Powerline Road can access this intersection. Views of vegetation along this road would be heavily affected.
2. Powerline Rd. at Community Garden. This viewpoint lies on the east side of Powerline Road near the south entrance to the community Garden. The camera angle is looking in a northwesterly direction.	Private Road: Garden users, cyclists, pedestrians.	Community garden users can drive to the community garden on Powerline Road. Pedestrians and cyclists also use Powerline Road.
3: Powerline Rd./Center Dr. This viewpoint lies on the northwest side of the intersection of Powerline Road and Center Drive. The camera angle is looking in a northwesterly direction.	Public: Vehicle passengers, DuPont residents	This represents a key public viewpoint. The public traveling along Center Drive can look into the site along the proposed access road and have a glimpse of the site alteration that is taking place. The view would be affected by removal of existing vegetation as part of mining operations...
4: Top of Ridge This viewpoint sits on top of the ridge between the active mining site and Sequalitchew Creek, at the southwest edge of the Expansion Area. The camera angle is looking in east northeast direction, giving an overview of the mine site after mining and restoration are complete.	Private: CalPortland employees	This viewpoint models a view that is located on the privately-owned site and is not available to the public. There currently is no public road or trail providing access to this spot. An observer must climb from the existing mine road up a small brush-covered knoll to reach it. Although not public, the viewpoint offers an extensive view of the project from above, which is intended to help the reader understand the character of the project landscape after reclamation.
Key Viewpoints considered but not simulated		
5: Sequalitchew Drive. This viewpoint lies at the current west end of this road, where public trail users frequently park. The camera angle is looking in a northwesterly direction.	Public: Trail users	This viewpoint shows where the project site stands in relation to this popular public trailhead along Sequalitchew Creek. Vegetation and topography block views of the project site.
6: Sequalitchew Trail - East This viewpoint lies on the public trail leading down to the Sound. The camera angle is looking in a northerly direction.	Public: Trail users	This viewpoint shows where the project site stands in relation to this popular public trail along Sequalitchew Creek. Vegetation and topography along Sequalitchew Creek block views of the project site.
7: Sequalitchew Trail - West This viewpoint lies on the public trail leading down to the Sound. The camera angle is looking in a northwesterly direction.	Public: Trail users	This viewpoint shows the lower portion of Sequalitchew Creek Trail at approximately the closest point on the trail to the project site. Because the site is directly uphill from this location, the view is not facing the site but shows the slope along the trail's north side. Vegetation and topography along Sequalitchew Creek block views of the project site and would not be affected.
8: The Home Course (Golf Course). This viewpoint lies near the edge of the golf course, near the edge of the Sequalitchew Creek ravine. The camera angle is looking in a northerly direction, toward Sequalitchew Creek and the project site.	Semi-Private: Golfers/Recreationists	This viewpoint shows where the project site stands in relation to the golf course. Vegetation within the golf course and along Sequalitchew Creek block views of the project site.

Simulations of the Proposed Action

Visual simulation of the project required depiction of vegetation removal and changes in topography, as well as revegetation of the landscape at a future point in time. The photos used for the 2006 Draft SEIS and 2013 EIS (City of Dupont 2006, 2013 respectively) capture a wider perspective than what the average human eye typically sees from a fixed position. In the versions presented here, due to the perspective of the KVPs, this approach would have minimized the effect on the views, therefore the images have a narrower perspective, more like what a human eye would focus on. To account for growth rates of woody vegetation, such as found in western Washington, growth rates from the Washington State University Extension program were used. An annual growth rate of 13-24 inches was applied to coniferous plant material in the simulations — with each plant model having a randomized size within the range of growth for the time of depiction. These growth rates generally reflect similar ongoing restoration area efforts within the existing mine. The growth rates are not guarantees of future plant growth, but act as an accepted method for modeling potential growth.

For the purposes of this analysis, simulations were prepared at three future points in time, referred to as Year X, Year X+ and Year Y. Where the proposed mining is not visible behind trees or another obstruction, the mine/portion of mine will be shown with hatching, brackets, or another method (See KVP 5, KVP 6, KVP 7 and KVP 8).

For KVP 1, 2 and 3, Year X simulates the view when the visual impact of the project would be the greatest. This is expected to occur in approximately two years from the beginning of mining). Tree planting along Powerline Road to provide a visual screen of mining activities at this location is in progress as of (late 2022) and completion of planting depends on seasonal factors. The fence would be moved to the eastern site boundary either when the trees are planted or at some time before the site is cleared to begin the mining operation. Vegetation on the site would be removed from the eastern perimeter except in buffer areas shown on the plans, in order to ready the site for mining to begin. An access road, temporary powerlines and newly planted trees would be installed to the west of the fence. In Year X, the trees are expected to reach heights between three and five feet. In Year X, trees would be removed from all areas to be mined. While there may be shrubby vegetation that remains in areas that will not be immediately mined, both the timing and the degree of clearing needed to remove the trees is difficult to predict. Therefore, for the simulations all areas to be mined are assumed to be either unvegetated or to have a native groundcover seeding.

At KVP 2, an additional simulation, Year X+ simulates the view approximately five years after the trees along Powerline Road have been planted, establishing a dense conifer screening that is expected to reach heights between eight and twelve feet by Year X+. A simulation was prepared for this future point in time for KVP 2, the most public-facing viewpoint at the eastern perimeter along Powerline Road near the Dupont Community Garden.

For all KVPs, Year Y is chosen to depict conditions ten years after the end of mining, when revegetation of the site is well established. Mining of the South Parcel is assumed to take approximately 14 years. Therefore, Year Y would be approximately 24 years after project inception. By that time, it is assumed that

the temporary powerlines along the east perimeter would have been removed and woody vegetation such as trees and shrubs would have been established on the slopes.

Year X and Year Y simulations were prepared for KVP 1, 2, and 3. KVP 4 is from a location where the public would not be permitted to be present, so a simulation was only prepared for the Year Y condition. Most of the interior mined areas are shown as reclaimed after mining with a native groundcover seeding. These areas are intended to eventually be developed for urban uses in the future, following completion of mining operations, and the reclamation area would likely change in the context of site-specific development.

Existing Conditions at Viewpoints

The following discussion describes existing conditions at the identified viewpoints.

KVP 1: Powerline Road at Wharf Road

The photo below was taken from the centerline of Powerline Road, immediately south of the right-angle bend, looking directly westward into the future mining expansion area. The gravel road on the right-hand side of the photo is an active service road for the existing mining operations. These operations are currently screened by existing mature vegetation that is typical of south Puget Sound prairie forests. The dense forest seen on the left side of the photo is typical of the dense buffer of Douglas fir that is found along the west side of Powerline Road from KVP 1 south to Center Drive.

The visual quality is judged to be moderate. No extended views are present. Existing vegetation is a mixture of disturbed and undisturbed vegetation. Some visual clutter is present, such as fences and gates.

Viewers are expected to be of a low sensitivity, including the occasional local motorist, bicyclist, or pedestrian. The landscape is common to the region and a prevalence of encroaching human elements or landscape modifications exist, which do not compatibly blend with the natural surroundings.

KVP 1 EXISTING

KVP 2: Powerline Road at Community Garden

This photo was taken from Powerline Road at the existing Dupont Community Garden between Wharf Road and Center Drive, looking northwest towards the proposed project.

The visual quality is judged to be moderate. No extended views are present. Existing vegetation is a mixture of disturbed and undisturbed vegetation. Some visual clutter is present, such as fences, gates, and signage. The east side of Powerline Road is dominated by large transmission line poles and overhead wires.

Viewers are expected to be of a low to moderate sensitivity and be more numerous than KVP 1. Viewers include the community garden users, and the occasional local motorist, bicyclist, or pedestrian, and City staff accessing a plant nursery. The landscape is common to the region and a prevalence of encroaching human elements or landscape modifications exist, which do not compatibly blend with the natural surroundings.

KVP 2 EXISTING

KVP 3 Powerline Road and Center Drive

This photo was taken from the berm on the east side of Center Drive (facing directly toward the proposed mining expansion site), approximately 15 feet back from the east-bound travel lane, directly in line with the centerline of Powerline Road as it intersects Center Drive. The character of the landscaped median of Center Drive contrasts strongly with the more haphazard nature of the distant landscape of firs and Scotch broom west of Center Drive. The existing power transmission towers following Powerline Road are clearly visible in the middle-ground of the photo. The dense forest of mature Douglas fir in the background is typical of the forest buffer along the eastern border of the proposed sand and gravel extraction site. It is a continuation of the forest seen in the left-hand side of the photo seen previously in KVP 2 Existing. This forest continues with similar density for approximately 1,800 feet to the west, directly away from the photo viewpoint. The density of the forest in the far-left hand side of the photo continues west along the existing Sequalitchew Creek all the way to Puget Sound, over 1.25 miles to the west.

The visual quality is judged to be moderate. The view is a mixture of mature second-growth forest in the background contrasting with a developed arterial collector road in the foreground, the Creekside Village Apartments on the left side of the view, and a high-tension power transmission line in the middle-ground.

Viewers are expected to be of medium sensitivity, including workers or residents of DuPont, as well as visiting recreationists driving along Center Drive.

KVP 3 EXISTING

KVP 4 Top of Ridge

This photo below illustrates the existing view from KVP 4. This photo was taken from a high point on the ridge between the Sequalitchew Creek canyon and the existing mine area. The viewpoint is on an existing mine site, in an isolated, inaccessible location, requiring a hike through unmarked forest. Although members of the public would not typically see it, the viewpoint was selected as one of the simulation viewpoints because it gives an unobstructed view of the South Parcel Project mining area. The grassy field in the foreground consists of reclaimed area from the existing mining operations that was re-contoured and hydroseeded. The forest in the background is the western edge of the forest first observed in KVP 2 Existing (in that photo, the viewer sees the eastern edge of this forested area).

Visual quality is classified as medium, with sweeping open views of the landscape and mature forests in the background. The middle ground view is dominated by the newly reclaimed mine area, showing evidence of recent vegetation growth.

Viewer sensitivity was not classified, as this view is on private property and will not be accessible once mining excavation begins. As noted, this view was simulated to help the reader understand the scope and extent of the mining operation, even though it is not from a place where the public would see the South Parcel Project.

KVP 4 EXISTING

KVP 5 Sequalitchew Drive

This photo illustrates the existing view from the current west end of Sequalitchew Drive. The camera angle is looking in a northwesterly direction towards the proposed project. Sequalitchew public trail users frequently park near this location. The photo shows the gravel trail entrance with residential structures in the background. The existing vegetation is comprised of evergreen native conifers and invasive scotch broom, which has overtaken the understory and open areas along the trail. The foreground includes a wooden fence, an “authorized vehicles only” sign and concrete slab with three wooden bollards painted white at the top to indicate the entrance to Sequalichew public trail.

KVP 5 EXISTING

KVP 6 Sequalitchew Trail- East

The photo below was taken from the center of the existing historic railroad bed to the southwest of the South Parcel Project. The photo shows the density of existing vegetation in the creek canyon, which obscures any clear view of the steep canyon walls. Viewers would be expected to be of high sensitivity, principally hikers, and other recreationists using the proposed trail system based on the existing old narrow gauge railway path. Visual quality is judged to be high, with an attractive view of a mature second-growth forest surrounding the viewer.

KVP 6 EXISTING

KVP 7 Sequalitchew Trail- West

The photo below shows the lower portion of Sequalitchew Creek Trail at approximately the closest point on the trail to the project site. The site is directly uphill from this location, so the view is not facing the site but shows the slope along the trail's north side on the right-hand side of the photo. Existing vegetation and topography along Sequalitchew Creek currently block views of the project site. Viewers are expected to be of high sensitivity, principally hikers and other recreationists. Visual quality is judged to be high, with an unbroken view of the forest and Sequalitchew Creek Trail.

KVP 7 EXISTING

KVP 8 The Home Course (Golf Course)

The photo below was taken from the top of a high knoll at the north side of the Home Course, a privately owned golf course immediately south of Sequalitchew Creek. This knoll is the highest point of land along the north side of the golf course. The tree line observed in the photo marks the top of the slope leading into the canyon. Viewers are expected to be of high sensitivity, principally users of the future golf course. Visual quality is judged to be high, with an unbroken view of an attractive mature second growth forest viewed across an open grassy meadow.

KVP 8 EXISTING

Impacts of the Proposed Action

Proposed Action

KVP 1 Powerline Road at Wharf Road

The deep excavation resulting from new mining operations of the Proposed Action would eliminate the mature trees that screen the existing mining operations from along Powerline Road. The beginnings of reforestation efforts are visible in the Year X simulation, which will eventually allow new trees to grow up and screen the views again. However, it will take 5 to 7 years to develop a full screen and longer for a more mature forest to develop. While visual change is evident, the Proposed Action would not have a significant adverse visual impact at Viewpoint 1. This is due to the lack of sensitive viewers, and the relative rapidity with which the landscape is expected to recover. Most of the unobstructed view from the road is expected to be screened within a five-year period due to vegetation regrowth. Existing and future views are shown below to help the reader see the degree of change.

KVP 1 EXISTING

KVP 1 YEAR X

KVP 1 YEAR Y

KVP 2 Powerline Road at Community Garden

KVP 2 is located on Powerline Road at the existing Dupont Community Garden between Wharf Road and Center Drive, looking northwest towards the South Parcel Project. Powerline Road extends from the foreground to the background. This angle was selected to show the angle from which most users, drivers of cars, and pedestrians, would view the South Parcel Project site. Evergreen trees will be planted along the property line adjacent to Powerline Road; estimated planted in fall/winter of 2022/2023, depending on weather conditions and the availability of trees. Prior to the beginning of mining the existing chain link fence will be moved to the property line.

Shrubby vegetation and large evergreen trees currently block views of the South Parcel Project site. That vegetation would be removed at the beginning of mining the South Parcel. An access road would parallel the east property line and would have temporary overhead powerlines to power dewatering wells. Removal of the second growth conifers and ground cover will contrast sharply with current conditions and will temporarily open up views of the South Parcel Project, an industrial use that is currently not visible from this location. Overhead lines would add an element of visual clutter. Given the sensitivity of viewers, this is considered a moderate impact on visual quality; the impact would be mitigated by the evergreen screening that would limit the duration of this impact.

In Year X, the site would be partially screened by densely planted evergreens along the fence line. By Year X+, the trees are expected to grow to approximately 8 to 12 feet in height. By Year Y, mining would be complete along this section. The power poles used for dewatering shown in Year X and Year X+ would be removed. Additionally, the fence along the perimeter would be removed in Year Y. The trees may be thinned as required for overall health. Existing and future views are shown below to help the reader understand changes over time.

KVP 2 EXISTING

KVP 2 AT YEAR X

KVP 2 AT YEAR X+

KVP 2 AT YEAR Y

KVP 3 Powerline Road and Center Road

The photo below is taken from the west side of Center Road looking northwest. Vehicles traveling on the west side of the Center Road would be going southwest, so this view is more like one that a pedestrian would see than what would be seen from a vehicle. The location and direction were selected to maximize the potential amount of disturbance visible in the simulation from the roadway.

Existing and future views are included to portray changes over time. As shown in the simulation of KVP 3 at Year X, the cut through the forest is clearly visible on the right-hand side closest to the power pole. The simulation demonstrates that the mining operation would not be visible from KVP 3. This is due to the grading, which causes the land to fall away quickly from the viewer. Additionally, a 20-foot-high berm planted with trees and other native landscape vegetation would be placed in this area to shield residents in Creekside Village Apartments from potential visual and auditory impacts resulting from mining activities in the expansion area. The South Parcel Project would not have a significant adverse visual impact at this KVP, due to a low degree of visual change, combined with the moderate existing visual quality and viewer sensitivity. The trees, which are cleared at Year X, would show regrowth by Year Y, although it would take many more years beyond Year Y before the trees would reach the same height as existing trees.

KVP 3 EXISTING

KVP 3 AT YEAR X

KVP 3 AT YEAR Y

KVP 4 Top of Ridge

This KVP occurs at the high point on the ridge between the Sequalitchew Creek canyon and the existing mine area. The viewpoint is on an existing mine site not typically seen by members of the public. It was selected as one of the simulation viewpoints because it gives an unobstructed view of the South Parcel Project mining area.

The scene in the Year Y simulation below depicts the interior of the mine following the completion of mining activity and restoration. In the foreground, the ground plane is relatively level with only minor variations in terrain. In the background, plateau benches step up towards the south end of the site to anticipate and facilitate future development. All side slopes are shown with dense tree plantings whereas the floor of the mine is relatively open having only been hydroseeded with native ground cover. Along the distant horizon, the screening vegetation effectively obstructs Powerline Road beyond.

Although the visual environment has been altered in this viewpoint, the impact is not judged to be significant. This is due to the inaccessibility of the viewpoint and total absence of sensitive viewers on the west and south sides of both the existing and proposed mining sites.

KVP 4 EXISTING

KVP 4 AT YEAR Y

KVP 5 Sequalitchew Drive

Vegetation and topography block views of the project site, which is generally indicated by the shaded band. all trees visible from this view are off-site from the project and would not be affected. this view has not been simulated as the visible trees are privately owned. viewers would be expected to be of high sensitivity, principally hikers, and other recreationists using the trail system. Visual quality is judged to be high because this is an established hiking trail.

KVP 5

KVP 6 Sequalitchew Trail- East

At KVP 6, all trees are located offsite and would not be affected by proposed mining, therefore no change to visual quality would occur as a result of this project. Sequalitchew Creek is below the trail to the left and the viewer is surrounded by lush undisturbed vegetation.

KVP 6

KVP 7 Sequalitchew Trail- West

The site is directly uphill from this location and is not visible; the view provided in the photo below shows the slope along the trail's north side on the right-hand side of the photo. Vegetation and topography along Sequalitchew Creek block views of the project site and would not be affected. All disturbance associated with the South Parcel Project will be outside of Sequalitchew Creek Park and set back a minimum of 100 feet from the top of the slope of Sequalitchew Creek Ravine. All trees in the photo below are offsite from the project and would not be affected. Viewer sensitivity and visual quality would not change as a result of the project site.

KVP 7

KVP 8 The Home Course (Golf Course)

The photo below was taken from the top of a high knoll at the north side of the Home Course, a privately owned golf course immediately south of Sequalitchew Creek. This knoll is the highest point of land along the north side of the golf course. All trees visible from this viewpoint are off-site from the project and would not be affected. Similarly, viewer sensitivity and visual quality would not be affected.

KVP 8

Cumulative Impacts

Cumulative impacts to views could, hypothetically, occur due to clearing that has taken place on the original mine and the North Parcel of the Pioneer Aggregate Mine. From viewpoints around the South Parcel Project, including KVPs 1, 2, and 3, however, there are no views of the original Pioneer Aggregate mine or the North Parcel. When clearing of the South Parcel occurs as part of the Proposed Action, views of the original mine and North Parcel would be temporarily opened up. The screening that is proposed for the South Parcel Project along the east perimeter will screen these views after the plantings reach a height of six feet or greater which is expected to occur by Year X+ or sooner. Views at KVP 5, 6, 7, and 8 would not be affected by clearing of the South Parcel; trees seen in the photos at those KVPs are located offsite. As such, cumulative impacts would be limited to the first few years prior to Year X. No other cumulative impacts are anticipated.

Impacts of the No Action Alternative

There are two No Action Alternatives- Scenario A Continuation of Existing Conditions; and Scenario B Site Development Under Existing Zoning.

In Scenario A Continuation of Existing Conditions, mining activities associated with the Re-Mine Area of the site and the Existing Mine would continue as currently permitted. The mining operation would retain a vegetated buffer at its perimeter with no lighting, and the interior of the mine would likely not be seen from existing public places. The Existing Mine has an estimated remaining life of 6 to 10 years with mining currently limited to 10 feet above groundwater. The South Parcel portion of the site is assumed to remain undeveloped and would continue in its vegetated condition.

In Scenario B, Site Development Under Existing Zoning, the proposal would not occur. The site would be developed for urban uses consistent with the City's Future Land Use Map. No attempt has been made to simulate the effects of future development; simulation would require the preparation of a development plan for the site which would be speculative. The majority of the area affected is currently designated by the City of DuPont Comprehensive Plan as Manufacturing and Research, with a smaller area designated for residential uses (City of Dupont 2021). The corner of the property near Center Drive is designated as Residential 12, which would allow higher density residential development where multifamily density averages 12 units per acre (City of Dupont 2021). Urban development, as permitted under current planning and zoning designations, would occur east of the lease line demarcating existing mining operations. The timing and nature of any such development would be driven by market forces.

In general, future structures would rise above the ground level and would be more visible within the surrounding landscape than the proposed South Parcel Project mining operations. Light and glare from buildings, the street, and security lighting would extend these effects into the nighttime hours. Future development would draw a greater number of daily users and viewers into the property than currently have access to it, both physically and visually. The degree of visual change outside of the property could be as great as or greater than the South Parcel Project, depending on buffer vegetation and the visual intensity and bulk of structures.

Mitigation Measures

The visual impact of the South Parcel Project is not expected to be significant. However, the following mitigation measure is proposed to further decrease the magnitude of potential impacts:

- Maintain a vegetated buffer along Powerline Road. Trees will be planted densely to establish screening during mining operations. After mining is completed, selective thinning may be necessary to facility a healthy future forest within the buffer.

Significant Unavoidable Adverse Impacts

The South Parcel Project would result in significant and unavoidable change to the visual character of the existing landscape within the proposed expansion area. The extraction of mined material will make this change virtually irreversible, because of the cost of transporting enough fill to replace the extracted sand and gravel. However, the South Parcel Project is not expected to result in a significant adverse effect to the visual environment of the surrounding community. The mining operation is expected to be only minimally visible to the general public from outside of the property boundary. In addition, mining is a transitional use of the site; although mining would alter the site for a number of years, after mining is complete, the site will likely be developed to another use.

References

City of DuPont. 2006. Glacier Northwest DuPont Mining Area Expansion and North Sequalitchew Creek Project Draft Supplemental Environmental Impact Statement.

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Appendix N

Traffic Impact Assessment

TECHNICAL MEMORANDUM

Project: **Pioneer Aggregates– South Parcel Project**

Subject: Traffic Impact Assessment

Date: July 18, 2022

Author: Marni C. Heffron, P.E., P.T.O.E.
Principal, Heffron Transportation, Inc.

Glacier Northwest (dba CalPortland) is seeking a permit to expand its existing Pioneer Aggregates Gravel Mine in Dupont, Washington. This expansion (hereafter referred to as the "South Parcel Project") would increase the mine footprint and extend the life of the mine. Current mine operations on the North Parcel and the respective transportation-related impacts were assessed in the June 2013 *Final Environmental Impact Statement (FEIS)*.[1] This memorandum evaluates the potential transportation impacts associated with the South Parcel Project and compares those to impacts previously evaluated in the FEIS.

1. Current and Planned Mine Operations

The Dupont Pioneer Aggregates Gravel Mine is located at the north end of the City of Dupont. The existing processing plant is accessed from Pioneer Avenue. The mining areas and processing plant location are shown on Figure 1.

Current Operations

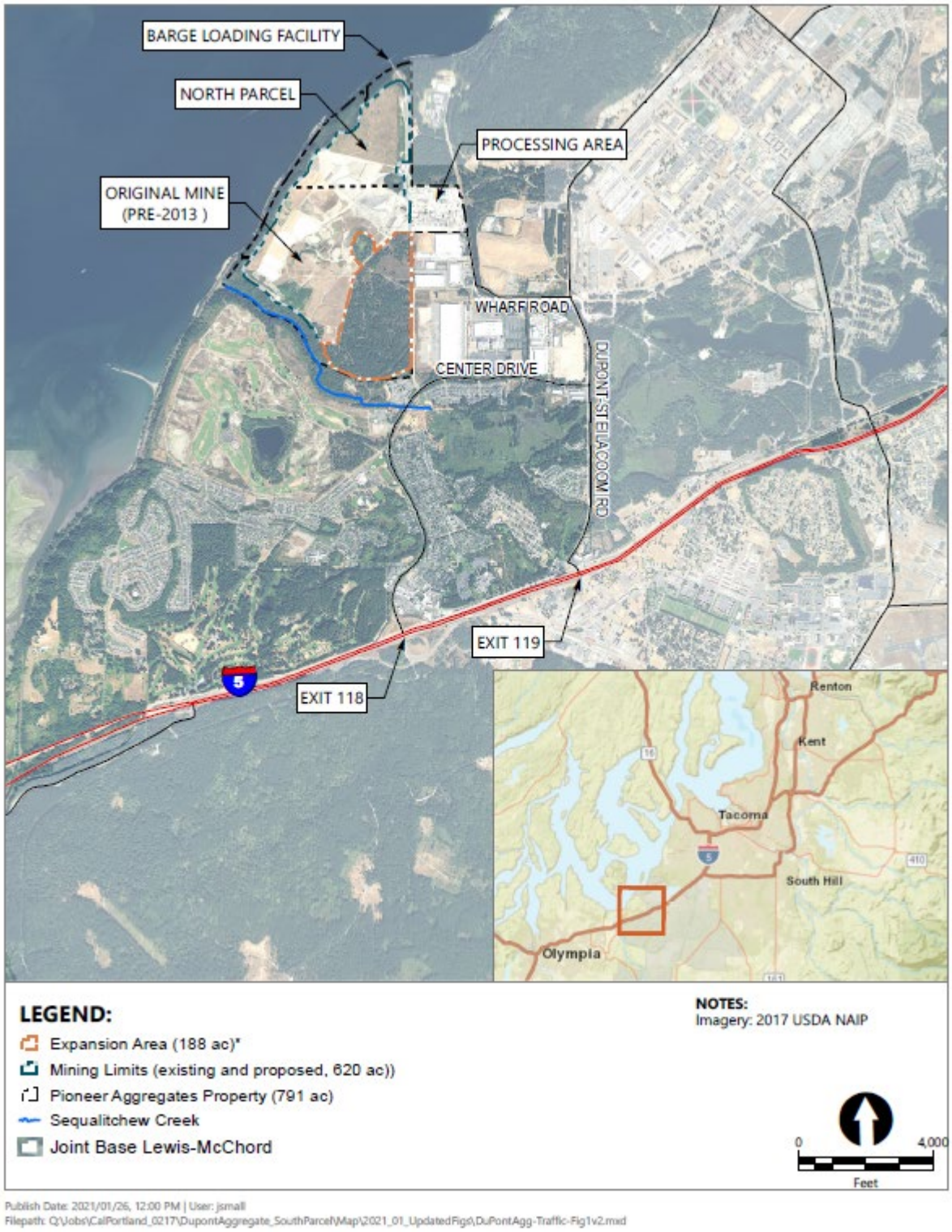
The mine, processing plant, and barge loading dock at Tatsolo Point have been in operation since 1997. The expansion of the mine to the 142-acre North Parcel (described in the 2013 *FEIS*) assumed extraction of approximately 2.8 million cubic yards of sand and gravel annually. It also assumed that 80% of that aggregate would be transported by barge, the same rate that had been historically barged before expansion. The remaining 20% was assumed to be exported from the site by truck, either as mined aggregate or as part of processed concrete. Section 2 of this memorandum presents information about the *FEIS*-estimated truck and employee traffic volumes, along with data about actual truck loads for the five years between 2015 and 2020.

Future Operations with South Parcel Project

The South Parcel Project would expand the footprint of the existing mine to include the 188-acre expansion area shown in Figure 1. It would increase the existing sand and gravel resources available to mine by 30 to 40 million cubic yards, and extend the life of the mine by an additional 14 years. This relates to an annual extraction rate of between 2.1- and 2.8-million cubic yards -per-year, which is similar to the maximum rate of extraction defined in the *FEIS*. CalPortland expects that 80% of the aggregate would continue to be transported by barge with the remaining aggregate exported by truck. The processing plant would remain in its current (and historic) location.

[1] City of Dupont, *Final Environmental Impact Statement for CalPortland Dupont North Parcel Mining,* June 2013.

Figure 1. Site Vicinity and Mining Operational Areas



2. Existing Mine-Generated Traffic Volumes

Predicted by FEIS

The 2013 *FEIS* included detailed trip generation estimates for the mine (see Chapter 3.11), which were based on historic operations and annual extraction rates. The trip generation estimates assumed that 20% of the mined aggregate would be transported from the site by truck (the remaining 80% would be by barge and not affect roadways). *FEIS* Table 3.11-4 summarized the trip generation estimates, and is presented below.

FEIS Table 3.11-4. Summary of Project-Generated Off-Site Trips

Trip Type	Vehicle Type	Daily	AM Peak Hour			PM Peak Hour		
			In	Out	Total	In	Out	Total
Typical Day								
Employee Commute	Automobile	126	3	0	3	0	3	3
Service & Deliveries	Light Truck	18	2	2	4	2	2	4
Product Transport	Heavy Truck	246	9	9	18	1	1	2
Logging [1]	Heavy Truck	0	0	0	0	0	0	0
Total		390	14	11	25	3	6	9
Peak Day								
Employee Commute	Automobile	200	7	3	10	0	4	4
Service & Deliveries	Light Truck	30	5	2	7	3	3	6
Product Transport	Heavy Truck	710	25	25	50	5	5	10
Logging [1]	Heavy Truck	24	0	0	0	0	0	0
Total		964	37	30	67	8	12	20

Source: Final Environmental Impact Statement for CalPortland Dupont North Parcel Mining, *June 2013.*

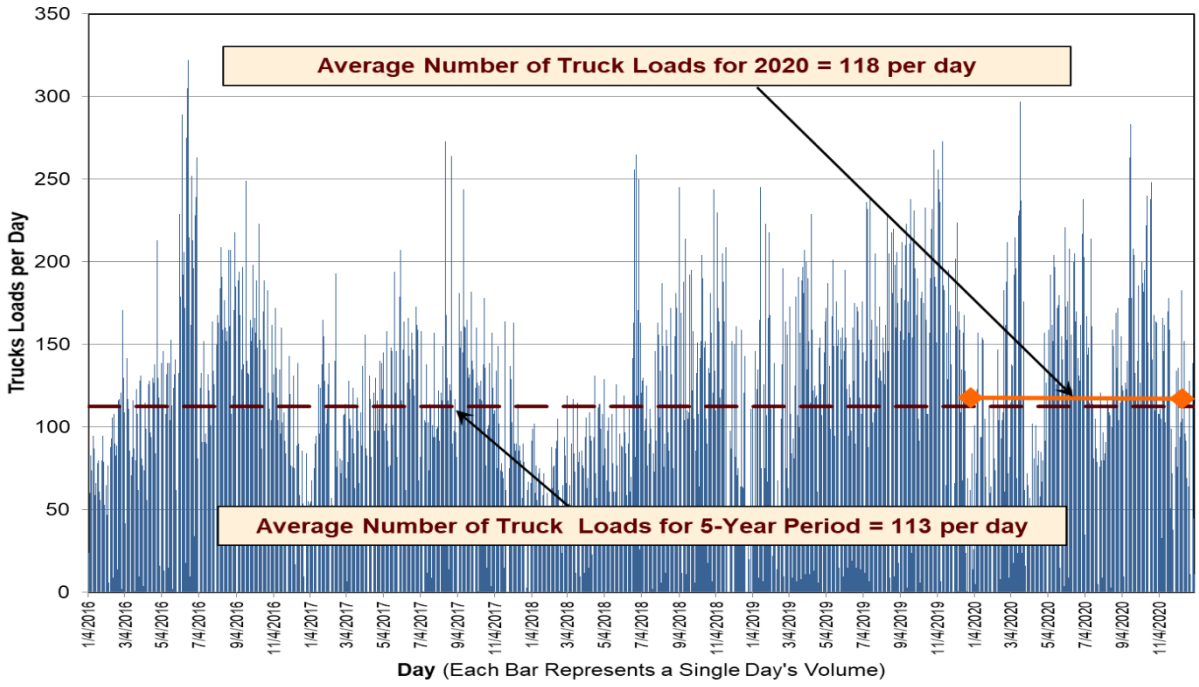
1. *Logging the North Parcel would occur only during the first year of operation.*

The FEIS had estimated that the mine would generate an average of 390 trips per day (195 trips entering the site and 195 trips exiting the site). Of these, 264 trips per day (132 inbound and 132 outbound) would be truck trips. On the peak day, daily trips were expected to increase to 964 trips per day (482 inbound and 482 outbound) of which 764 would be truck trips (382 inbound and 382 outbound). Trips during each of the commuter peak hours—AM and PM—were also determined. More traffic was expected to occur during the AM peak hour when product is typically transported out to construction sites. During the peak day, the mine was expected to generate 67 AM peak hour trips (37 inbound and 30 outbound). The PM peak hour would have much lower volumes, expected to be 20 trips on the peak day (8 inbound and 12 outbound).

Actual Truck Trips – Years 2016 through 2020

CalPortland tracks all trucks that exit the site with a load of material (e.g., truck loads). Five full years of data (from January 1, 2016 through December 31, 2020) were obtained from CalPortland and compiled to show the number of truck loads that exit the site each day. It is noted that each truck load reflects an outbound trip (an inbound trip is made by an empty truck and is accounted for later in the analysis). Figure 2 below shows each day's concrete and aggregate loads (trucks exiting the site).

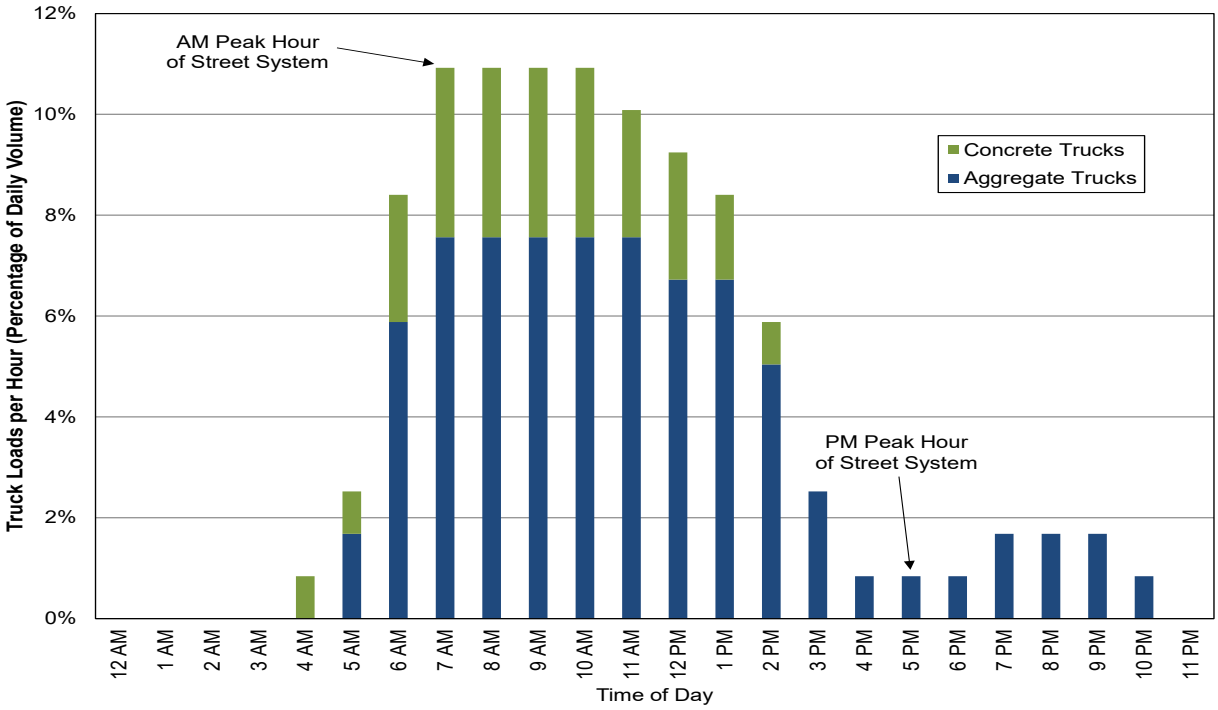
Figure 2. Daily Truck Loads (Outbound Truck Trips) – Actual for Years 2016 through 2020



Source: CalPortland Data compiled by Heffron Transportation, Inc., February 2022.

More detailed information was compiled for 2020. While the COVID-19 pandemic affected activity during some weeks of the year, the total aggregate mined was 2,776,615 cubic yards, just below the 2.8 million cubic yards anticipated by the FEIS. The average truck loads per day over the five-year span (113 truck loads per day) were very similar to the average for the year 2020 (118 truck loads per day). Further analysis was performed for the full year of 2020 data to derive average truck loads by time of day. Figure 3 shows the percentage of each day's trucks for each hour.

Figure 3. Percent Trucks by Hour – Weekday (2020)



Source: CalPortland Data compiled by Heffron Transportation, Inc., January 2021. Data reflect the average of full year of truck loads from 2020.

Table 1 compares the daily and peak hour truck trips from 2020 to those assumed in the *FEIS.* A total of 118 truckloads were processed on the average day in 2020, which results in 236 truck trips (empty truck inbound plus loaded truck outbound). The peak day of the year had 297 truckloads, equaling 594 truck trips. The total daily trips were below the level estimated in the *FEIS*. Actual AM peak hour trips were slightly higher for an average day (26 trips compared to the estimated 22 trips), but lower on the peak day (52 trips compared to the *FEIS* level estimated 57 trips). PM peak hour trips were lower for the average day and the same as expected for the peak day.

Table 1. Comparison of *FEIS* Truck Estimates to Actual Truck Volumes

Trip Type	Daily	AM Peak Hour			PM Peak Hour		
		In	Out	Total	In	Out	Total
FEIS Estimated Truck Trips [a]							
Average Day	266	11	11	22	3	3	6
Peak Day	740	30	27	57	8	8	16
Actual Truck Trips – Year 2020							
Average Day [b]	236	13	13	26	1	1	2
Peak Day [c]	594	26	26	52	8	8	16
Absolute Peak Day in Five- Year Period (06/15/2016) [d]	644	13	49	62	10	2	12

a. *Source:* Final Environmental Impact Statement for CalPortland Dupont North Parcel Mining, *June 2013.*
b. *Based on average loads per hour for all of year 2020.*
c. *Based on actual loads for the Peak Day in 2020 (March 18, 2020).*
d. *Highest day in five-year period between 01/01/2016 and 12/31/2020. This day had substantial concrete truck activity associated with a continuous pour operation.*

As shown above on Figure 2, the absolute highest volume in the past five years (June 15, 2016) generated 322 truck loads or 644 truck trips per day. This day had a very high number of concrete truck trips associated with a continuous-pour operation. The actual trips for that day were compiled to determine the peak hour volumes. The daily and PM peak hour trips were below the values assumed in the FEIS, but the AM peak hour was slightly higher due to the high number of outbound trips in the morning for the continuous pour. That type of event is very rare, and those volume levels were only observed one time in the five-year period.

3. Future Traffic with South Parcel Expansion

The South Parcel Project would allow for continued mine operations that are similar to those already permitted. The processing plant would remain in the same location, and the market area and travel patterns are expected to remain the same. Trip generation is expected to continue at current levels and would remain below the peak day estimates that had been evaluated in the 2013 *FEIS*. Expansion to the South Parcel would have a short period when logging trips are added to the traffic stream. The *FEIS* had estimated up to 24 logging truck trips per day (12 loads). This is likely to be conservatively high since the timber to be logged on the South Parcel is of poorer quality than for the previously-logged North Parcel.

The 2013 *FEIS* had evaluated traffic operations at area intersections for the future horizon year of 2035. The year 2035 conditions had accounted for substantial growth in traffic due to a dozen major development projects and background growth, and were consistent with assumptions in the *I-5 Joint Base Lewis-McChord (JBLM) Transportation Analysis*.[2] Impacts of the project were evaluated for the peak day condition, which as shown above, reflect a higher trip condition than occurred during the peak day in 2020. The *FEIS* traffic operations analysis found that, "…*project-generated trips are expected to constitute 3 percent or less of total trips through the LOS E and F intersections in the AM peak hour, and less than 1 percent in the PM peak hour. This reflects projected conditions on a day of peak mining operations; on days of more typical mining operations, these proportions would be even lower."* It goes on to conclude, *"Because the project-generated trips would represent a small proportion of traffic volumes at the study area intersections and would have negligible effect on the levels of service at the I-5 ramps and city intersections, no adverse level of service impacts are project to result from the South Parcel proposal."* The conclusion is still reasonable given that the trips are expected to remain similar to or less than those evaluated in the *FEIS,* and that the horizon year evaluated (2035) is reasonable to capture the extended life of the mine with expansion to the South Parcel.

4. Summary

The South Parcel Project is not expected to exacerbate transportation conditions in the study area. Trip generation is expected to continue at current levels and would remain below the peak day estimates that had been evaluated in the 2013 *FEIS*. Traffic operations had been evaluated in the *FEIS* for the anticipated South Parcel traffic and extended mine life, and concluded that the South Parcel would not adversely affect traffic operations in the site vicinity. This conclusion is still reasonable.

MCH/tsm

CalPortland Pioneer Mine - South Parcel Expansion - Traffic Impact Assessment - FINAL - 07-18-2022

[2] Washington State Department of Transportation (WSDOT) and the Tranpso Group, *I-5 Transportation Alternatives Analysis & Traffic Operational Model*, from Mounts Road to SR 512. Prepared for the City of Lakewood, September 2010.

Appendix O

Parking Narrative

1201 3rd Avenue, Suite 2600
Seattle, Washington 98101
206.287.9130

ANCHOR QEA

Memorandum

November 17, 2020

To: City of DuPont, Department of Community Development

From: John Small, Anchor QEA

cc: Pete Stoltz, CalPortland

Re: Pioneer Aggregates South Parcel Mine Expansion Parking Narrative

The purpose of this memorandum is to provide a narrative describing the existing and proposed parking and employee count related to the CalPortland South Parcel Mine Expansion Project. Current and proposed parking meets the requirements of Dupont Municipal Code (DMC) 25.95. The South Parcel Mine Expansion will not result in any change to the operation or employment at the facility. The project does not include erection or modification of any buildings. Parking for employees will remain the same at approximately 60 spaces for personal vehicles, plus additional space for company owned vehicles including trucks, trailers and heavy equipment. The total employment associated with CalPortland's existing mining operation in DuPont, an estimated 60-100 jobs depending on market conditions.

A paved parking lot with disabled parking and access is available at the mine office. Space in this lot is also available for high occupancy vehicles. Bicycles are not allowed inside the gates of the mine for safety reasons. Spaces in this lot meet the city standards for stalls and aisles set forth in DMC 25.95.050. Two additional gravel lots are located between the processing plant and Pioneer Ave and between the concrete batch plant and Solo Point Road. The gravel lots provide flexibility to accommodate more employee vehicles as needed in response to fluctuations in demand. Vehicle and pedestrian traffic are controlled throughout the site to protect worker safety and the site is closed to the public. There are established vehicle and pedestrian travel routes used to access parking areas, buildings and other locations on the site as well as for ingress and egress from the site.

In summary:

- The number of spaces provided is and will remain consistent with DMC 25.95.030 (1)
- The locations for parking are and will remain consistent with DMC 25.95.40
- Preferential Parking requirements are and will continue to be met consistent with DMC 25.95.070
- Parking areas have been developed in consistency with the provisions of DMC 25.9.5050 where applicable (gravel lots are not striped) and will remain so.

- Preferential parking provided meets and will continue to meet the requirements of DMC 25.95.060
- All loading and unloading facilities are and will remain in off street locations that do not impede or interfere with traffic on public roads.

Appendix P

Fiscal Condition Assessment

Pioneer Aggregates South Parcel Project

Fiscal Condition Assessment

February 28, 2024

Prepared for: City of Dupont

Final Report

ECONorthwest
ECONOMICS · FINANCE · PLANNING

Park Place
1200 Sixth Avenue
Suite 615
Seattle, WA 98101
206-823-3060

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1. Overview of Fiscal Condition Assessment

Purpose

This report provides a reasonable analysis examining the tax revenues generated at the project in contrast to the costs of service that can be allocated to site. The analysis examines these revenues and costs that can be attributed to the site from an annual current year (2022) perspective given the best information available.

It should be noted that the analysis is limited to estimated revenues directly accruing to the City general fund. Indirect revenues, such as B&O taxes paid by companies providing repair and maintenance services to CalPortland, and charitable cash or in-kind contributions such as those made to the City Parks Department or DuPont Historic Society are not included. Similarly, the analysis does not identify all revenues generated by the CalPortland proposal that would accrue to other levels of government, including the State of Washington, or to non-city service districts, such as the school district. Although not quantified in this analysis, these revenues would benefit the respective governmental entities. In addition, the analysis does not address indirect effects to the broader economy, such as spending by employees or potential attraction of complementary businesses to the City.

Project Context

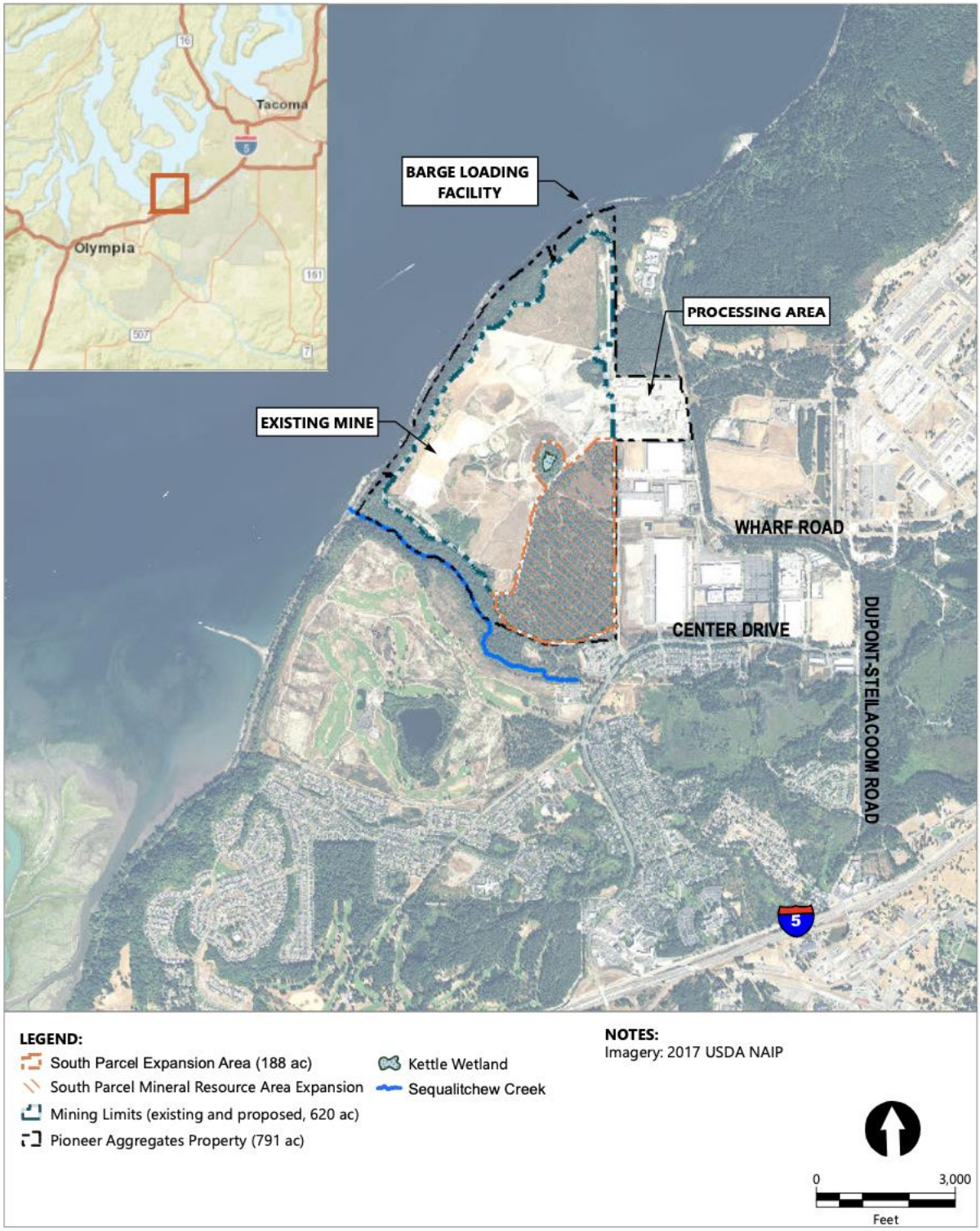
CalPortland's original sand and gravel mine was permitted in 1997 (355 acres). As provided under the Settlement Agreement, CalPortland applied for permits in 2013 for the North Parcel Mine Expansion to allow mining of approximately 142 acres within the North Parcel. Following the publication of a Final EIS in June 2013, the North Parcel mining expansion was permitted in 2014.

Mining activities at the existing site include mining, processing, transport of sand and gravel, and manufacturing of concrete. The processing area is located adjacent to the mine site on a 52-acre parcel owned by Glacier. Sand and gravel are removed from the mine by bull dozers and wheel loaders and transferred to the processing area by conveyor belts. At the processing facility, the material from the mine is crushed, washed, and separated into different size gradations. Aggregate products are stored in stockpiles in the processing area for distribution.

After completion of the production process, most of the finished aggregate products are transported from the plant area by conveyors and placed onto barges (approximately 80 percent) at Glacier's dock and barge-loading facility at Tatsolo Point. The remainder (approximately 20 percent) is sold as aggregate or used to make concrete on-site; in both cases it is transported by truck (see map below for context).

Exhibit 1: Pioneer Aggregates South Parcel Project Context Map

Source: Anchor QEA



Project Proposal Description and SEPA

The proposal is to expand the mining operations currently occurring on the North Parcel to the South Parcel. The South Parcel Project would include horizontal expansion of mining into approximately 188 acres previously undisturbed by mining, and vertical expansion of approximately 125 acres where re-mining will deepen a portion of the existing mine. The South Parcel Project would extend mining at the current rate for approximately 14 additional years.

The City of DuPont is the lead agency for SEPA review for projects within the city and is responsible for performing the statutory duties required for the Pioneer Aggregates South Parcel Project. Based on review of the May 2021 application materials submitted on the current project, the City of DuPont, as SEPA lead agency, determined that this project may have significant adverse impacts on the environment, and that an EIS should be prepared, consistent with RCW 43.21C.030 (2)(c).

The EIS will address probable significant adverse environmental impacts of the proposed Pioneer Aggregates South Parcel Project and will build upon the information and analysis in other environmental review for the mines at the site. While fiscal and economic issues are not required components of an EIS, the city has requested that it be studied. The purpose of this analysis is to understand how the existing mine operations contribute to both the tax revenue picture to the city as well as public service costs.

2. Existing Fiscal Conditions

City Fiscal Overview

Fiscal conditions presented below provide background about the revenues, expenditures, and tax bases of the city of Dupont. This analysis is focused on general government funds primarily include the city's General Fund which accounts for services to the public including public safety, street maintenance, land use, parks and recreation, and administrative functions. These services are largely supported by taxes, fees and charges, and intergovernmental revenues (i.e., state and federal contributions). This analysis is specifically focused on the taxes used to support the city's public services.

The analysis does not include the enterprise funds related to operating the Water Utility and Stormwater Utility. These enterprises are operated like a stand-alone business where with customer user fee are used to support all operating costs. Resources of the utilities cannot be used to subsidize general government functions.

City Tax Revenues Sources

This section discusses the city of Dupont's primary tax revenue sources and trends from 2011 to 2021. Unless cited otherwise, informing this memorandum is data from Washington state's Local Government Financial Reporting System for the city of Dupont. As with many cities in Washington State, the three largest revenues sources for the City of Dupont are (1) property taxes, (2) sales and use taxes, (3) utility taxes, and (4) business and occupation taxes (B&O). Taxes made up 74% of the city's overall revenue in 2021.

Current Expense Property Taxes

Initiative 747 limited local property tax increases to 1.0 percent each year, resulting in an erosion of the tax's purchasing power over time. Because of the method for calculating Dupont's property tax levy (equal to the 101% of the previous year's levy plus new construction add-on value), new construction is important to the city's ability to limit the erosion of the purchasing power of the property tax and to grow the levy beyond the statutory limitations. In 2023, property tax levy $2,014,558.

EMS Property Taxes

The city also collects a regular property tax for emergency medical services provided by the city. In 2023, property tax levy is $877,716.

Local Option Retail Sales and Use Taxes.

One of the key revenue sources that cities rely on is the retail sales tax. Of the 9.4% sales tax currently collected in the city on general retail purchases, a 1% "local" share of the tax accrues to local jurisdictions. The city receives 85% of the 1% local tax and Pierce County gets 15%. The

current rate accruing to the city is 0.85%. The local option sales tax generated $2,353,599 in local sales tax revenues for the city in 2021. This tax is levied not only on businesses in the area, but also on construction activity and some transactions that are related to housing, such as certain online purchases. The city also receives a population pro-rata share of 90% of the city allocation of Pierce County's 0.1% criminal justice sales tax.

Business and Occupation Taxes

This category of revenue includes monies received from business and occupation taxes on general business activities. The B&O tax rate in DuPont is 0.1%. The B&O tax generated $746,828 in tax revenues for the city in 2021.

Utility Taxes

The city levies a business and occupation tax on utilities; however, this tax is passed on to users of the utilities as part of their periodic bills. The city levies the following rates to the gross receipts of the utility providers:

- Electricity: 6%
- Water: 12%
- Sewer: 6%
- Stormwater: 10%
- Telephone: 6%
- Natural Gas: 6%
- Solid Waste: 8%

The utility tax generated $ $1,647,377 in tax revenues for the city in 2021.

Other Revenue Sources

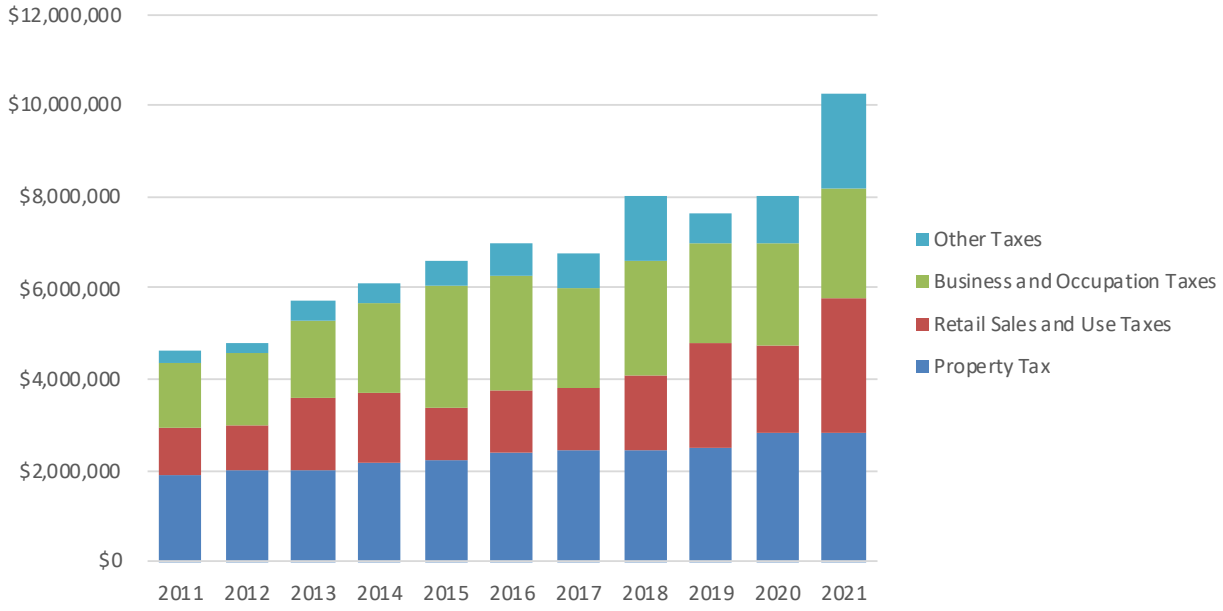
The City of Dupont collects revenues from a range of other local sources, including:

- Hotel/Motel Tax: The city receives a sales tax credit against the state portion of the sales tax of 2% on accommodations purchases. The proceeds of the tax are dedicated to economic development purposes supporting the tourism sector.
- Real Estate Excise Tax (REET). Real estate transactions are subject to a 0.50 percent local tax on the value of the transaction. REET revenues are restricted to finance capital projects. REET revenues are uncertain, given the volatility in the real estate market. Since REET is based on the total value of real estate transactions each year, the amount of REET revenues the city receives can vary substantially from year to year based on the normal fluctuations in the real estate market.
- Admission Tax. The city charges a tax on the value of transactions on admissions to a place or event. The admissions tax rate in DuPont is 5%.

City Tax Revenue Trends

Exhibit 2 presents a summary tax revenue for the city from 2011 to 2021. B&O tax revenues include both the tax on business gross receipts and utility providers (utility taxes). Property taxes have been a consistent and growing source of revenue for the city over the time. Sales taxes have also grown but a more volatile source of funding. The city has seen stronger relative growth in its B&O taxes (gross receipts and utility taxes). Other taxes are primarily consisted of the REET.

Exhibit 2: Summary Trends of Major Taxation Sources, City of Dupont, 2011 through 2021
Source: Washington State Auditor, Local Government Financial Reporting System.



City Expenditures

This section discusses the City of Dupont's primary expenditures and trends from 2011 to 2021. Unless cited otherwise, informing this memorandum is data from Washington state's Local Government Financial Reporting System for the city of Dupont.

City Expenditure Categories

The City of Dupont's major expenditures are as follows:

Public Safety

This category of expenditures includes costs for law enforcement, fire and emergency medical, detention/corrections, protective inspection services, and dispatch services. As of 2021, expenditures for public safety accounted for 55 percent of total city-wide expenditures.

General Government

This category of expenditures includes costs for personnel and centralized services; legislative, and executive activities; financial, recording, and election activities; and legal. As of 2021, expenditures for the general government accounted for 21 percent of total city-wide expenditures.

Transportation

This category of expenditures includes roads/streets maintenance, roads/streets administration and overhead. As of 2021, expenditures for transportation accounted for 7 percent of total city-wide expenditures.

Culture and Recreation

This category of expenditures includes library and park facilities costs. As of 2021, expenditures for culture and recreation accounted for 10 percent of total city-wide expenditures.

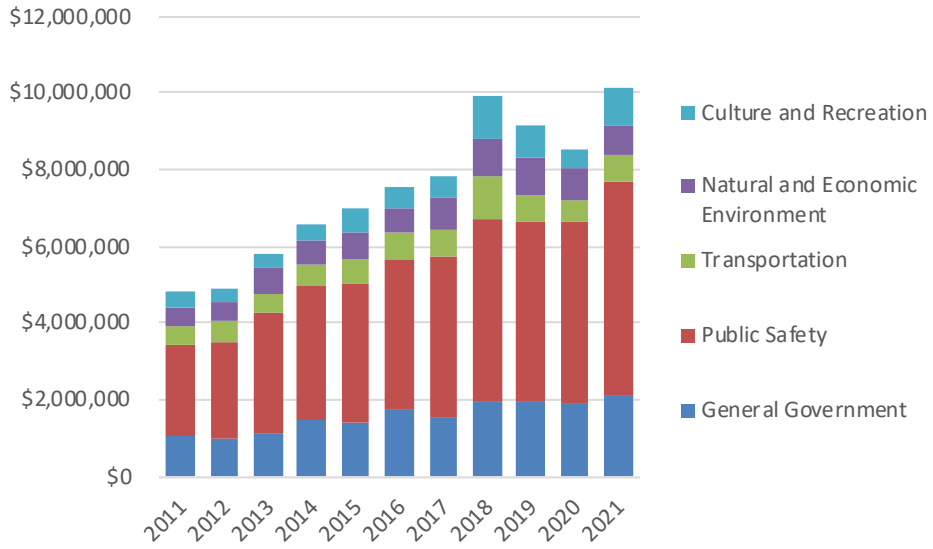
Natural and Economic Environment

This category includes work in community and economic development. As of 2021, expenditures for culture and recreation accounted for 7 percent of total city-wide expenditures.

City Expenditure Trends

Expenditures in the City of Dupont totaled $10.1 million in 2021, up from $4.9 million in 2011 (104 percent change).

Exhibit 3: Summary Trends of Expenditures, City of Dupont, 2011 through 2021
Source: Washington State Auditor, Local Government Financial Reporting System



Selected City Tax Bases

This section provides background on the following:

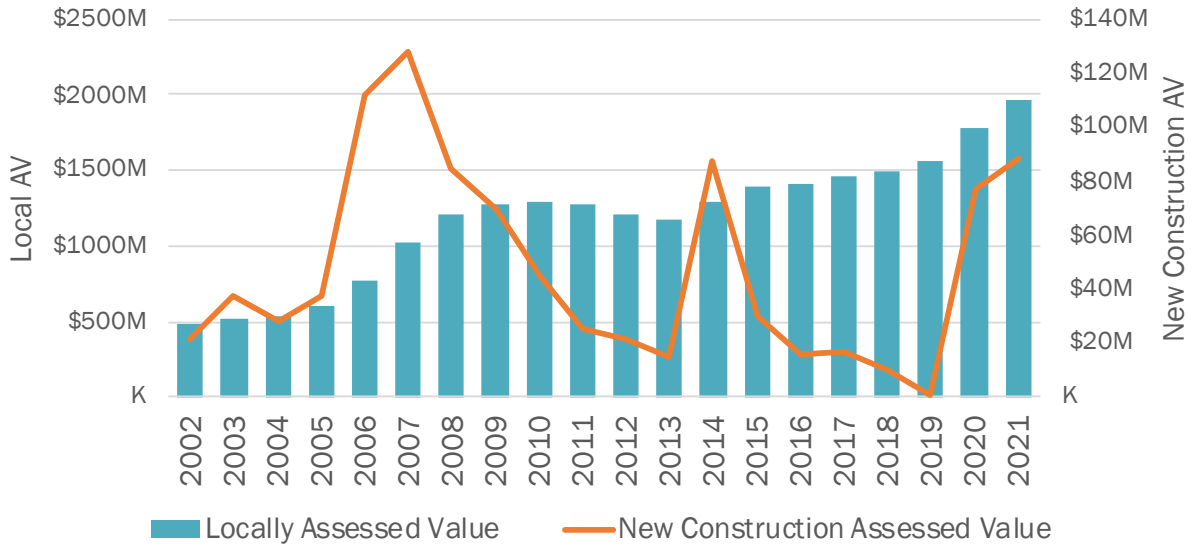
- Assessed value and new construction trends.
- Taxable retail sales trends

Assessed Value and New Construction

The Pierce County Assessor assesses the land and improvement value of all properties in the county for the purpose of levying property taxes. The assessor also values the amount of new construction for calculating the amount of "add-on" value to property tax collections. The trends for the city follow.

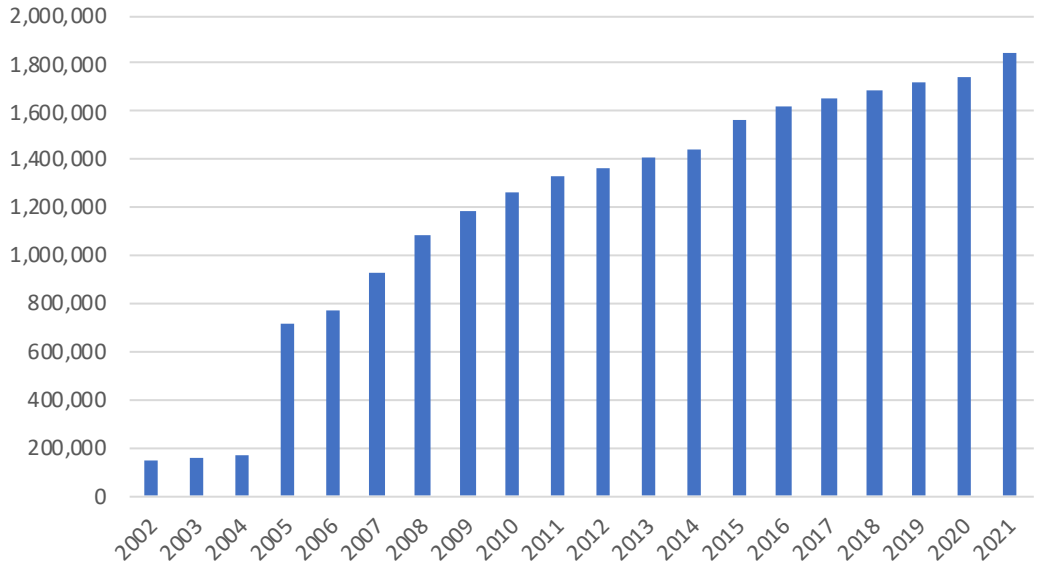
- In 2011, Dupont's local assessed value (AV) was $1.9 billion, about $1.5 billion more than local assessed value estimates in 2002.
- Valuation from new construction added substantially to Dupont's base from 2006 through 2009. The Great Recession did, however, cut this trend short. In 2010. New construction levels have picked up in the last several years but continue to be at levels lower than they have in the past.

Exhibit 4: Assessed Value and New Construction, City of Dupont, 2002 through 2021
Source: Washington State Department of Revenue.



Most taxing jurisdictions in Washington state must ensure that the amount of revenue they levy in the current year will not exceed the amount levied in the preceding year (plus additional funds for new construction, improvements to property, newly constructed wind turbines, solar, biomass, geothermal facilities, if the facility is not state assessed, increases in the value of state-assessed property, annexations, and refunds). In 2021, Dupont's highest lawful levy was $ $1,971,024 prior to the additional funds for new construction.

Exhibit 5: Highest Prior Levy, City of Dupont Regular Levy, 2002 through 2021
Source: Washington State Department of Revenue.

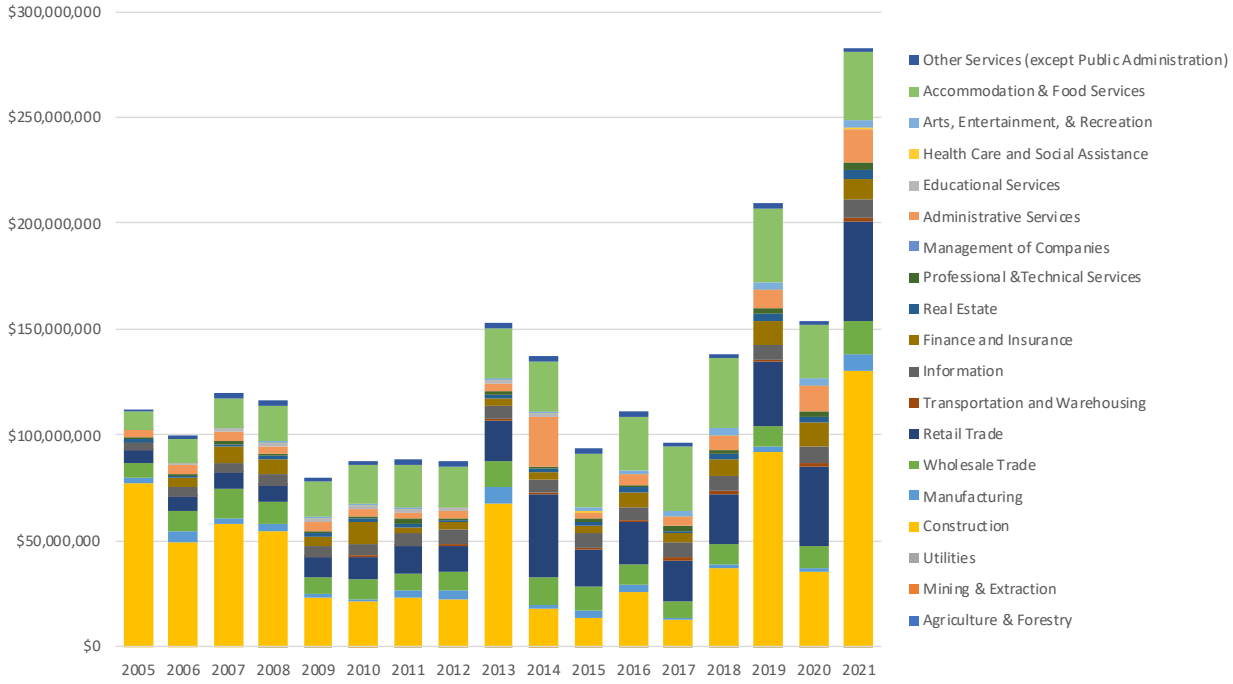


Taxable Retail Sales

Retail sales reflect spending that occurs within the city and is a significant source of tax revenue for the city.

- Taxable retail sales (TRS) have grown steadily over the last several years. Total sales (particularly for the construction sector) dipped following the onset of the recession (around 2009), but sales have since increased.
- The retail trade sector and accommodations & food services accounts for most of the remaining growth.

Exhibit 6: Taxable Retail Sales, City of Dupont, 2005 through 2021
Source: Washington State Department of Revenue.



3. Tax and Service Allocations

Tax Revenues

The tax analysis computes an estimated tax using the following methods applicable for a 2022 analysis year.

Property Taxes

Property tax revenues are estimated using the parcel list of the project and their 2022 certified taxable assessed values (for 2023 property taxes). The assessed values are then multiplied by the tax rate for the city's regular levy and EMS levy. Based on this summary, the project currently generates $58,000 in property taxes ($40,000 for the regular levy and $17,600 for the EMS levy).

Exhibit 7: Summary of Assessed Value and Levy Estimates
Source: Pierce County Assessor, 2022.

	Assessed Total	Taxable Total	Tax Rate (2023 taxes)	City Regular Levy	City EMS Levy	City Total
South Lease Area	$3,142,100	$3,142,100	$1.14924	$2,515	$1,096	$3,611
Existing Mine Lease Area	$5,845,200	$5,845,200	$1.14924	$4,679	$2,039	$6,718
Processing Area	$39,406,900	$39,406,900	$1.14924	$31,544	$13,743	$45,288
North Area	$2,075,700	$2,075,700	$1.14924	$1,662	$724	$2,385
Total	$50,469,900	$50,469,900		$40,400	$17,602	$58,002

The property also pays property taxes for personal property. Personal property includes machinery, equipment, furniture, and supplies of businesses and farmers. It also includes any improvements made to land leased from the government (leasehold improvements). The project applicant provided an estimate of their valued personal property.

Exhibit 8: Summary of Personal Property Value and Levy Estimates
Source: CalPortland, 2022.

	Personal Property Assessed Total	Personal Property Taxable Total	Tax Rate (2023 taxes)	City Regular Levy	City EMS Levy	City Total
Personal Property	$13,300,000	$13,300,000	$1.14924	$2,515	$1,096	$3,611

Personal property taxes are estimated to generate $3,600 in taxes in 2022.

Sales & Use Taxes

Of the 9.4% sales tax currently collected in the city on general retail purchases, a 1% "local" share of the tax accrues to local jurisdictions. The city receives 85% of the 1% local tax and Pierce County gets 15%. The current rate accruing to the city is 0.85. Sales tax collected at the site can vary substantially from year to year depending on level of purchases. For example, CalPortland may purchase a new Caterpillar 992 loader (the largest wheel loader that Caterpillar makes) is scheduled in the 2023 year and will substantially impact local sales tax revenue from the mine due to its location of delivery within the city's taxing boundaries. It also makes annual capital

improvements at the site that would be taxable construction expenditures. Likewise, sales tax revenue from customers making retail purchases at the site can also vary depending on the size of projects locally. CalPortland estimates that in a typical year the following taxable retail sales are made:

- Capital purchases: $100,000 - $300,000.
- Customer purchases: $10,000 - $30,000.

The analysis uses the mid-point for these categories: capital purchases: $200,000 and customer purchases: $20,000. Using these values produces a sales tax estimate of $1,870 in 2022.

Exhibit 9: Sales Tax Estimates
Source: CalPortland and ECONorthwest calculations, 2022.

	Estimated Taxable Retail Sales	City Sales Tax Rate	Estimated City Tax Due
Taxable Retail Sales	$220,000	0.0085	$1,870

Business and Occupation Taxes

This category of revenue includes monies received from business and occupation taxes on general business activities. The B&O tax rate in DuPont is 0.1%. CalPortland estimates from its B&O tax filing that in a typical year it reports a local gross receipt of $40,000,000. Using these values produces a B&O tax estimate of $75,690 in 2022.

Exhibit 10: B&O Tax Estimates
Source: CalPortland and ECONorthwest calculations, 2022.

	Estimated Gross Business Income	City B&O Tax Rate	Estimated City Tax Due
City B&O Tax Contribution	$40,000,000	0.0010	$40,000

Utility Taxes

The city levies a business and occupation tax on utilities; however, this tax is passed on to users of the utilities as part of their bills – in this case, payable by CalPortland. The city levies the following rates to the gross receipts of the utility providers:

- Electricity: 6%
- Water: 12%
- Sewer: 6%
- Stormwater: 10%
- Telephone: 6%
- Natural Gas: 6%
- Solid Waste: 8%

CalPortland estimates from its previous spending that the following purchased are made in a typical year:

- Cell Phone: $7,200
- Phone: $10,500
- Electricity: $1,130,000
- Water: $46,000
- Sewer (private): $1,240
- Solid Waste: $15,500

Using these values produces a utility tax estimate of $75,690 in 2022.

Exhibit 11: Utility Tax Estimates
Source: CalPortland and ECONorthwest calculations, 2022.

	Estimated Utility Purchases	City Utility Tax Rate	Estimated City Tax Due
Water	$46,000	12%	$5,520
Sewer	$1,240	6%	$70
Electricity	$1,130,000	6%	$67,800
Solid Waste	$15,500	8%	$1,240
Phone	$17,700	6%	$1,060
Total	$1,210,440		$75,690

Summary of Taxes Generated

The exhibit below summarizes the taxes generated by the mine in 2022. The analysis estimates that the mine generated $180,000 in taxes to the city. This figure represents 2.4% of the city's overall collections of these taxes.

Exhibit 12: Summary Tax Estimates
Source: CalPortland and ECONorthwest calculations, 2022.

Tax	Tax Estimate
Property Tax	$61,613
Sales Tax	$1,870
B&O Tax	$40,000
Utility Tax	$75,690
Total	$179,173

Public Services

Cost Allocation Approach

Public agencies do not typically allocate the costs of their general services (e.g., those supported by general taxes) to individual or classes of taxpayers. These services are all differentially consumed not just between different classes of taxpayers, but are also consumed by non-taxpayers as well (such as a visitor requiring public safety services). However, all taxpayers derived at least some indirect benefit in the form of things like crime deterrence, economic stability, and quality life that accrue a very local, city-specific level.

Given this complex issue, this analysis uses two different approaches to assign some cost "responsibility" to CalPortland's operations to provide some context on this challenging issue. The first approach reasons that residents and businesses derive roughly equal value from city services regardless of how much they may use those services. The second approach uses more specific data proxies to estimate an amount public service use.

The average value approach to estimating a cost allocation to the mine uses the 2022 DuPont Adopted Budget costs divided by number of people and covered employees in the city. The rationale for this approach, while not perfect, provides a simple measure of constituent demand for services, namely that the main recipients of a city's public services (those that are in the general fund) are its resident population and employees of its businesses.

However, this approach may overstate public service demand and costs associated with non-residential development/employees relative to residential land uses. To the extent that service demand and costs related to non-residential development generally or to mining operations specifically are overstated, the projected fiscal surplus to the City could be increased. The analysis uses the 2022 estimated population by the state's Office of Financial Management (10,180 people) and the Puget Sound Regional Council's estimate of covered employment in the city for 2021(5,123). Combined, a population-employment factor of 15,303 is used for this analysis.

The second approach uses more specific data in two key service areas where data is available. The city has been able to provide data on police calls for service near the mine as well as heavy vehicle traffic on the roads.

The cost allocation of approach for the Police Department creates a cost-per-call for service metric by tabulating the average number of calls for service over the five-year time period (2016-2021) across the city. This metric is then applied to calls for service within a police service area that includes the mine.

The cost allocation approach for Street Maintenance portion of the Public Works department is allocated differently. It assumes that 90% (accounting for the pavement related costs) are attributable to vehicle traffic and almost all the roadway wear and tear is attributable to heavy

vehicles. The cost allocation of the Street Maintenance uses roadway counts for heavy vehicles and apportions them based on average daily trips from CalPortland of heavy vehicles.

Cost Allocation Metrics

Using this cost allocation metrics, the following cost per population-employee and cost per use (for police and public works) is derived. This is done by dividing the budget item by 15,303, the population-employment factor for those elements. For police and public works, they are derived on a calls for service basis for police and heavy vehicle trips for streets.

Exhibit 13: Cost Allocation for City of Dupont Public Services
Source: City of Dupont and ECONorthwest calculations

	2022 Adopted Budget	Cost Allocations Per Population-Employee	Cost Allocations Per Use (Police and Public Works)
Mayor/Council	$140,214	$9	$9
Executive	$211,051	$14	$14
City Clerk	$248,611	$16	$16
Human Resources	$274,481	$18	$18
Legal	$129,722	$8	$8
Finance	$303,941	$20	$20
Central Services	$47,900	$3	$3
Information Technology	$80,860	$5	$5
Police Department	$2,643,834	$173	$407
Fire Department	$2,300,405	$150	$150
Community Development	$904,241	$59	$59
Parks, Facilities, and Greenways	$1,104,844	$72	$72
Public Works - Streets*	$616,992	$40	$544

Note: * Streets are allocated on heavy vehicle basis. Police are allocated on calls for sevice.

Cost Allocation to the Mine

Based on the analysis contained in the Traffic Impact Assessment conducted by Heffron Transportation for Pioneer Aggregates, it is noted that 2013 FEIS estimates that a typical day would have 126 employee commute trips (assumed in this analysis to be 63 employees making inbound and outbound trips to the site). Given that this analysis was done in 2013, employee numbers have been estimated at 80 in 2022 for this report. This figure represents 0.5% of the city's overall costs in these areas.

The exhibit below summarizes the cost allocation to mine using the two different methods. The Overall, the average cost approach allocates a smaller cost to the mine than the use approach. However, while the police cost under the use approach allocates a smaller amount than the

average approach, the use approach allocates a relatively larger amount to streets than the average approach.

Exhibit 14: Cost Allocation to Mine – Average and Cost Approach
Source: ECONorthwest, 2022.

	Average Approach	Use Approach
Mayor/Council	$700	$700
Executive	$1,100	$1,100
City Clerk	$1,300	$1,300
Human Resources	$1,400	$1,400
Legal	$700	$700
Finance	$1,600	$1,600
Central Services	$300	$300
Information Technology	$400	$400
Police Department	$13,800	$2,200
Fire Department	$12,000	$12,000
Community Development	$4,700	$4,700
Parks, Facilities, and Greenways	$5,800	$5,800
Public Works - Streets	$9,500	$128,400
Total	$53,300	$160,600

Tax and Cost Allocation Balance

The exhibit below compares tax revenues against public service costs. Based on this analysis, in 2022 revenues generated outpace costs and generate an annual surplus in the range of $18,400 to $125,700. These surpluses represent a cross subsidy to other taxpayers, which by itself, is not an atypical result when looking at narrow land uses. While the methods used in this analysis represents a reasonable approach to conducting the analysis given the information available, some caution should be warranted in consuming the information.

First, it is a single year and taxes and costs can vary from year to year – a surplus in a single year (here, 2022) does not guarantee a surplus in another year when taxes or costs might be different. Second, different measures to allocate costs might produce different cost allocations to the mine. Ultimately, the information provided in this report shed light on the nature of taxation and public services in the city of Dupont and how the specific conditions at the mine contribute to the city's fiscal bottom line.

Exhibit 15: Annual Surplus/Deficit
Source: ECONW calculations, 2022.

	Estimate	Estimate
Taxes Generated	$179,000	$179,000
Allocated Costs	$53,300	$160,600
Surplus/Deficit	$125,700	$18,400

Fiscal Impact under the No Action Alternative

The No Action Alternative assumes no mining on the South Parcel within the context of existing conditions. In this case, the short-term fiscal effects would be similar to those discussed in this analysis since there would be no change in operations and the output of the facility. However, over the longer-term the fiscal effects downstream of mining output limits on the site would be hard to gauge. On the cost side, less mining output would likely impact the largest cost driver to the city (i.e., less wear and tear on city operated streets) but it would also likely impact city revenues as sales taxes, utility taxes, and B&O taxes would decline.

The No Action Alternative also includes a scenario where the site may be developed under existing zoning. Generally, it is understood that zoning of the site could allow approximately 75% Manufacturing/Research Park and approximately 25% Single-Family Residential. The fiscal impact in this scenario will be different than the continued operation of the mine in a couple respects. Regardless, the longer-term downstream fiscal effects of this development would be hard to gauge without a specific proposal. On the revenue side, both manufacturing/research and residential uses represent a more intense use of the land that would lead to more property, sales, and utility, and other taxes on a per square foot basis. However, on the cost side these uses also generate more needs for public services such as public safety services for residential uses and public works needs to support manufacturing uses.