Photo source: NHC (February 2018)

Skagit River Delta Flood Drainage Project
Flood Modeling, Mapping, and Mitigation Analysis

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EXECUTIVE SUMMARY

The Skagit River delta, which includes the cities of Burlington, Mount Vernon, Sedro-Woolley, and extensive areas of highly productive agricultural lands within unincorporated Skagit County, is characterized by minimal topographic variation and elevations close to or below sea level. The topographic setting results in poor drainage and poses flood risks due to riverine flooding sources and coastal storms. Riverine flood risk reduction in the Skagit lowlands is provided by a combination of reservoirs, and levees. Drainage of the area landward of the levees is managed through a system of ditches, pipes, tide gates, and pumps.

Extreme precipitation events have caused major flood damage within the delta, with five of the largest post-regulation floods within the lower Skagit River occurring after 1990. In 2014, the USACE completed the Skagit River Flood Risk Management General Investigation Feasibility Report and Environmental Impact Statement (USACE, 2014) which identified the potential for the Skagit River levees to breach during a 100-year flood and performed a detailed alternatives analysis to identify options for reducing flood risk within the lower Skagit River basin, including the delta region. The alternatives identified by the USACE have not been constructed and Skagit County identified a need to reduce the impacts of flooding within the delta if a dike breach were to occur. The Skagit Delta Flood Drainage Project was initiated by Skagit County as an important step towards addressing this need. The County retained Northwest Hydraulic Consultants (NHC) to provide consulting services for that effort, by providing engineering design services to support projects that will reduce the depth and duration of flooding within the delta under conditions following a Skagit River dike breach, like that predicted by the USACE as likely to occur during a 100-year return period Skagit River flood. NHC's project scope of work includes design of new floodgates at priority sites within the Samish River floodplain that were identified in coordination with Drainage Districts 5 and 25 as well as monitoring, and flood hazard modeling and mapping services. This report includes documentation of the flood modeling, mapping, and mitigation analysis performed for the project.

Two-dimensional (2D) numerical hydraulic modeling was developed as the primary tool for use in characterizing Skagit River delta flood conditions and for evaluation of flood mitigation options as part of the study. That modeling was performed using three models, each covering a separate sub area within the delta: the Samish/Edison/Joe Leary Slough area, the La Conner/Sullivan/No Name Slough area, and the Fir Island area. The US Army Corps of Engineers HEC-RAS software (HEC, 2022) was used for all hydraulic modeling. Inputs required for simulation of flood conditions were developed using observed rainfall, river flow, and tidal water-level datasets as well as Skagit River breach inflow hydrographs developed by USACE (2014).

Observed water-level time-series data, highwater mark elevation data, and photo documentation of flood conditions collected between late 2017 and 2022 served as the primary datasets used for hydraulic model calibration. The project team deployed recorders to collect water-level data at nine locations within the project area. Shortly after deployment of the water-level recorders the February 4-5, 2018 "Superbowl" flood caused heavy flooding along the Samish river floodplain. An inventory of highwater marks and air photo documentation of flood conditions collected within the Samish River vicinity was used to verify the hydraulic model's ability to simulate flood levels and inundation extents that match observed conditions. A second flood, the November 13-15, 2021 flood, also caused flooding within the basin and was also utilized to validate simulated flood inundation extents.

The calibrated flood models were applied to characterize existing conditions and identify problem areas to prioritize for mitigation within each of the three sub areas.

- Within the Samish/Edison Slough/Joe Leary Slough vicinity maximum flood depth and inundation mapping showed that a Skagit River dike breach in the Stirling vicinity would result in a flood wave that would flow primarily northwest where flood waters would be impounded by the sea dike at Samish Bay, primarily on the west side of the Samish River. Simulated flood depths in the Samish vicinity range from 0.5 to 6.0 feet, with maximum inundation durations in the Samish Area of approximately 34 days.

- Within the La Conner/Sullivan Slough/No Name Slough vicinity maximum flood depth and inundation mapping showed that a right bank North Skagit River dike breach near Bradshaw Road would result in a flood wave that would flow north/northwest and inundate most of the area between the breach location and Padilla Bay. Simulated flood depths within this area range from 3.7 to 6.9 feet, with maximum inundation durations of approximately 34 days.

- Within the Fir Island vicinity maximum flood depth and inundation mapping showed that a left bank North Skagit River dike breach west of Dry Slough Road would result in a flood wave that would inundate most of Fir Island. Simulated flood depths within this area range from 7 to 8 feet, with maximum inundation durations of approximately 17 days.

A set of flood risk mitigation solutions was developed for each of the project areas, generally including a combination of installing new or retrofitting existing tide gates, levees, pump stations, closed conveyance (i.e., culverts) and open channel conveyance (i.e., ditches). Solutions were developed and evaluated with the primary goal of enhanced egress for residents during flood conditions.

- Within the Samish/Edison/Joe Leary vicinity a composite alternative scenario allows for reductions of up to 29 percent inundation duration of the Bayview-Edison Road, which is beneficial given its key egress use for many residents of Samish Island.

- Within the La Conner/Sullivan/No Name area a proposed ring levee project shows potential for as much as 3 feet of flood depth reduction within the town of La Conner, including elimination of flooding over Maple Avenue. However, the alternative did increase flood depths by as much as 0.2 feet at areas outside of the town of La Conner and modification to the design could be considered to reduce these increases.

- Within the Fir Island area, the evaluated mitigation solutions are expected to reduce durations of key egress route flooding by as much as 30 percent. The mitigation option that provided the most benefit within this area was addition of new conveyance at the Dry Slough tide gate location.

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1 INTRODUCTION

The Skagit River and its tributaries originate in the Cascade mountains, flowing south and then west towards Puget Sound. The Skagit River delta, formed by alluvial deposits, has nutrient-rich soils that support what is regarded as the most productive agricultural community in Western Washington, covering approximately 68,000 acres of land[1]. Farming within the Skagit River lowlands contributes 25 percent of the world's cabbage and beet seed, and 8 percent of the world's spinach seed (WSU, 2014). Wetlands, estuaries, and tideflats within the delta provide valuable habitat for highly diverse ecosystems. The delta encompasses cities including Burlington, Mount Vernon, Sedro-Woolley, and several other population centers. The Skagit River delta is characterized by minimal topographic variation and elevations close to or below sea level. The topographic setting results in poor drainage and poses flood risks due to riverine flooding sources and coastal storms.

1.1 Flood and Drainage Management in Lower Skagit Basin

Skagit County Surface Water Management administers both the Skagit River Comprehensive Flood Hazard Management Plan (CFHMP) and the Drainage Utility. The CFHMP guides flood control improvements within the County and the Drainage Utility[2] provides a funding mechanism to address drainage and stormwater projects and programs that otherwise would not have a funding source or would be too large of a burden for individual residents.

Riverine flood risk reduction in the Skagit lowlands is provided by a combination of reservoirs and levees. In the upper watershed, Ross Dam provides 120,000 acre-feet of flood storage and Upper Baker Dam provides up to 74,000 acre-feet. The dams provide flood regulation by storing floodwaters and releasing the water after the flood peak has passed through the delta. The USACE manages the flood regulation operations at both dams through agreements with Seattle City Light (the Skagit River Project) and Puget Sound Energy (the Baker River Project). Together, the existing flood regulation at the two dams can reduce the 100-year return period peak flow by nearly 50,000 cfs at the town of Concrete (USACE, 2014).

A system of approximately 50 miles of levees and 39 miles of sea dikes in the lower basin is overseen by diking districts. The levee systems along the Skagit River generally have the capacity to contain an approximately 20-year return period flood. The diking districts manage the dike systems within the boundaries of their districts. The dike systems play a role in prolonging flooding by preventing drainage from precipitation that falls within the Delta from running off to the sea or into a river or slough. Addressing the 'interior drainage' of the regions within the dike system is an important aspect of the design of these systems and is a central focus of this study. The Skagit River delta also includes drainage and irrigation districts that manage this drainage infrastructure that is designed to convey drainage and floodwaters off the agricultural lands, through dikes and levees and out to receiving waters by way of

[1] https://www.skagitcounty.net/Departments/Flood/hazard.htm

[2] https://www.skagitcounty.net/Departments/PublicWorksSurfaceWaterManagement/drainageutility.htm

ditches, gates and pumps. Dike, drainage, and irrigation districts in the Skagit basin tax themselves to fund maintenance of their infrastructure. Mapping of both Skagit County drainage and diking district boundaries are available online[1].

1.2 Skagit River Flooding and USACE General Investigation

Extreme precipitation events have caused major flood damage in the Skagit River Delta. Five of the largest post-regulation floods within the lower Skagit River occurred after 1990. These include the following, based on the USGS Skagit River near Mount Vernon, Station# 12200500, flow record:

- November 25, 1990 152,000 cfs
- November 30, 1995 141,000 cfs
- November 7, 2006 138,000 cfs
- October 21, 2003 135,000 cfs
- November 16, 2021 127,000 cfs

In the early 2000's, the USACE and Skagit County initiated efforts to evaluate flood hazards within the lower Skagit River basin and develop solutions to reduce flood impacts. In 2014 the USACE completed the Skagit River Flood Risk Management General Investigation Feasibility Report (GI Study) and Environmental Impact Statement (USACE, 2014) that included an alternatives analysis to reduce flood risk within the lower Skagit River basin. That study identified as its Tentatively Selected Plan (TSP) what was called the Comprehensive Urban Levee Improvement (CULI) Alternative. This alternative would provide flood risk reduction for the urban areas of Burlington and Mount Vernon by raising existing levees along the Skagit River and constructing a new Burlington Hill Cross Levee along the eastern and northern edges of Burlington.

1.3 Purpose

One flood mitigation effort related to the CULI alternative – the Skagit River Bridge Modification and Interstate Highway Protection – was initiated by Skagit County in coordination with WSDOT. The project was aimed at raising and setting back levees within the "Three Bridges Corridor" to reduce the flood risk to I-5, SR 20, SR 536, and the Burlington Northern Railroad. For various reasons the identified levee improvement projects within the urban corridor have not been constructed. Instead, Skagit County redirected the efforts of the Skagit River Bridge Modification and Interstate Highway Protection Project to reducing flood impacts within the Skagit River delta, with the intent of reducing the depth and duration of flooding within the delta if a Skagit River dike breach were to occur. A Skagit River dike breach would result in heavy inundation and incur damages to the properties, livestock, infrastructure, and overall community residing on the Delta. The County retained Northwest Hydraulic Consultants

[1] Drainage Districts https://www.skagitcounty.net/GIS/Documents/Drainage/drain.pdf
Diking Districts https://www.skagitcounty.net/GIS/Documents/Drainage/dike.pdf

(NHC) to provide consulting services for that effort. For clarity, this phase of the resulting project, which is described herein, was subsequently renamed the Skagit River Delta Flood Drainage Project.

One-way tide gates have been installed to allow drainage during a low tide cycle while keeping saltwater from flowing in the landward direction. Skagit County is proposing to install additional flood relief structures (i.e., tide gates and/or flood gates) to improve interior drainage and flood relief in the event of a severe river flood and/or Skagit River dike breach scenario commensurate with the 100-year return period flood. Generally speaking, tide gates imply a connection to saltwater and flood gates freshwater, however, for the purposes of this report the terms tide gates and flood gates are used interchangeably.

The primary objectives of this project were to:

1. Identify locations for new flood relief structures that will reduce the magnitude and/or duration of flood impacts within Skagit River delta resulting from a dike breach that is likely to occur during a 100-year return period Skagit River flood (referred to hereafter as a 'Skagit River 100-year dike breach'. This report is provided as the documentation of the flood modeling, mapping, and analysis that was used to meet this objective. Other supporting documents completed as part of the project are also attached.

2. Develop designs for priority flood relief structures within the Skagit River delta. These design efforts are documented separately but were supported by the modeling documented in this report.

1.4 Study Area and Coordination with Drainage Districts

The project study area, shown in Figure 1.1, comprises the entirety of the Skagit River delta, including the low-lying areas bounded by the town of Sedro-Woolley in the northeast, the Skagit River on the east, Conway on the southeast, Skagit Bay to the southwest, the Swinomish Channel to the west, and Samish and Padilla Bays to the northwest. Initially the project was focused on three priority flood drainage project sites within the Samish area but then was expanded to include hydraulic modeling and evaluation of flood drainage opportunities near Edison Slough, Joe Leary Slough, La Conner/Sullivan Slough, and Fir Island. The urbanized areas of Mt. Vernon and Burlington were not a focus of the study; however, some data was exchanged with a Skagit County Drainage and Irrigation District #17 led flood mitigation planning study of the Maddox Creek and Big Ditch system, which did include portions of Mt. Vernon (NHC, 2019).

Due to their role operating and maintaining the drainage infrastructure in the delta, coordination with drainage districts was central to the success of the project. The project team met with drainage commissioners throughout the study, asking for feedback on locations with drainage issues as well as coordinating on identifying locations for new flood drainage infrastructure. Figure 1.1 includes boundaries of the drainage districts responsible for drainage infrastructure within the Skagit River delta. Some diking districts are also shown in areas where there is no drainage district, but a diking district exists.

In September 2017, following shortly after the initiation of this project, twelve Skagit County Drainage and Irrigation Special Purpose Districts[1] formed the Skagit Drainage and Irrigation Districts Consortium (Skagit Consortium). All of the Districts that were engaged as part of this project are members of the Skagit Consortium, and as a result, in June 2018 the Skagit Consortium became an important partner in this project with regards to communication with individual districts.

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[1] The twelve Skagit Consortium members include: Dk. 03; Dk. Drn. and Irr. 5, Dk. Drn. and Irr. 12; Drn. and Irr. 14, Drn. and Irr. 15, Drn. and Irr. 16, Drn. and Irr. 17, Drn. and Irr. 18, Drn. and Irr. 19, Drn. and Irr. 22, and Dk. Drn. And Irr. 25. (Abbreviations used in this list, Dk. for Dike, Drn. for Drainage, and Irr. for Irrigation. "Improvement" excluded from names for sake of brevity)

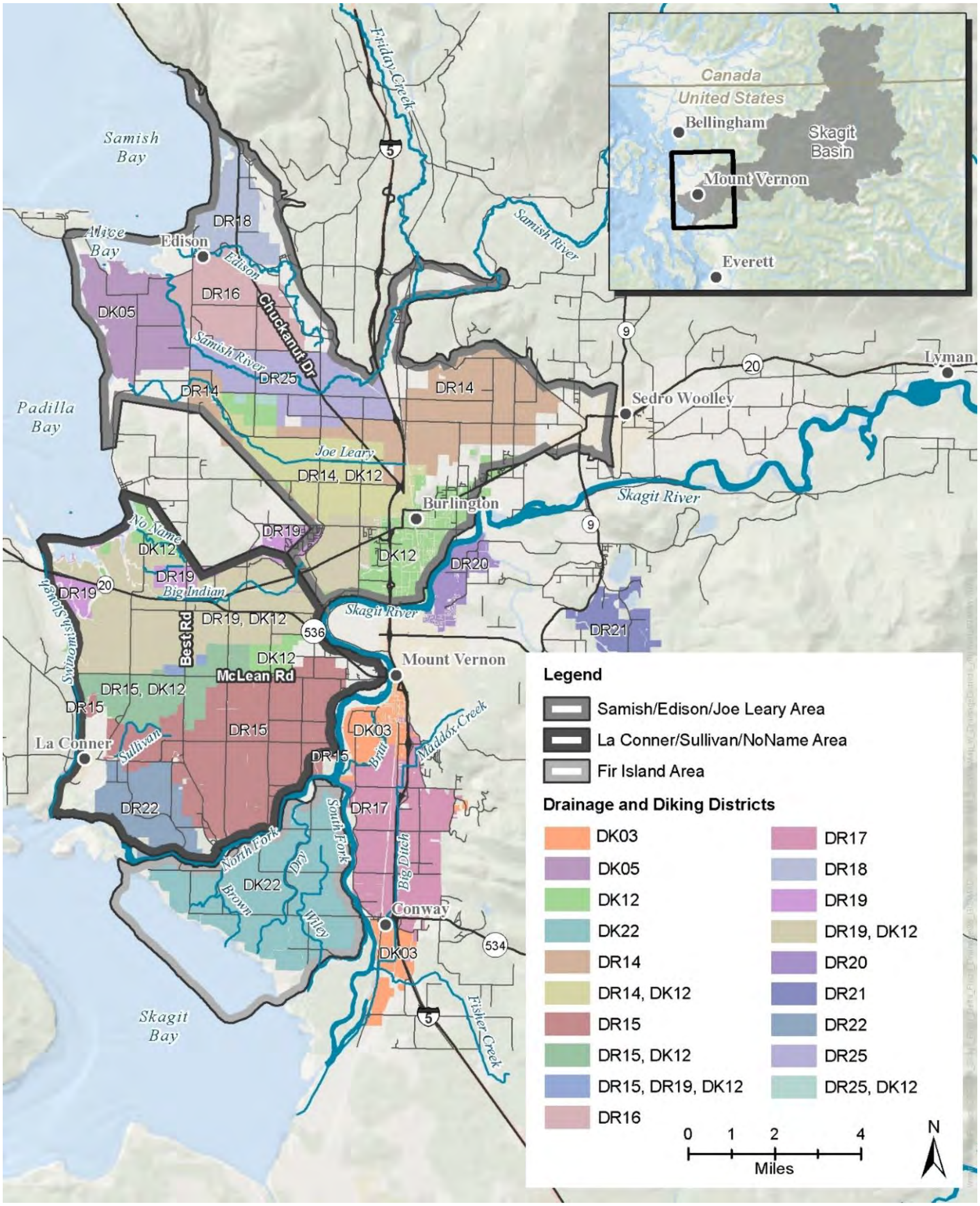

Figure 1.1 Study Focus Areas and Drainage and Diking District Boundaries.

1.5 Scope of Work and Report Outline

This project was executed as two sets of Task Assignments.

The first Task Assignment was initiated in September 2017 and was primarily focused on design of new floodgates at three priority sites within the Samish River floodplain that were identified in coordination with Drainage Districts 5 and 25. The first Task Assignment also included planning tasks that included monitoring, and flood hazard modeling and mapping. All permit coordination associated with design efforts for the project were performed by the Skagit County staff. The focus of this report is documentation of the hydraulic modeling and mapping effort, however, because this is the most substantial document developed as part of the project it is also used here to reference other deliverables developed as part of this project.

The Samish area priority design sites were located at Samish Bay and along the left bank of the Samish River. The site in Samish Bay, called the Bayview Edison North site, currently has no culverts or tide gates and the proposed project includes installation of new culverts and tide gate structures. The two sites along the bank of the Samish River (called Bayview Edison South and Farm to Market) have existing culverts and tide gates and the proposed project includes adding new culverts and tide gate structures. As currently planned, the new flood relief structures will consist of multiple new 4-foot-diameter corrugated polyethylene pipes (CPPs) with seepage collars and side-hinged tide gate doors. The floodgates are designed to allow basin floodwaters to drain to the Samish River or Samish Bay and prevent back-flow from these water bodies during high tides.

In September 2020 a second set of Task Assignments was initiated. These included detailed design of a new tide gate structure at Alice Bay, monitoring of the Edison Slough Tide Gate structure, design of a vortex breaker for the Britt Slough Pump Station, and a flood mitigation assessment for West Edison Lane which was ultimately deferred.

This report, which documents the flood modeling, mapping, and mitigation analysis performed for the project, is structured in five major sections:

- Section 2, Hydrometric Monitoring and Post Flood Observations – Provides a high-level description of the hydrometric monitoring and post-flood observations performed as part of the project.
- Section 3, Flood Hydrology – Provides a description of the analysis performed to develop flow inputs for hydraulic modeling.
- Section 4, Flood Model Development – Provides documentation of the development and calibration of a HEC-RAS 2D model of the Skagit River delta.
- Section 5, Flood Model Results and Proposed Mitigation Measures – Provides documentation of the model results, flood inundation mapping, and evaluation of proposed mitigation measures.
- Section 6, Conclusions and Recommendations.

Three appendices provide supplemental information developed in support of flood modeling, mapping, and analysis:

- Appendix A – Flood Observation and other Photographs
- Appendix B – High Water Mark Inventory Following November 2021 Flood Memorandum
- Appendix D – Supplemental Figures of Simulated Flooding

Memoranda and reporting not directly associated with flood modeling, mapping, and analysis are attached as the following appendices:

- Appendix E – Samish Area Flood Mitigation Basis of Design Report
- Appendix F – Alice Bay Tide Gate Basis of Design Report
- Appendix G – Edison Slough Monitoring and Recommendation Memorandum
- Appendix H – Britt Slough Pump Station Vortex Breaker Design
- Appendix I – Tide Gate Types and Performance Summary

1.6 Skagit Delta Tidegates and Fish Initiative

Maintenance of existing drainage infrastructure within the Skagit River delta is guided by a key document called the Skagit Delta Tidegates and Fish Initiative (WWAA, NMFS, and WDFW, 2008), hereafter referred to as the TFI. The TFI states that:

- Its purpose is that of "*identifying pathways and protocols for federal, state and local permitting of tidegate and floodgate repair and replacement activities within the Skagit and Samish River deltas. This Agreement will address actions at tidegate and floodgate sites that are under the ownership or control of Drainage, Diking, and/or Irrigation Districts that are Parties to this Agreement.*"

  and

- The agreement *"will facilitate the achievement of functional estuarine habitat restoration within the Skagit delta area in a manner that will result in the least possible impact to established agricultural lands in the Skagit Delta, and their related drainage infrastructure. The Implementation Agreement stipulates that up to 2,700 acres of delta agricultural lands may be converted to estuarine habitat, and that such conversion, when and where appropriate, will be undertaken in a manner consistent with the objectives of the Skagit Chinook Recovery Plan, as approved and adopted by NMFS in December 2006."*

The TFI provided an important inventory of existing flood drainage infrastructure within the delta and a guideline for design of replacement flood gates as maintenance measures. New gates designed at locations where gates do not currently exist, were permitted outside of the TFI document framework.

2 HYDROMETRIC MONITORING AND POST FLOOD OBSERVATIONS

2.1 Hydrometric Monitoring

NHC conducted hydrometric monitoring to support hydraulic model development and analysis. A summary of the monitoring sites is provided in tabular and visual form via Table 2.1 and Figure 2.1, respectively. With the exception of a focused monitoring effort at Edison Slough (see Appendix G), water level was the only metric monitored. The locations of three Edison Slough monitoring sites are shown on Figure 2.1, but these were not used directly for hydraulic modeling described in this report.

Table 2.1 Monitoring Stations

Watercourse	Station	Monitoring Period
Samish River	Bayview Edison Road[1]	Nov. 2017 – Mar. 2018
	Farm to Market Road[2]	Nov. 2017 – Mar. 2018
	Thomas Road[3]	Nov. 2017 – Dec. 2022 (ongoing)
	Chuckanut Drive[2]	Nov. 2017 – Mar. 2018
Alice Bay	Downstream of sea dike[2]	Jul. 2021 – Sep. 2021
Joe Leary Slough	Upstream of sea dike[2]	Nov. 2018 – Jan. 2019
	Downstream of sea dike[2]	Nov. 2018 – Jan. 2019
Edison Slough	Upstream of sea dike[2] Downstream of sea dike[2] Other (see Appendix G)	Oct. 2020 – Jul. 2021

[1] Two water-level sensors were deployed at Bayview Edison Road, one was deployed within a stilling well attached to the bed on the right bank upstream of the bridge and the other was attached to a weight that was deployed from the bridge.

[2] Water-levels at Farm to Market Road, Chuckanut Drive, Alice Bay, Joe Leary Slough, and Edison Slough Main Avenue were recorded using pressure transducers within stilling wells attached to the bed.

[3] Water-levels at Thomas Road are measured by a downward looking distance sensor mounted to the bridge. Data from this station was telemetered to an on-line portal throughout the duration of the study.

Monitoring data from the National Estuarine Reserve Research Center (NERRC)[1] is also being collected within Padilla Bay and specifically Joe Leary Slough. The data at NERRC Centralized Data Management Office Padilla Bay Joe Leary Estuary Station PDBJEWQ (2001-2018) station (ID# 19 on Figure 2.1) was used for model calibration discussed in Section 5.2.4, but the three other NERRC stations shown on Figure 2.1 (ID# 16 PDBBYWQ, ID# 17 PDBBPWQ, and ID# 18 PDBGSWQ) were not used directly and are included for reference only.

[1] https://cdmo.baruch.sc.edu/dges

National Oceanic and Atmospheric Administration (NOAA) observed tide data at Cherry Point, WA station (Station ID: 9449424)[1], located south of Birch Bay, was used directly and indirectly for the model development as discussed further in Section 4.3.2.

Flow monitoring performed by NHC on behalf of the Skagit County Drainage and Irrigation Improvement District 17 as part of the Maddox Creek/Big Ditch Alternatives Evaluation study (NHC, 2019) is also shown on Figure 2.1 as those data served as a validation of the HSPF hydrology model parameters. The use of these data is discussed in further detail in Section 3.3.1.4. Water-level data collected downstream of the Big Ditch gates shown on Figure 2.1 (ID# 15) is also included for reference only and was not used directly in the current study.

[1] https://tidesandcurrents.noaa.gov

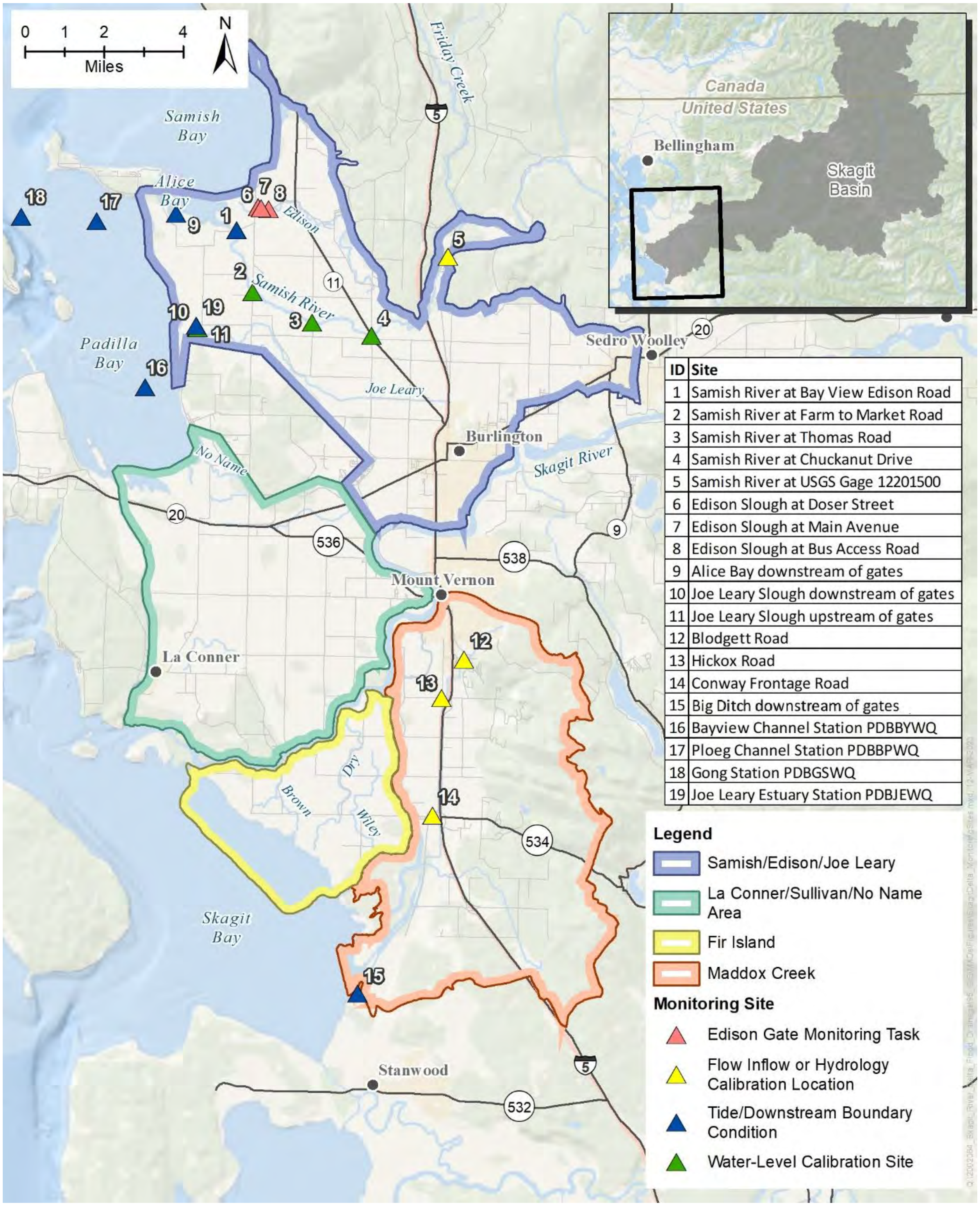

Figure 2.1 Monitoring sites within the study focus areas.

2.2 Observations of the February 2018 Flood

Between the 4th and 5th of February 2018, a westerly wind delivered 2.5 inches of rainfall within a 24-hour period[1] that resulted in heavy flooding along the Samish river floodplain known locally as the Superbowl flood of 2018. Peak flows observed at the USGS Samish River near Burlington Station 12201500 reached 5,840 cfs, the fifth largest peak within the 65-year record for the station. Water-levels at the project's hydrometric monitoring station at Thomas Road reached an elevation of 17.7 feet (NAVD 88). High water levels at the Samish river eventually caused a dike breach to form on the river's left bank approximately one-half mile downstream of Thomas Road that exacerbated the flood condition in that area.

NHC deployed staff to collect high-water marks within the Samish River basin during the flood and on the days following. On February 8, 2018, a fixed wing plane was used to collect imagery of inundation extents within the floodplain and UAV imagery in the vicinity of the dike breach downstream of Thomas Road was also provided by a third party. Application of the collected high water-mark and hydrometric monitoring data to hydraulic model calibration to the 2018 flood is discussed in detail in report Section 4.6.1. Two example photographs of flood inundation collected from the fixed wing aircraft are provided as Photo 2.1 and

Photo 2.2. A collection of nine different 2018 flood observation photo sets focusing on different areas within the Samish River and Edison Slough regions is included in Appendix A.

 

Photo 2.1 Looking south across at Samish River dike breach from above a location near 15014 Field Road February 8, 2018, during flood (left).

Photo 2.2 Looking south along Bayview Edison Road toward Padilla Bay from above a location near Sullivan Road, taken February 8, 2018 (right).

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[1] WSU AgWeatherNet Sakuma Station (https://weather.wsu.edu)

2.3 Observations of the November 2021 Flood

During the month of November 2021, a series of atmospheric river weather patterns created extreme flooding conditions through Skagit and Whatcom Counties. Between the 13th and 15th of November approximately 2 inches of rainfall fell on the Skagit River lowland region and nearly 7.2 inches of rainfall fell in the upper watershed near Lake Samish (within a 48-hour period)[1]. Skagit County requested that NHC collect high-water marks of the Skagit River upstream of Interstate-5, which are documented in Appendix B. While fixed wing flights were not initiated as part of the project following the November 2021 flood, some limited photography of the study area was collected as part of independent efforts (e.g., extensive flooding at Allen is shown in Photo 2.3) and as part of the high-water mark inventory field activities (e.g., Photo 2.3). These and a limited number of other photos documenting the November 2021 flood are included in Appendix A.

Photo 2.3 Samish River flooding at Allen, taken November 16, 2021 (left).

Photo 2.4 Looking south along Petit Street in Hamilton across Careys Creek toward Skagit River, taken November 15, 2021 (right).

3 FLOOD HYDROLOGY

The three primary sources of flood waters considered as part of flood modeling discussed in Sections 4 and 5 of this report include: dike breach inflows leaving the Skagit River during the 100-year riverine flood, inflows from the upper Samish River, and local runoff within the Skagit River delta. When evaluating conditions that include a Skagit River dike breach, that flow source is much larger than the other two combined. The approaches used to characterize these sources for the purposes of the flood modeling required of this study are described in this section.

[1] MesoWest Station E7158 located east of Lake Samish near Lake Whatcom (https://mesowest.utah.edu/)

3.1 Skagit River Dike Breach Inflows

Selection of potential Skagit River dike breach locations was consistent with the respective physical locations identified within the GI Study for the various study areas. Locations were verified with County staff where anecdotal information was available. Various GI study breach locations were examined to determine the breach resulting in the worst-case scenario related to flood impacts for a given study area, which were then used in the identification of problem areas mitigation measures (Section 5). Selected breach inflow characteristics are summarized in Table 3.1 below and shown spatially via Figure 3.1. The division of hydraulic modeling areas shown in Figure 3.1 is discussed in further detail in Section 4.2.1.

Although not identified within the GI Study, a North Fork Skagit River right bank breach was considered for flood modeling within the La Conner area, consistent with design documentation available for the Town of La Conner Dike Protection project (CHS, 2016). Levee and floodplain ground elevations were used in determination of a most likely right bank breach location near Bradshaw Road. The Fir Island North Fork Skagit River breach hydrograph was assumed to be representative for this location and resultant water levels validated with design WSELs for the Dike Protection project (see Section 4.6.2). Application of this breach scenario was determined as worst-case, and is therefore used for the purposes of this study.

Table 3.1 Breach locations from GI Study. Note, for the La Conner study area, the breach hydrograph used was identical to that of Fir Island, with the breach applied to the right bank of the North Fork.

Study Area	Damage Reach ID[1]	Model RM[1]	Physical Location	Peak Flow (cfs)
Samish / Edison / Joe Leary	1	RM 21.3	Skagit River mainstem Right Bank near Lafayette Road	37,259
Fir Island	3	RM 8.3	Skagit River North Fork Left Bank west of Dry Slough Road	23,988
La Conner / Sullivan / No Name	3	RM 6.4	Skagit River North Fork Right Bank near Bradshaw Road	23,988

[1] From GI Study

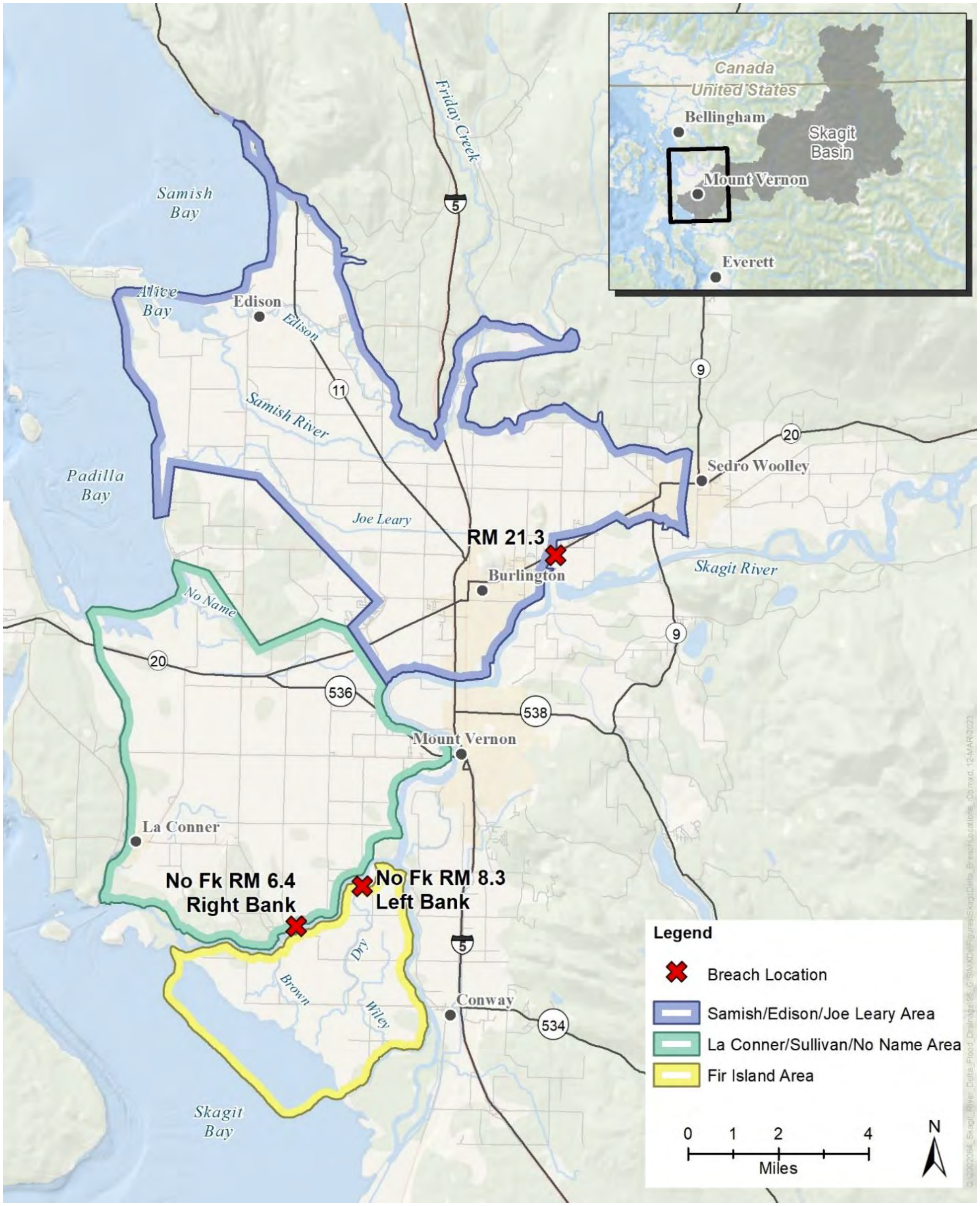

Figure 3.1 Dike breach locations in the model areas.

3.2 Inflows from Upper Samish River

Inflows from the upper Samish River are obtained from USGS monitoring station 12201500 located upstream of the Old Highway 99 North bridge crossing in Belfast, Washington. This station provides sub-hourly data for discharge and river stage dating back to October 1996 and October 2007 respectively.

3.3 Local Runoff within Skagit River Delta

NHC developed a hydrologic model using version 12.5 of the USEPA's Hydrologic Simulation Program Fortran (HSPF) program (Donigian, 2018) to determine runoff inflows from local rainfall within the study area, the model also includes some upland areas west of the study area near the City of Mount Vernon (e.g., Fisher Creek). Validation of the model's ability to match observed runoff volumes was limited to data within the Maddox Creek basin that was performed as part of the Maddox Creek/Big Ditch Alternatives Evaluation (NHC, 2019), see Section 3.3.1.4.

The HSPF model was applied to develop local runoff inputs for hydraulic modeling discussed in Sections 4 and 5 using two approaches for flow routing:

- For flood modeling that targeted improving conveyance conditions during more frequent floods the spatial variability of local runoff has important implications on model results, so runoff was routed sub-basin by sub-basin between the HSPF hydrology model and the hydraulic model by defining internal flow boundary conditions within the HEC-RAS 2D model domain. Use of this approach was limited to the Joe Leary Slough channel improvement alternatives discussed in Section 5.2.4 because it utilized the 10-year return period flood as the local runoff input. Due to the widespread flooding expected during a Skagit River 100-year flood, the sub-basin by sub-basin runoff routing method was not used primarily because there will be less variability in runoff conditions than during smaller floods due to the fact that the soils will be fully saturated. A secondary reason this method was not applied to the Skagit River 100-year dike breach simulations is provided below.

- For flood modeling that targeted reducing flood depths and durations following various possible dike breaches that are considered likely during a Skagit River 100-year return period flood within the Samish, La Conner, and Fir Island areas, a simpler (relative to the sub-basin by sub-basin routing approach) unit area runoff approach was used to apply local runoff inputs to the hydraulic model. This simple method was used because the relatively small spatial differences in local runoff rates that are ignored by the approach do not affect hydraulic modeling conclusions.

A secondary reason that sub-basin by sub-basin flow routing was not used for evaluation of the Skagit River 100-year dike breach simulations is that Version 5.0.3 of the HEC-RAS 2D hydraulic model, which was the latest available at the time the project initiated hydraulic modeling of the Samish area in early 2018, did not yet include the ability to define internal flow boundary conditions, a requirement for defining separate sub-basin inputs within the 2D model domain. This feature was first added to HEC-RAS with Version 5.0.4, which was released in May 2018. Within Version 5.0.3 a uniform local runoff rate can be defined across the 2D model domain. When the Joe Leary Slough model application initiated in 2019, Version 5.0.7, which includes the ability to define internal flow boundary conditions, was available and use of this relatively new feature was determined necessary to properly characterize the spatial distribution of the smaller flow inputs assessed as part of that effort. As noted later in Section 4.5, Version 6.2 of the HEC-RAS 2D model was used for the final hydraulic model simulations of the Skagit River 100-year dike breach scenarios. While Version 6.2, which was released in March 2022, does include the ability to define internal flow boundary conditions, it was decided that the simplified approach for defining local runoff flow inputs was still appropriate for these applications.

3.3.1.1 Basin Delineation

Drainage area delineations and routing were developed as part of this project and the Maddox Creek/Big Ditch Alternatives Evaluation. Sub-basin boundaries shown in Figure 3.2 were refined as needed using stormwater conveyance data, field observations, topography (Puget Sound LiDAR Consortium, 2017), and 2017 orthoimagery (USDA, 2017). In general, the HSPF model includes the areas west of the Nookachamps basin, a divide located approximately 1-3 miles west of Highway 9. The model does not include any areas north of Edison Slough or upstream of the USGS Samish River near Burlington Station 12201500 in the Samish River basin.

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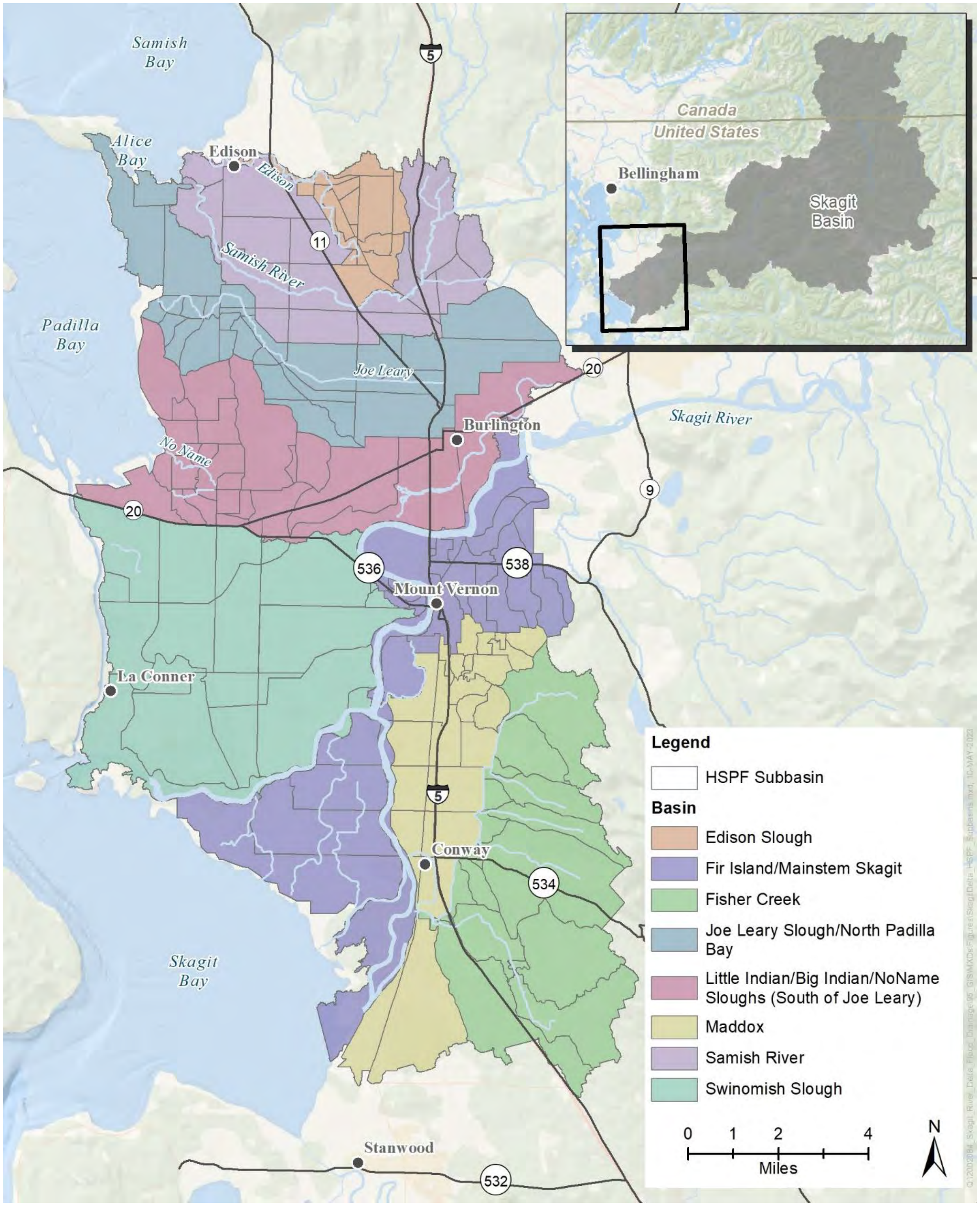

Figure 3.2 HSPF Model basins and sub-basins.

3.3.1.2 Land Surface Representation

HSPF uses distinct types of hydrologic response units (HRUs) to represent runoff generation from different types of land surfaces. Each HRU represents a unique combination of land cover and soil/geology type that produce different runoff responses. A GIS overlay process was used to process the individual land surface datasets to compute areas of each HRU by model sub-basin for input to HSPF.

Land use was delineated within the project area using GIS datasets of 2016 regional land cover (NOAA, 2016), comprehensive plan and zoning designations for the cities of Mount Vernon and Burlington as well as Skagit and Snohomish Counties, and 2017 orthoimagery (USDA, 2017). Land use classifications were used to compute percent pervious and effective impervious area (EIA) based on EIA percentages defined in the Snohomish County Drainage Needs Report Hydrologic Modeling Protocols (Snohomish County, 2002). Table 3.2 provides pervious cover and EIA percentages defined for each land use designation and a GIS map of the designations is provided in Appendix C as Figure C-1.

Table 3.2 Land use designations.

Land Use	Percent Forest	Percent Pasture	Percent Grass	Percent EIA
Forest	100	0	0	0
Pasture	0	100	0	0
Grass	0	0	100	0
Rural	0	100	0	0
Single Family Residential - Low	0	0	97	3
Road	0	0	14.5	85.5
Single Family Residential – Medium	0	0	90	10
Single Family Residential - High	0	0	70	30
Multi-Family Residential	0	0	52	48
Commercial	0	0	14.5	85.5
Water	0	0	0	100

Pervious areas were further characterized by overlaying soils data from the Natural Resources Conservation Service's (NRCS) Soil Survey Geographic (SSURGO) Database (NRCS, 2019). SSURGO soil units were reclassified as either till, outwash, Custer-Norma, or saturated soil types (Appendix C, Figure C-2), which are commonly used for HSPF modeling in this region. Soil types were then overlain with the land covers described above to determine the distribution of unique HRUs (PERLNDs and IMPLNDs in HSPF) within each sub-basin. Characteristic regional parameters previously developed by NHC for the Snohomish County Hydrologic Modeling Protocols (Snohomish County, 2002) were used to define land surface runoff parameters by HRU type. The Snohomish County (2002) parameters are similar to those originally established by the USGS (Dinicola, 1990), with minor differences, most notably for this study was the inclusion of a pasture land cover type that was used to characterize agricultural areas within the study area. The Snohomish County (2002) parameters used by the HSPF model are included in Appendix C as Table C-1.

3.3.1.3 Meteorology

Precipitation and evaporation data were input to the model and run at a 15-minute time-step to generate a continuous runoff time series from January 1, 1956 to April 18, 2019. Precipitation datasets were obtained from the National Oceanic and Atmospheric Administration (NOAA) Burlington station for the period of January 1, 1956 through November 30, 1993 and from the WSU AgWeatherNet Mount Vernon station for the period of December 1, 1993 to April 18, 2019. Data from the WSU AgWeatherNet Sakuma station was also used for simulation of the February 2018 flood conditions due to its closer proximity to many of the areas modeled within the delta.

Table 3.3 Precipitation time series sources.

Time Series Period	Precipitation Data Source
01/01/1956 – 11/30/1993	NOAA Burlington Station
12/01/1993 – 04/18/2019	WSU AgWeatherNet Station

The model uses a daily pan evaporation data time series developed based on the Puyallup Experimental Station record for the period 1961 through 1997. The period before 1961 and after 1997 were filled with monthly average values calculated from the available observed record at Puyallup Experimental Station.

3.3.1.4 Validation of Simulated Runoff Volumes

Due to the focus of the Skagit Delta Flood Drainage Project on the 100-year Skagit River flood event, a decision was made not to perform flow monitoring within the delta region. However, because the same HSPF model inputs and parameters were also used for the Maddox Creek/Big Ditch Alternatives Evaluation study, the validation that was performed to observed flow data on Maddox Creek as part of that concurrent effort provides an indirect validation of the model's performance for the delta study as well.

Observed flow data was collected on Maddox Creek at Blodget Road, Hickox Road, and Conway Frontage Road between November 28, 2018 and May 29, 2019[1]. The locations of these monitoring sites were shown previously on Figure 2.1 in Section 2.1 as ID#'s 12, 13, and 14 respectively. The HSPF model validation focused on the December 28-30, 2018 storm event, the largest during the Maddox Creek flow monitoring effort. Figure C-1 in Appendix C show that the average HSPF flows were approximately 11 percent and 15 percent lower than observed at the Blodget and Hickox Road monitoring sites

[1] Blodget Road flow monitoring included the period December 5, 2018 through May 29, 2019, Hickox Road flow monitoring included the period November 28, 2018 through January 8, 2019, and Conway Frontage Road flow monitoring data was lost due to vandalism at the hydrometric monitoring site.

respectively. The reader is referred to the NHC (2019) for further discussion of the HSPF model validation.

While the HSPF model parameters defining runoff response from the land surface are identical between the delta modeling and that performed for the Maddox Creek study, there are minor differences between the two applications. Most notably, the Maddox Creek basin includes significant stormwater flow control infrastructure (e.g., stormwater ponds) that do not exist in the areas that are the focus of the delta study. The HSPF model application utilized for the Maddox Creek study includes detailed routing through these facilities that was ignored for the delta applications (both the simplified approach used for the Samish, La Conner, and Fir Island areas and for the Joe Leary Slough application which included sub-basin routing).

3.3.1.5 Local Runoff Routing

As noted previously, a simplified approach was used for local runoff flow routing for flood modeling applications that targeted reducing flood depths and durations following a Skagit River 100-year dike breach (i.e., the Samish, La Conner, and Fir Island areas). In these areas a single unit area runoff rate time-series (units of inches per hour) was applied across the entire HEC-RAS 2D model domain. The runoff rate was calculated as a percentage of the precipitation time-series at each hour. The percentage, 25 percent, was calculated as the average of the HSPF simulated pasture landcover on till (i.e., high runoff) soils during the wet February 2018 storm period. The percentage ignores the groundwater component of runoff referred to as AGWO within the HSPF model.

As noted previously, the Joe Leary Slough drainage assessment included routing HSPF simulated runoff from individual sub-basin to input locations within the HEC-RAS mode's 2D domain. A total of 23 sub-basin inputs were used for the model, the boundaries of which are the areas identified as "Joe Leary Slough/North Padilla Bay" in Figure 3.2, which was presented previously.

4 FLOOD MODEL DEVELOPMENT

Hydraulic modeling was used to examine flood conditions during dike breach scenarios, determine areas of high flood risk, and examine performance of both potential future mitigation measures and those currently in design.

4.1 Prior Modeling Efforts and Baseline Flood Model

There have been several hydraulic models applied within the study area in recent years. These include:

- Skagit River General Investigation, 1 Dimensional HEC-RAS and 2 Dimensional Flo-2D models.
- U.S. Army Corps of Engineers (Corps), coupled 1 and 2 Dimensional HEC-RAS model.

A public records request was made to the Corps for the coupled 1 and 2-dimensional hydraulic model of the lower Skagit River noted above. This model included a coarse representation of the Skagit River Delta, providing the baseline model for this project. The following sections describe updates to this model for greater resolution within the study area.

4.2 Geometry

4.2.1 Model Domain

Based on review of existing topography and flowpaths estimated from the baseline model, it was determined appropriate and optimal for model run times to split up the model into three separate model domains: Samish, Fir Island, and La Conner areas (Figure 3.1). The Joe Leary Slough area is included in the Samish area but was also modeled separately for evaluation of several Joe Leary Slough specific mitigation measures.

The Samish area model (Figure 4.1) includes the areas north of Mount Vernon and west of the Skagit River (excluding the river), including the lower Samish River floodplain, Edison Slough, and Joe Leary Slough. The model domain extends to nearshore areas within Samish and Padilla Bays. Evaluation of mitigation solutions was focused within the Samish Bay drainage. A secondary version of the Samish area model was also created that was coupled to the La Conner area model where the two model areas adjoin near Avon for existing conditions flood inundation mapping and problem area identification (see Section 5.1.1). Through testing of that model it was confirmed that, while floodwaters do flow from the Samish area into the La Conner area model domain, the two model areas can be run independently for alternatives analyses of flood relief measures near Samish and Padilla Bays and along the Samish River.

The La Conner area model includes the area north of the North Fork of the Skagit River and west of the mainstem of the Skagit River (excluding the rivers), including Sullivan Slough and No Name Slough. The model domain is bounded by nearshore areas of Padilla and Skagit Bays to the north and south respectively, where the terrain was low enough to use deep-water tidal time-series as a boundary. The entire reach of the Swinomish Channel, which forms the western edge of the area is also included (see Figure 4.2).

The Fir Island area model includes the area between the south and north forks of the Skagit River (excluding the rivers) and extends to the nearshore area within Skagit Bay, where the terrain was found to be low enough to use deep-water tidal time-series as a boundary (see Figure 4.3).

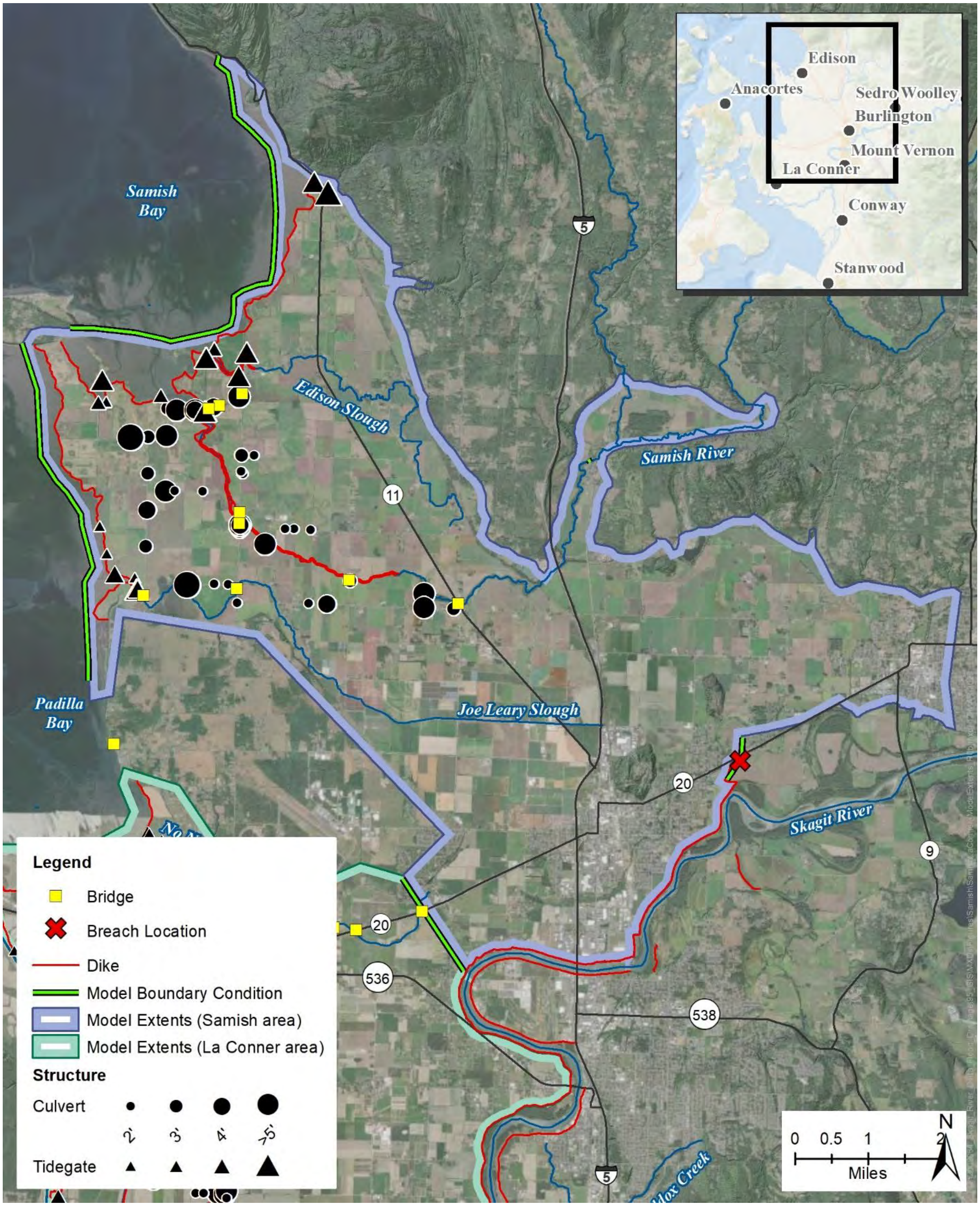

Figure 4.1 Samish model domain and features.

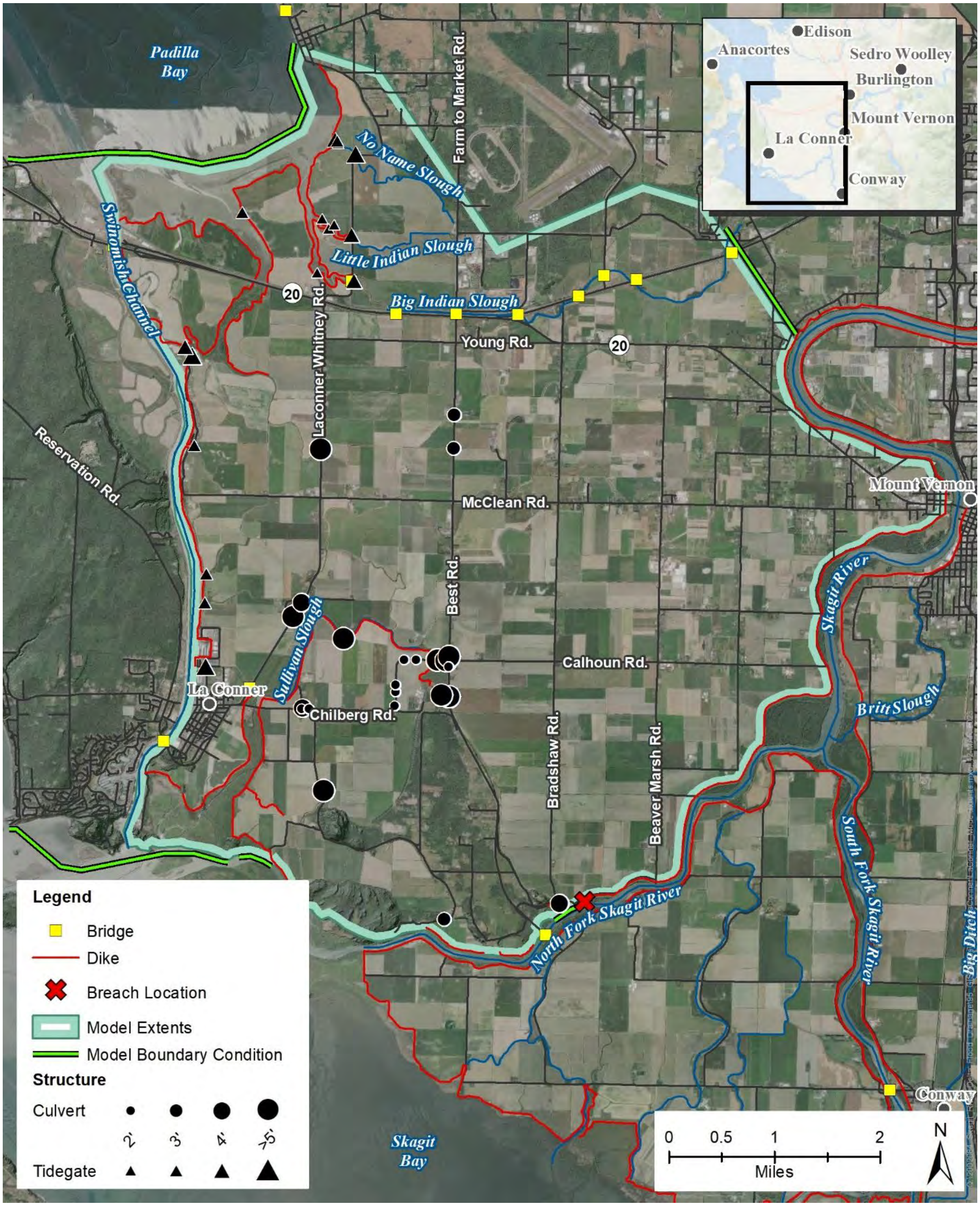

Figure 4.2 La Conner model domain and features.

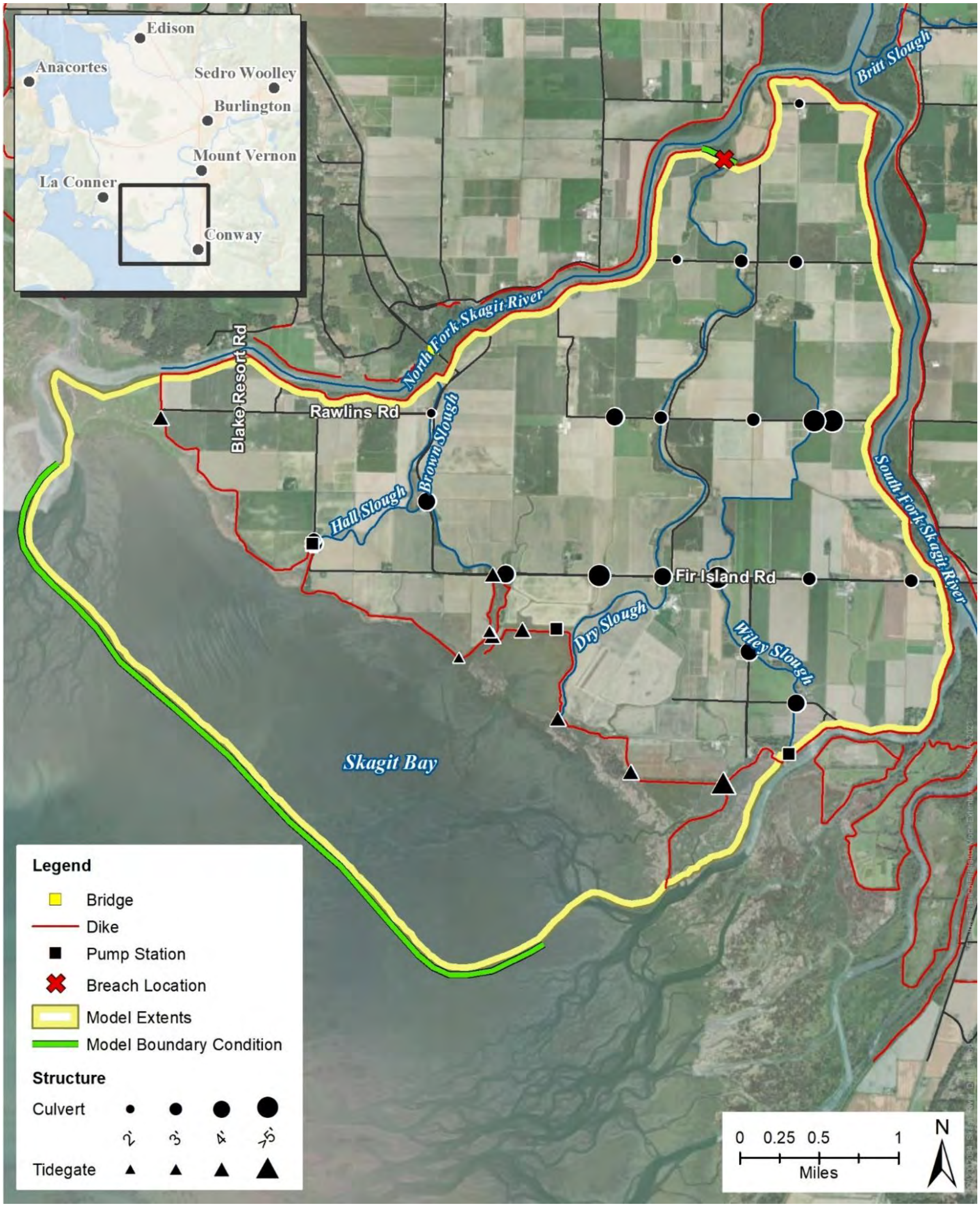

Figure 4.3 Fir Island model domain and features.

4.2.2 Terrain

NHC conducted terrestrial and bathymetric surveys to supplement available LIDAR elevation data that together were used to develop an aggregate terrain dataset for hydraulic model development and analysis. The datasets included in the terrain are summarized with Table 4.1 below.

Four publicly available LiDAR data sources[1] were combined to create the model terrain data. These LiDAR datasets have been listed in Table 4.1 in order of hierarchy in data merging process. Bathymetric surveys were performed by NHC on November 9, 2017, November 16, 2017, December 27, 2018, and January 15, 2019 to collect bathymetry at key areas within the project limits (see Table 4.1). Elevations were collected using a boat-mounted single-beam eco-sounder coupled to RTK GPS. Additional bathymetric surveys conducted by USACE (2022) and USGS (2014) were reviewed and incorporated into the model where applicable. Terrestrial and bathymetric survey was performed between 2017 and 2022 to collect missing information related to key drainage features (location, elevation, size, etc.). Data were collected using RTK GPS.

Table 4.1 Description of terrain surveys used in the study.

Survey Type	Approximate Coverage	Source/Comment
LiDAR	Skagit Bay and Padilla Bay (Puget Sound Topobathy Skagit 2014)	Topobathymetric LiDAR - USACE (2014)
	Fir Island and nearshore regions adjacent to Skagit Bay, Padilla Bay, and Samish Bay (Skagit Delta 2019)	Standard LiDAR - Tetra Tech (2020)
	Fir Island, La Conner, and nearshore portions of Skagit Bay (Skagit Estuary 2012)	Standard LiDAR – Watershed Science (2012)
	Skagit Basin excluding Fir Island and La Conner (North Puget 2017)	Standard LiDAR – NV5 (2017)
Bathymetric	Lower nine miles of the Samish River, beginning approximately at the Interstate-5 bridge and extending to its outlet to Samish Bay	NHC in 2017
	Lower sections of Joe Leary Slough, beginning at Bayview Edison Road and extending to its outlet to Padilla Bay	NHC in 2017
	Main channels of the Samish River and Joe Leary Slough through the tidal flats	NHC in 2017

[1] Accessed via https://lidarportal.dnr.wa.gov

Survey Type	Approximate Coverage	Source/Comment
	Sullivan Slough, La Conner	NHC in 2022
	Center of the Swinomish Channel	USACE (2022)
	North Fork, South Fork, and portions of Skagit Bay	USGS (2014)[1] – less detailed compared to the LiDAR data
Terrestrial - including drainage structure information (pipe size, IEs, location, etc.)	Samish River	PSE (2018), NHC in 2017, 2018, and 2019
	Alice Bay	PSE (2018), NHC in 2021
	Joe Leary Slough	NHC in 2018 and 2019
	Fir Island	NHC in 2022
	La Conner	NHC in 2022

4.2.3 Structures and Culverts

4.2.3.1 Data Collection

One of the modeling objectives of the project is simulation of post-flood recession durations. In order to accurately simulate these conditions, existing flood drainage structures in the study area need to be represented within the hydraulic model. NHC developed an inventory of existing drainage features via review of available data from a variety of sources, supplemented with survey (see Table 4.2).

Table 4.2 Summary of data used for incorporating drainage structures into the models.

Dataset Name	Coverage area	Structure type	Source/Comments
Skagit delta Tidegates and fish Initiative (TFI) (2008)	Skagit and Samish River deltas, including the tidal delta areas of Skagit Bay, Padilla Bay, Samish Bay, and the Swinomish Channel	Tide and flood gates	Some structures are not updated in this report
Joe Leary Slough new gates	Joe Leary Slough	Tide gate	Communications with Skagit Consortium
Culvert inventory (GIS data)	Same as TFI report	Culverts	From County
Tide gates inventory (GIS data)	Same as TFI report	Tide and flood gates	From County

[1] This was not used in the study because the North and South Fork channels model representations were not updated from the 1D sections used in the 2013 GI Study

Dataset Name	Coverage area	Structure type	Source/Comments
Watercourse classifications and drainage infrastructure maps	District 5 and 25	Tide and flood gates, pump stations, dike and levee system	From Skagit County and Dike, Drainage, and Irrigation Districts 5 and 25
Dike district assessment areas of Skagit County (2022)	Dike districts of Skagit county	Tide and flood gates, pump stations, dike and levee system	Skagit County – some structures are not updated in this map
Wylie Slough Tide Gate Replacement maps (2014)	Wylie Slough	Tide gate	Shannon & Wilson Inc. (available Online)
Fir Island farm ecosystem restoration maps (2011)	Davis Slough	Tide gate	Shannon & Wilson Inc., 30% Preliminary (available Online)
Surveyed data	Samish River, Joe Leary Slough, and Alice Bay	Tide gates, culverts, Sullivan Slough channel geometry	see previous table
Surveyed data	La Conner and Fir Island	Tide gates, culverts, Sullivan Slough channel geometry	see previous table

From the inspection of available data, performed surveys and the aerial maps, in case of discrepancies, the location, size, or invert elevations of drainage structures was updated based on the most recent available data. For example, within Sullivan Slough and canal at La Conner LiDAR bare earth elevation data indicated higher channel elevations (i.e., shallower depths) than were observed in the field, resulting in an underestimation of channel conveyance. Survey was conduced at several locations, from the tide gates at 3rd St. out to the confluence with the main slough, east of La Conner-Whitney Road. Survey data provided correct channel elevations and side slopes, allowing for better representation of conveyance capacity of the existing channel. The model was modified to represent a 2:1 bank slope throughout the channel, with channel depth set as a strait line between surveyed points. Figure 4.4 provides a cross-section at one example location sampled from the Sullivan canal.

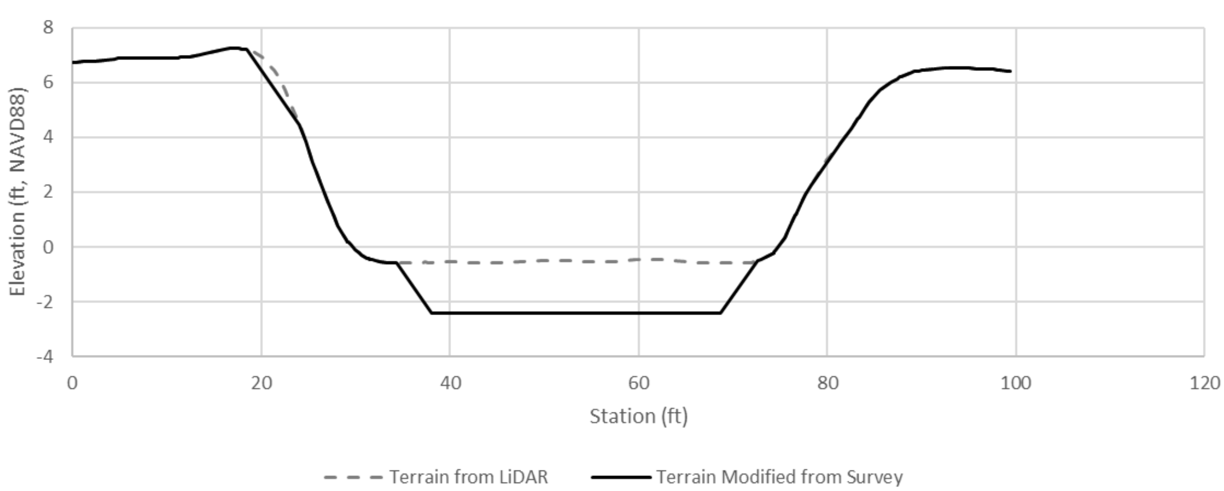

Figure 4.4 Cross section through Sullivan Slough north of La Conner. The dotted line represents LiDAR of the channel which was consistently shallower than the surveyed channel geometry (solid line), with an approximately 2:1 side slope which agrees with the survey.

4.2.3.2 Model Representation

A summary of the application of the information presented within Table 4.2 above for representation within the hydraulic models is described below:

- Tide gates: modeled as culverts with a flap gate preventing inflow during high tide and/or riverine flood conditions (e.g., connections to the Samish River). Where no survey elevation data was available, invert elevations were assumed to match the terrain data generally adjacent to the structure or a zero slope was assumed.
- Culverts: In general, only those greater than 2’ in diameter were added, assuming negligible contribution of smaller structures to drainage during large flood conditions. Similar to the gates, where no survey elevation data was available, invert elevations were assumed to match the terrain data generally adjacent to the structure or a zero slope was assumed.
- Pump stations: Pump capacity was provided for 2 of the 5 pump stations included in the model (both in the Fir Island model). Where no capacity information was available, capacity was assumed to be 4000 gallons per minute (gpm). Efficiency curves were developed based on the maximum capacity, assuming a typical efficiency curve shape. They were assumed to turn on at a water surface level corresponding to the first wave of the flood and turn off at a water surface elevation corresponding to the antecedent flood condition.
- Terrain modifications: In some instances, terrain updates local to a given hydraulic structure (generally up to 20 feet upstream/downstream) were necessary, in order the to match or be lower than the invert elevations, allowing for flow conveyance within the model.
- Bridges: It was assumed that all bridges within the model domain were constructed to current design standards, providing freeboard to the bridge deck under modeled flows (i.e., 100-year). Therefore, bridge superstructure (i.e., deck) and substructure (i.e., piers) elements were not included within the model. Conveyance was estimated via used of the available terrain data through the bridge opening.

4.3 Boundary Conditions

4.3.1 Inflow Hydrographs

Dike breach inflow hydrographs were applied in a manner consistent with the GI study and anecdotal information where available. See Table 3.1 and Figure 3.1 for breach inflow characteristics summarized in tabular and visual format. For the Samish River Floodplain model, additional riverine hydrologic inputs were applied for representation of Samish River hydrology (see Section 3.2). For the Joe Leary Slough channel improvement alternatives modeling, which as noted previously was focused on conveyance conditions during more frequent floods rather than the Skagit River 100-year flood breach conditions, no breach hydrographs were applied to those model simulations (see Section 5.2.4) and more detailed sub-basin by sub-basin HSPF hydrographs inputs were assigned as internal boundaries.

4.3.2 Tidal Stage Hydrograph

Tidal boundary conditions for the hydraulic model are specified at the marine discharge from each of the model areas. Two different tidal stage conditions were required for the analysis: A) a boundary condition for simulation of historic conditions in cases where model calibration and/or validation was possible, and B) a boundary condition for scenario simulations used to inform flood drainage improvement planning.

For the purposes of model calibration and scenario simulations, the observed Cherry Point tide record was used as the downstream boundary condition for all modeling. However, due to the limited extents of bathymetry data available at the time modeling was initiated in 2017 and an interest in limiting model extents to minimize simulation times, the 2D Samish area model discharges to Samish Bay and Padilla Bay within shallower water than the minimum low tide elevations included in the Cherry Point tide record. Special attention was paid to these boundary conditions to ensure that the simulated outflows are controlled by accurate sea-levels, within the entire tidal cycle range.

- For the Joe Leary Slough channel improvement model, the Cherry Point tide record was translated from the deepest areas of Padilla Bay to the edge of the 2D model boundary near Joe Leary Slough using a 1D model covering only the nearshore area seaward of the 2D model boundary. The 1D model was adjusted until the simulated stages matched observed water-level data collected at the NERRC Padilla Bay Joe Leary Estuary Station PDBJEWQ.

- The sensitivity of the Samish area model water-levels at the discharges to Samish Bay were tested by running the model with two different 2D model domain extents, one extending 2D model domain seaward to the deepest areas of Samish Bay and a second extending approximately 2000 feet seaward of the Bayview-Edison Road bridge over the Samish River. Both model versions were then run with the Cherry Point tide record applied at each seaward model boundary to simulate water-levels at the Bayview-Edison Road bridge where water-levels were recorded for the period November 2017 through March 2018. The resulting water-level time-series were effectively identical during non-flood conditions and even during the Superbowl flood of 2018 generally only deviated by up to a half foot for short periods at low tide. Due to the general lack of sensitivity of the simulated water-levels to the 2D model domain extents, the smaller model domain was used for all subsequent Samish area model simulations.

NOAA published tidal water-level reference elevations at Cherry Point station are provided in Table 4.3.

Table 4.3 Observed Tidal elevations at Cherry Point Station (9449424).

Event	Water Level at Cherry Point station, per vertical datum reference (feet)	
	MLLW	NAVD 1988[1]
Mean Higher-High Water	9.15	8.19
Mean High Water	8.32	7.36
Mean Tide Level	5.47	4.51
Mean Sea Level	5.28	4.32
Mean Low Water	2.61	1.65
Mean Lower-Low Water	0.00	-0.96
Highest Observed Tide	12.84	11.88

[1]Cherry Point MLLW elevations are converted to the NAVD 1988 vertical datum by subtracting 0.96 feet, based on the reported elevations for NGS Benchmark (9424 J 1977).

4.3.3 Runoff from local rainfall

As discussed in Section 3.3.1.3, a uniform rainfall excess (runoff) as 25 percent of observed precipitation from the WSU AgWeatherNet Sakuma station was applied across the entire 2D model domain for all the models other than the Joe Leary Slough model.

4.4 Hydraulic Roughness

All three model vicinities utilized a land cover layer to determine the hydraulic roughness of the terrain based on earlier NHC modeling of the Greater Skagit Delta. The final Manning's n roughness values were determined through a calibration of the Samish vicinity model to known water surface elevations (see Section 4.6). The calibrated roughness values were then applied to all study areas. Table 4.4 shows the land cover and range of final roughness values used.

Table 4.4 Summary of Land Use and Hydraulic Roughness Values.

Land Cover	Range of Final Manning N Value
Agriculture	0.025-0.030
Developed	0.025-0.050
Forest	0.025-0.060
River/Slough Channel	0.008-0.200
Floodplain	0.025-0.030
Sandbar	0.02-0.025
Wetland	0.025

4.5 Run Control Parameters

The Samish/Edison/Joe Leary and La Conner/Sullivan/No Name projects model utilized Version 6.2 of the US Army Corps of Engineers HEC-RAS software (HEC, 2022), while the Fir Island utilized Version 6.1. Model parameters were selected to minimize volume accounting error (less than 1 percent) while maintaining reasonable run times. Shallow Water Equations – Eulerian-Lagrangian Method (SWE-ELM) equation set was used with no turbulence model application. Computational time step varied across the models, with the Samish River floodplain and La Conner models applying a fixed time step of 1 minute and the Joe Leary Slough model a fixed time step of 3 minutes. The Fir Island model applied a dynamic time step based on the Courant number, where the maximum and minimum Courant numbers were 5 and 2.45 and the base time step was 2 minutes.

4.6 Calibration and Validation

Model calibration was primarily done through use of available water level and highwater mark data with validation completed using available aerial imagery acquired during flood events. The typical performance measure for mitigation strategies associated with the study is reduction in duration of inundation, not just reductions in peak water levels. Therefore, model calibration considered not only matching flood peak water levels but also flood volumes. The following sections provide detail for model calibration and validation efforts within each of the study areas.

4.6.1 Samish/Edison/Joe Leary Area

Samish River and Joe Leary Slough models were calibrated using observed water level and highwater mark data, as well as aerial imagery for validation (Table 4.5). Calibration was most sensitive to main channel Manning's roughness coefficients which were adjusted to match observed water levels. The final range of calibrated hydraulic roughness values are summarized previously in Table 4.4.

Table 4.5 Summary of Data Utilized for Calibration Samish River Area Floodplain Models.

Model	Flood Event(s)	Data Type
Samish River Floodplain	February 2018	Water level and highwater marks
	November 2021	Aerial Imagery
Joe Leary Slough	January 2019	Water level

4.6.1.1 Samish River

Calibration of the Samish River area model was focused on the February 2018 flood event. Primary calibration efforts focused on matching observed flood peaks and volumes at the Samish River monitoring stations at Farm to Market Road, Thomas Road, and Chuckanut Drive. Secondary efforts were oriented towards matching highwater marks and the observed inundation extents collected for the event (see Figure 4.5). Observed water-level data at Bayview-Edison Road was not available during the peak of the February 2018 flood so these data were only used to validate the coastal boundary condition as described in Section 4.3.2.

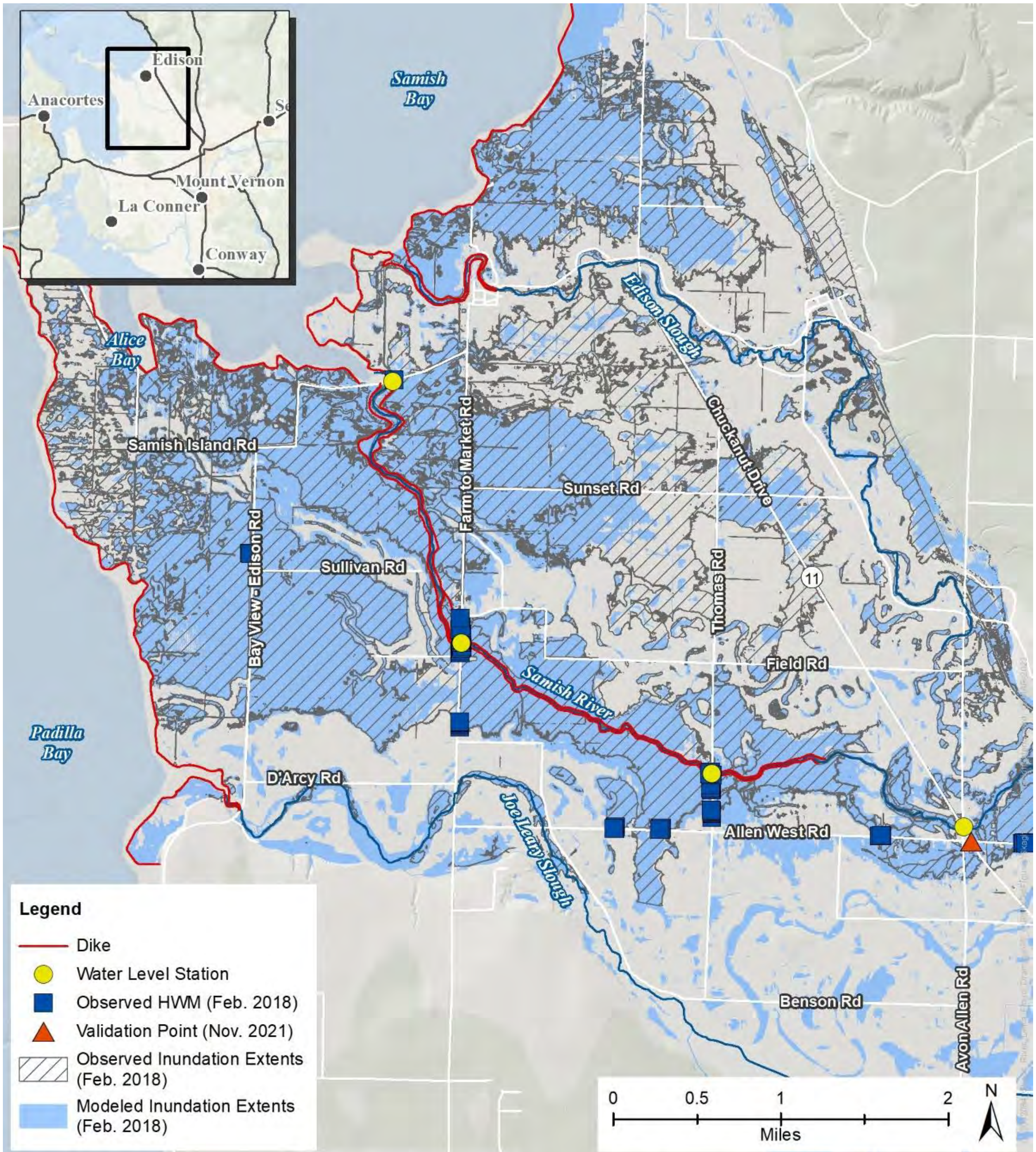

Figure 4.5 Inundation extents and stations used for Samish model calibration and validation.

Good agreement was obtained, with maximum absolute differences of 0.34 and 0.91 feet for peak stage and the 90th percentile statistic[1], respectively. Table 4.6 and Figure 4.6 through Figure 4.8 summarize the calibration results in tabular and graphic form. The largest errors at the Thomas Road and Chuckanut Drive stations occur at the end of the simulation period, with errors increasing with decreases in discharge. However, as noted above, a generally good overall calibration result is achieved, especially during periods of peak flow that are the focus of the study.

Model validation was also completed via use of aerial imagery acquired for the November 2021 flood event. Modeled inundation extents were found to provide good agreement with observed flood extents near the town of Allen (see Figure 4.9).

Table 4.6 Peak difference and 90th percentile of differences in observed and simulated flow stages data at different gaging stations during the simulation period.

Station	Absolute peak difference (ft)	90th percentile of absolute differences (ft)
Farm to Market Road	0.34	0.48
Thomas Road	0.13	0.91
Chuckanut Drive	0.08	0.65

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[1] Calculated over the duration of the approximately 34-day simulation period.

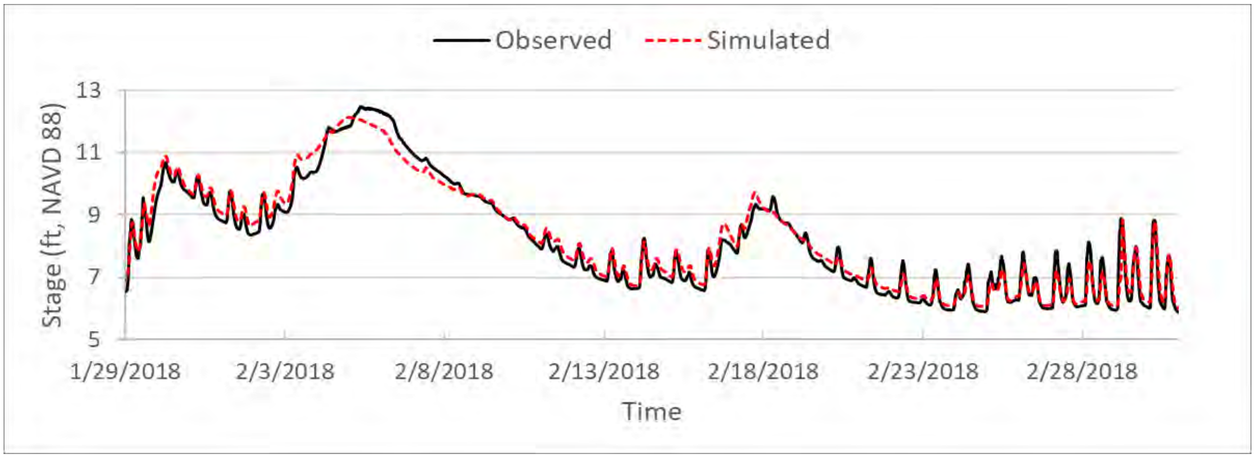

Figure 4.6 Simulated and observed flow stages during simulation period at Farm to Market Road.

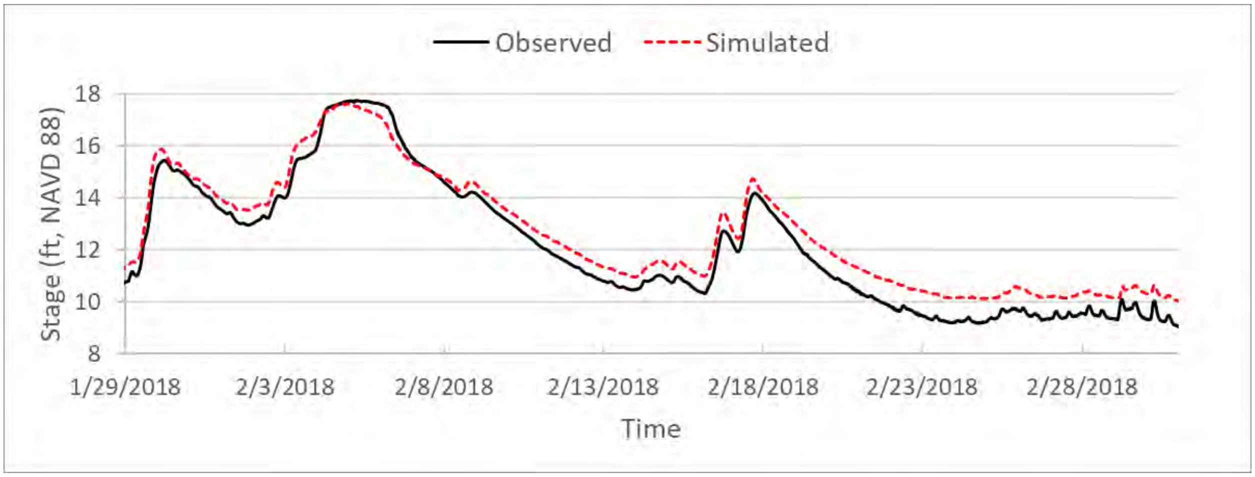

Figure 4.7 Simulated and observed flow stages during simulation period at Thomas Road.

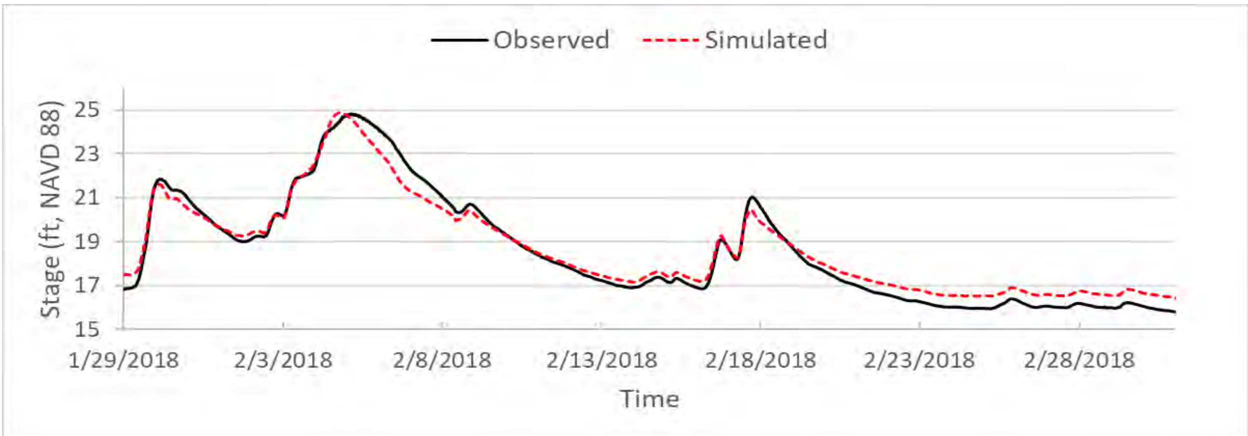

Figure 4.8 Simulated and observed flow stages during simulation period at Chuckanut Drive.

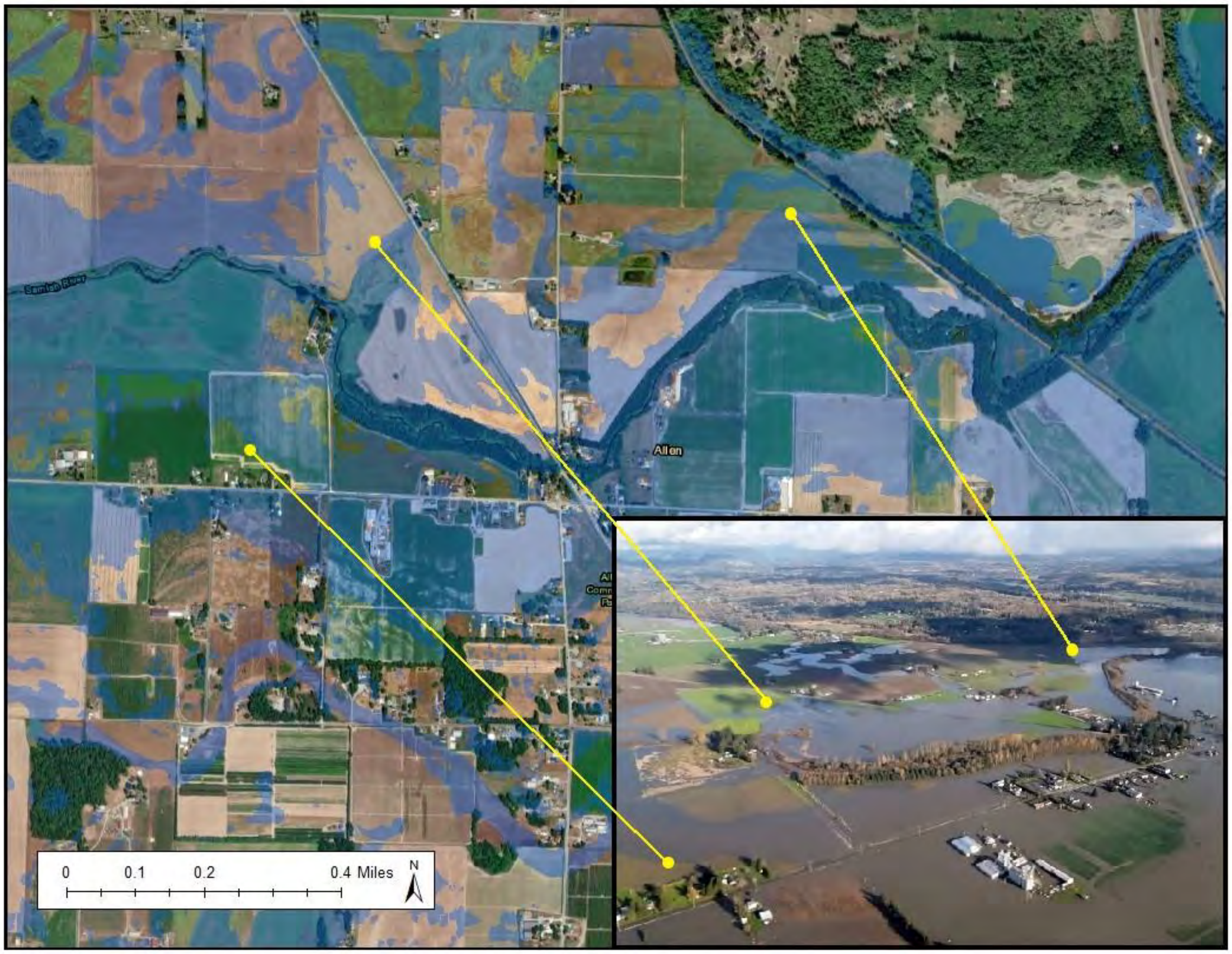

Figure 4.9 Background shows model output using hydrologic input from the November 2021 flood event. Foreground shows aerial photograph from this event. Lines connecting example points of agreement between the model and observed highwater marks.

4.6.1.2 Joe Leary Slough

The Joe Leary Slough model was calibrated to water level data from downstream and upstream of the tide gates, for the November 2018 to January 2019 period corresponding to a 2-year flood return period. The calibration period is prior to recent gate replacement; therefore, the old gate geometry was used for calibration purposes. The absolute peak differences upstream and downstream of the gate were 0.85 and 0.06 feet, and the 90th percentile of stage difference between the simulated and observed data were 1.15 and 0.51 feet. This indicated better performance of the model downstream of the gates. Table 4.7 and Figure 4.10 summarize the calibration results in tabular and graphic form.

Table 4.7 Peak difference and 90th percentile of differences in observed and simulated flow stages at different gaging stations for Joe Leary Slough model.

Station	Absolute peak difference (ft)	90th percentile of absolute differences (ft)
Joe Leary Gate Upstream	0.85	1.15
Joe Leary Gate Downstream	0.06	0.51

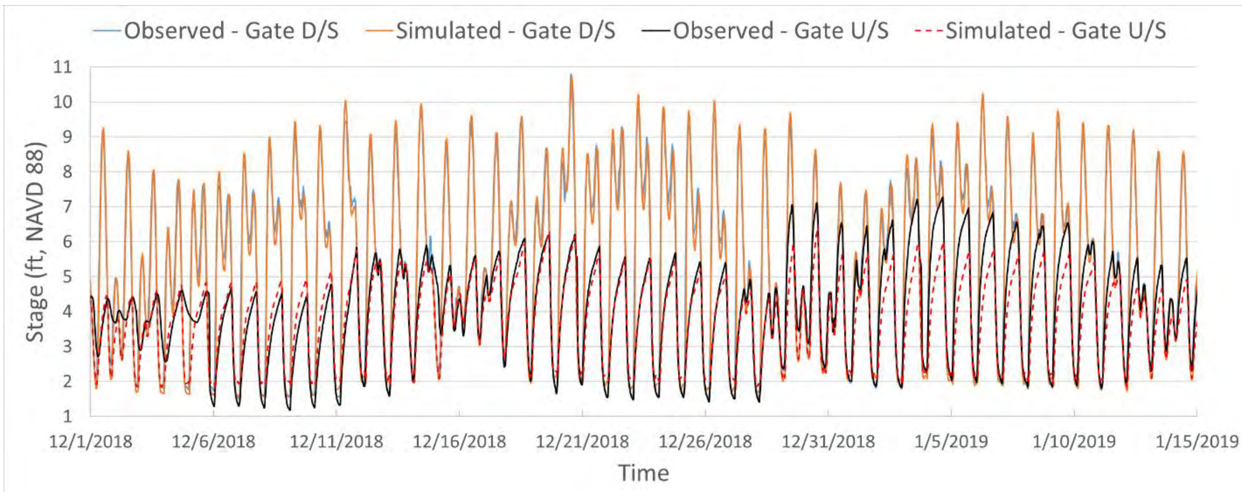

Figure 4.10 Simulated and observed flow stages during simulation period at Joe Leary Slough tide gates stations.

4.6.2 La Conner/Sullivan/No Name Area

No water level or anecdotal flood data was available to be used for calibration of the La Conner Vicinity model. However, as noted previously, documentation available for the Town of La Conner Dike Protection project indicate a design WSEL of 12.00 feet (NAVD 88) per the USACE Sullivan Slough Levee Floodplain Modeling, under a 100-year North Fork Skagit River breach scenario (CHS, 2016). Modeled WSELs at this location are about 12.38 feet (NAVD88), demonstrating good agreement with the available information. However, it is advised that the results should be used for comparison purposes, rather than the actual values, as more detailed information about the derivation of the project design WSELs was unavailable.

4.6.3 Fir Island Area

No water level or anecdotal flood data was available for calibration or validation of the Fir Island model. Therefore, results should be used to evaluate the relative performance of mitigation solutions only and not considered as absolute values.

5 FLOOD MODEL RESULTS AND PROPOSED MITIGATION MEASURES

For the purposes of this study a single Skagit River levee breach scenario was assumed to estimate resultant overland hydraulics and flow patterns within the Skagit River delta and the lower Samish River floodplain. Hydrologic inputs and general hydraulic model development are described above in Sections 3 and 4, respectively.

5.1 Existing Conditions and Problem Area Identification

Existing condition flood model results were examined to identify problem areas where flood risks are concentrated. Upon validation of the inventory of problem areas with County staff, flood risk mitigation solutions were then developed and evaluated for performance. Detailed descriptions of existing flood conditions and proposed mitigation concepts and performance, for the various study areas, is provided within the sections below.

5.1.1 Samish/Edison/Joe Leary Area

The maximum flood depth and inundation duration maps for the Samish vicinity existing conditions are shown in Figure 5.1 and Figure 5.2 respectively. The maps primary intent is to show flood conditions within the Samish area that would result from a Skagit River dike breach in the Stirling vicinity. Such a breach would result in a flood wave that would flow primarily northwest towards Samish Bay. However, a smaller secondary flow path from a breach at Stirling would also split to the southwest and be conveyed to Skagit and Padilla Bays. The La Conner area model domain was used to capture this southwesterly flow path. In general, maximum flood depths summarized in
Table 5.1 range from 0.5 to 6.0 feet, with maximum inundation durations ranging from 1.5 to 34 days, for the 100-year breach scenario (excluding the tidal area of the model). Both the flood depth and flood duration figures show that the highest intensity of flooding occurs west of the Samish River with an epicenter at the intersection of Bayview Edison Road and Sullivan Road. There is also substantial flooding from the east end of Samish Island Road, southeast to the intersection of Farm to Market Road with the Samish River. The region to the east of the Samish River shows an extended inundation duration, however the depths are markedly less than those seen west of the river (see Figure 5.1 and Figure 5.2).

For the Joe Leary Slough vicinity, the maximum flood depth was up to about 2.1 feet in the floodplain and 11 feet in the main channel. Significant inundation durations can be seen west of Farm to Market Road and in Josh Wilson Road area with maximum values of approximately 2 and 3 days, respectively.

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Table 5.1 Summary of existing condition maximum depth and maximum inundation duration (100-year breach scenario) for Samish/Edison/Joe Leary Area

Location/Feature	Depth (ft)		Inundation Duration (days)	
	Maximum	Average	Maximum	Average
Bayview Edison Road (From Samish Island Road intersection, south to Leary)	6.0	3.6	32.6	7.1
Bayview Edison Road (From Samish Island Road, east to Farm to Market Road	4.8	2.1	34.2	6.3
Farm to Market Road (From Edison, south to high ground south of Allen West Road)	3.1	1.0	34.2	2.6
Chuckanut Drive (From Bow Hill Road, south to Interstate-5	2.0	0.1	34.0	1.3
Allen West Road (From Farm to Market Road to Chuckanut Drive)	1.9	0.2	16.9	1.5
Sunset Road (From Farm to Market Road to Chuckanut Drive)	0.8	0.1	1.5	0.7

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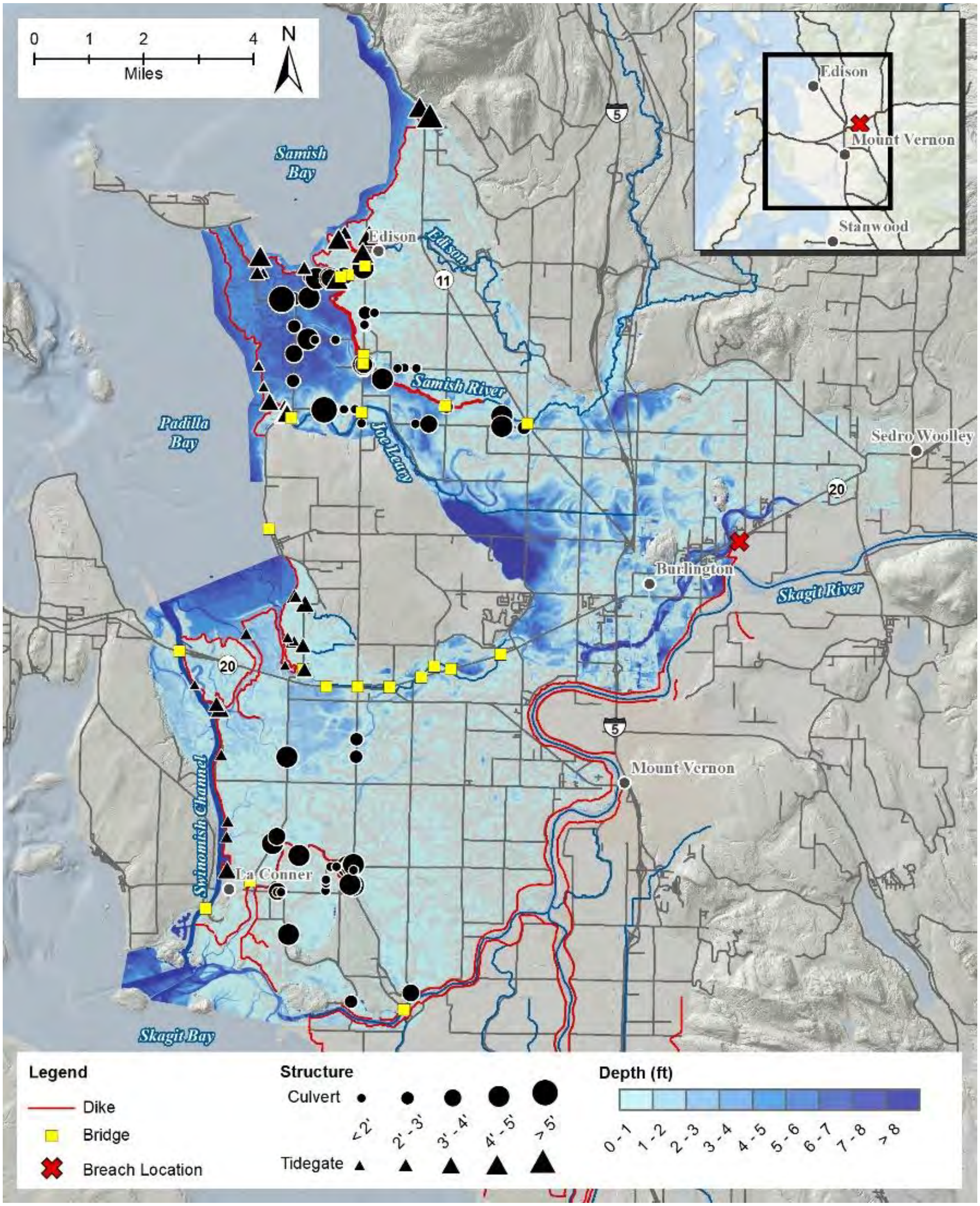

Figure 5.1 Maximum depth (100-year breach scenario) for Samish/Edison/Joe Leary Area.

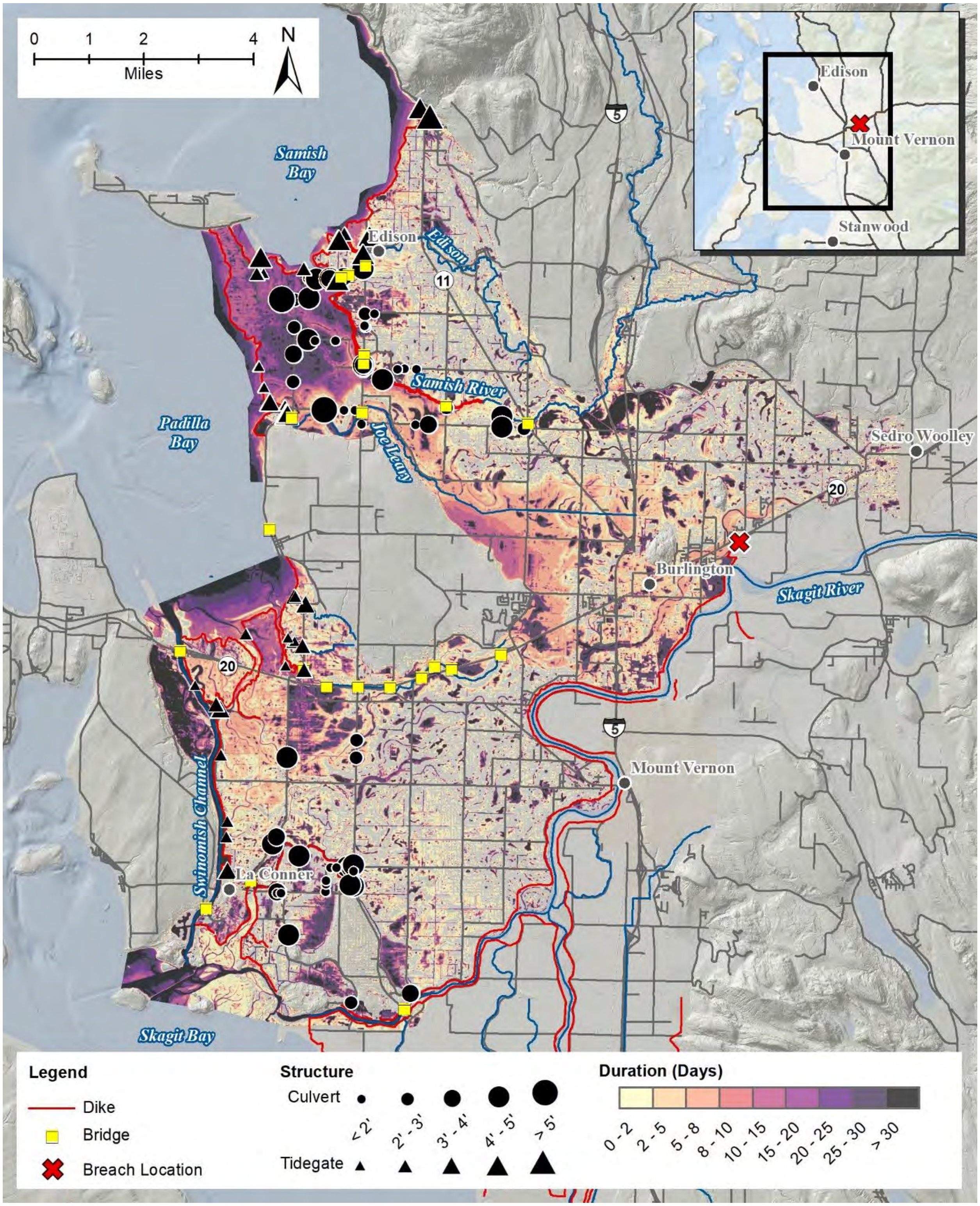

Figure 5.2 Maximum inundation duration map (100-year breach scenario) for Samish/Edison/Joe Leary Area.

5.1.2 La Conner/Sullivan/No Name Area

A right bank North Fork Skagit River dike breach near Bradshaw Road would result in a flood wave that would flow north/northwest and inundate most of the area between the breach location and Padilla Bay. Maximum estimated 100-year breach scenario depths and durations ranged from 3.7 to 6.9 feet. and 11 to 34 days, respectively. Results for the town and understood key egress locations are summarized in Table 5.2 below. In general, maximum durations of inundation bound Chilberg Road and La Conner-Whitney Road, for the majority of their length. Maximum depth and duration results are shown as maps in Figure 5.3 and Figure 5.4.

Table 5.2 Summary of existing condition maximum depth and maximum inundation duration (100-year breach scenario) for La Conner/Sullivan/No Name Area.

Location/Feature	Depth (ft)		Inundation Duration (days)	
	Maximum	Average	Maximum	Average
Town of La Conner	6.9	3.0	34.1	10.4
Chilberg Road (From La Conner to Best Road)	3.7	2.4	16.0	7.8
Maple Avenue	4.6	3.3	16.5	10.0
La Conner-Whitney Road (From La Conner to Hwy 20)	4.3	2.7	11.0	7.5
Best Road (from Chilberg Road to Hwy 20)	3.7	1.2	10.8	4.5

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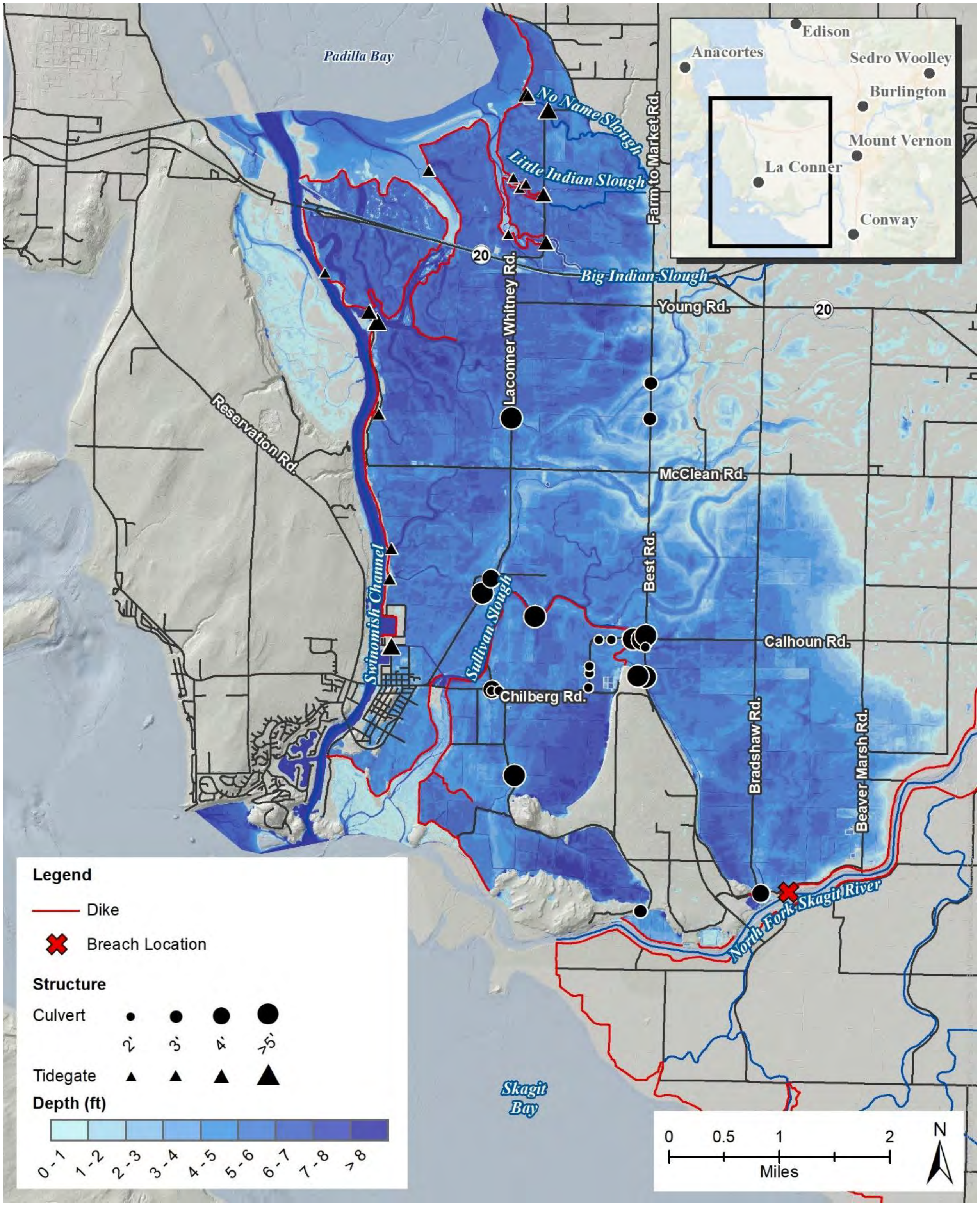

Figure 5.3 Maximum depth (100-year breach scenario) for La Conner/Sullivan/No Name Area.

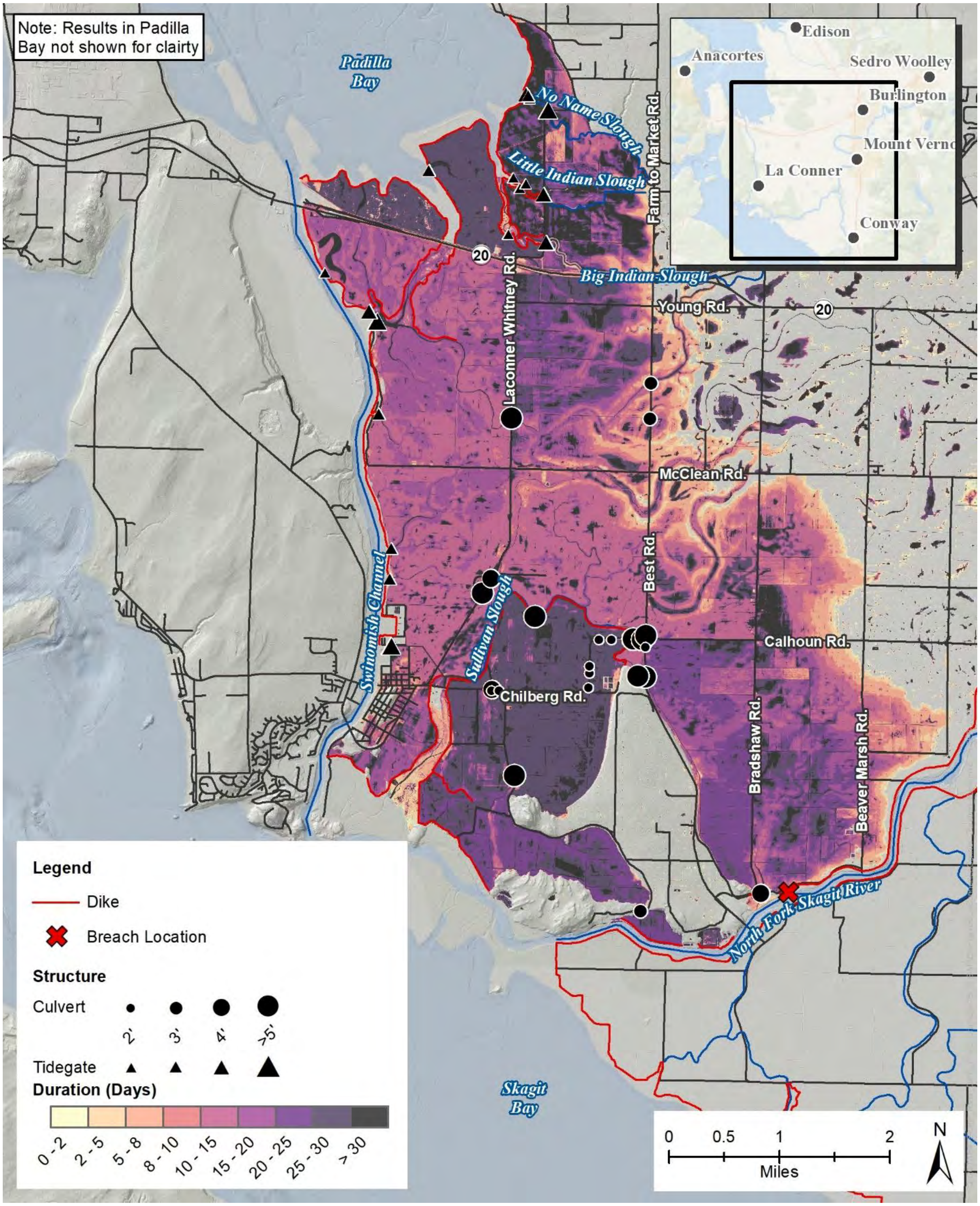

Figure 5.4 Maximum inundation duration map (100-year breach scenario) for La Conner/Sullivan/No Name Area.

5.1.3 Fir Island Area

A left bank North Fork Skagit River dike breach west of Dry Slough Road would result in a flood wave that would flow south and inundate most of Fir Island, the area bounded by the North and South Forks of the Skagit River and Skagit Bay. The maximum simulated flood depths within the Fir Island area, shown in Figure 5.5, range of 7 to 8 feet (excluding Skagit Bay area). Significant inundation durations occur south of Fir Island Road between Dry Slough and Wiley Slough, within the area labeled ‘Region I’ on Figure 5.6, with maximum inundation durations of approximately 14 days. Extended inundation durations also occur south of Rawlins Road between Brown Slough and north fork of Skagit river, within the area labeled ‘Region II’, with maximum inundation duration of approximately 17 days. Table 5.3 summarizes maximum flood depth and inundation durations at key roadway locations identified as important in terms of egress based on based on housing density and road size.

Table 5.3 Summary of maximum depth and inundation duration for the existing condition in Fir Island model.

Location/Feature	Depth (ft)		Inundation (days)	
	Maximum	Average	Maximum	Average
Fir Island Road (east west)	4.6	3.1	9.9	7.2
Wylie Road (north south)	7.3	5.3	13.6	10.2
Fir Island Road (south north)	4.6	2.1	9.8	6.0
Rawlins Road	5.7	4.2	15.4	9.2
Blake Resort Road	7.8	5.8	19.5	15.5

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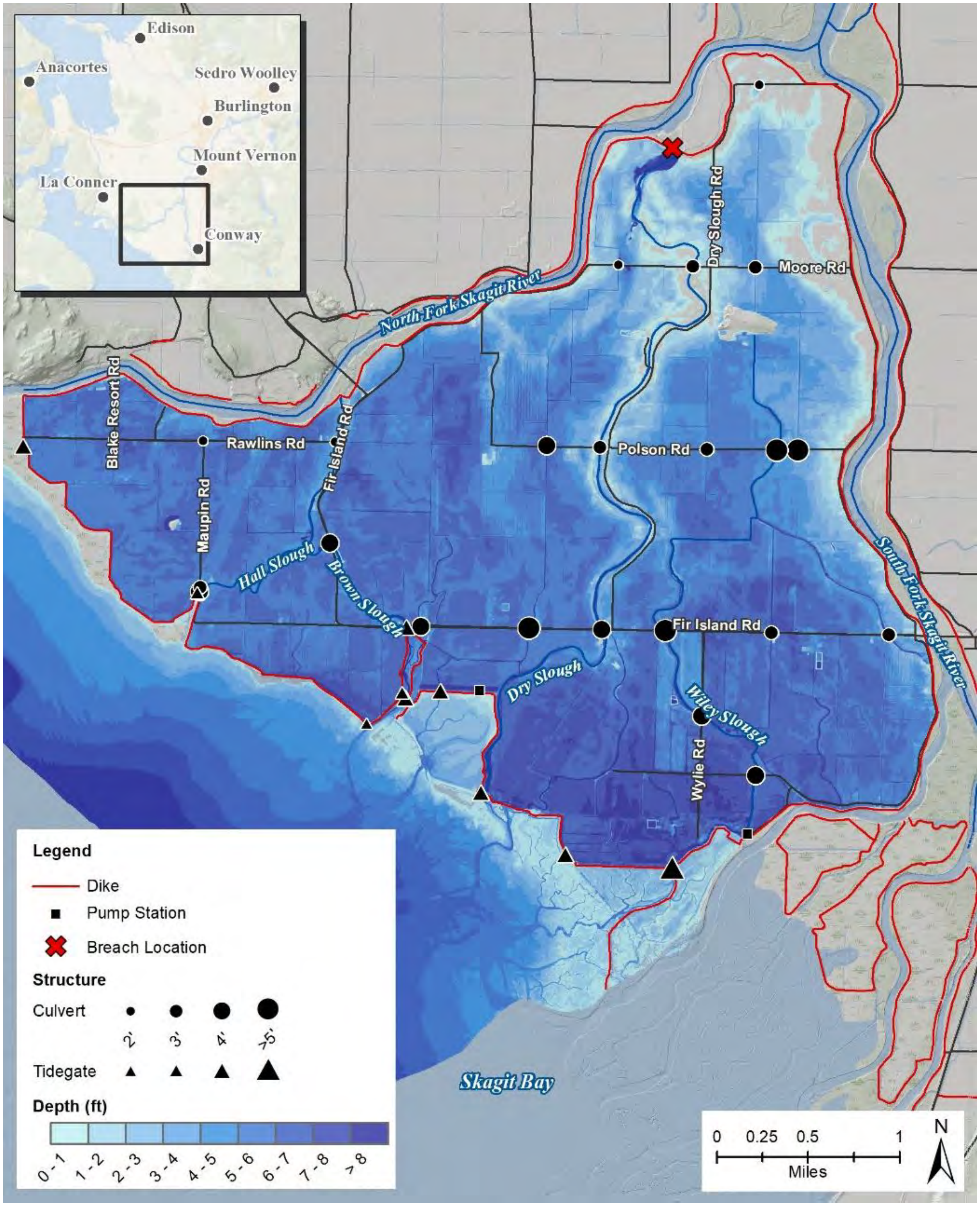

Figure 5.5 Maximum depth (100-year breach scenario) for Fir Island Area.

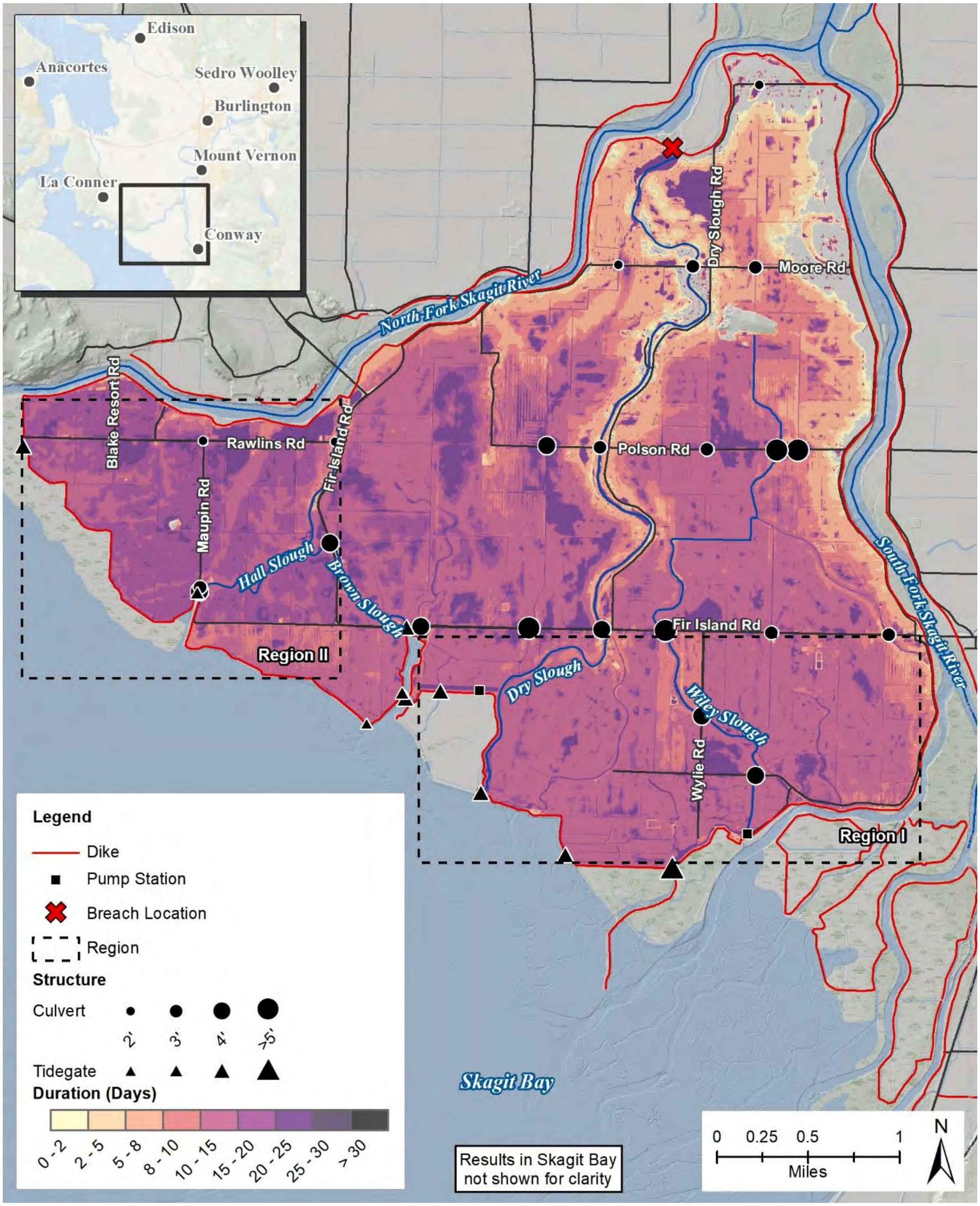

Figure 5.6 Maximum inundation duration map (100-year breach scenario) for Fir Island Area.

5.2 Proposed Flood Mitigation Measures

A set of flood risk mitigation solutions were developed for each of the project areas, generally including a combination of installation of new or retrofit of existing tide gates, levees, pump stations, closed conveyance (i.e., culverts) and open channel conveyance (i.e., ditches). Solutions were developed and evaluated for performance at the regional scale, with the primary goal of enhanced egress for residents during flood conditions. Therefore, evaluation of solution performance was based on reductions in water depth over roadways (greater than 6 inches determined hazardous for vehicular travel [FEMA, 2007]) and roadway inundation duration (i.e., time of water over roadway). Detailed descriptions of proposed measures and performance for each area are provided below. Supplemental flood inundation mapping is also provided in Appendix D.

5.2.1 Samish/Edison/Joe Leary Area

Mitigation of flooding in the Samish vicinity was primarily focused on floodplain drainage improvements, with one alternative looking at a flood gate improvement on the Samish River. Three "High Priority Sites" flood mitigation sites (Alternatives 1, 2, and 3) were recommended to Skagit County by commissioners of Drainage, Diking and Irrigation Districts 5 and 25 and preliminary flood modeling was utilized to identify the need for additional flood conveyance relief in the Alice Bay vicinity that led to the identification of Alternative 4 site. The projects at the four sites, all of which have been advanced to preliminary or final design, include upgrades to existing conveyance and new tide gate structures. Figure 5.7 provides a map showing the location of the sites. Table 5.4 provides a summary of five Samish area projects that have recently been advanced to design and/or construction. The project at Joe Leary Slough, which was constructed by Drainage and Irrigation Improvement District 14 in summer of 2019, is included in the table for reference, but modeling of that structure and Joe Leary Slough discussed separately in Section 5.2.4.

The model described in previous sections was utilized to analyze the current design for each site and make recommendations for necessary design changes to mitigate any potential adverse impacts and optimize flood mitigation benefit. Flood mitigation was assessed qualitatively through difference plots with existing conditions (Figure 5.8 and Appendix D), and quantitatively over primary egress routes (

Table 5.5). Modeling results show little to no change in average peak depth over egress routes, due to the magnitude of the peak Skagit breach flow impounding against the Samish Bay sea dike to the north. While all mitigation measures show improvements from existing conditions in respect to inundation duration due to changes in conveyance and structure invert, the flood wave is large enough to prevent these structure changes from having appreciable impact to peak depth. Additional discussion, detailing evaluation of mitigation alternatives for the Joe Leary Slough Area is provided within Section 5.2.4.

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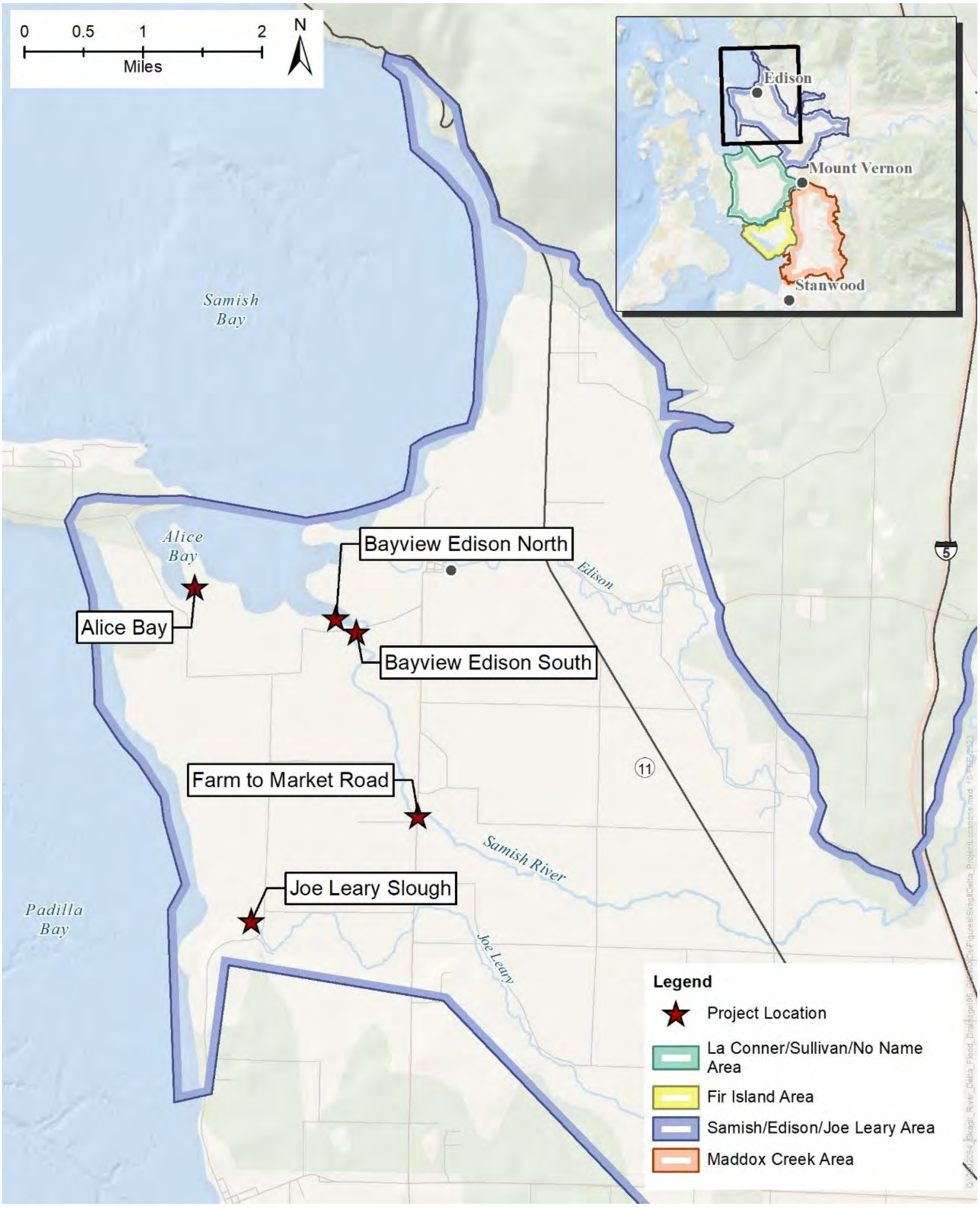

Figure 5.7 Samish/Edison/Joe Leary project site locations.

Table 5.4 Summary of Flood Drainage Projects in Design.

Alternative	Project Location	Project Type	Existing Structure Geometry	Proposed Structure Geometry	Preliminary Construction Cost Estimate
1	Samish River at Bay View Edison North	Tide Gate Addition	NA (no structures through dike)	4x48" Dia. Culverts Side hinged tide gates.	$324,100
2	Samish River at Bay View Edison South	Tide Gate Addition	4x48" Dia. culverts Top hinged tide gates.	8x60" Dia. Culverts Side hinged tide gates.	$523,300
3	Samish River at Farm to Market Road	Tide Gate Replacement	2x48" Dia. & 1x36' Dia. Culverts, Top hinged tide gates.	Replaced two upper pipes and with side hinged tide gates in 2021. The lower tube is yet to be replaced.	Completed by District 25
		Tide Gate Addition		4x48" Dia. Culverts, replace 36" Dia. Culvert. Side hinged tide gates.	$304,000
4	Alice Bay (near Samish Bay Sports Club)	Tide Gate Replacement as per TFI guidelines	2x40", 1x36", & 1x48" Dia. Culverts, Top hinged tide gates.	8'x4.5' box culvert, Side hinged tide gates (two doors on box).	$1,554,586
NA[1]	Joe Leary Slough	Tide Gate Replacement as per TFI guidelines	12 culverts with top hinged tide gates. 10x48" and 2x36". Inverts: -0.12' to 1.65	One large box with two side hinge tide gate doors. Two 8.75'x9.7'.	Completed by District 14

[1] The Joe Leary Slough tidegate replacement, which was completed by Drainage and Irrigation Improvement District 14 in summer of 2019, is included in modeling discussed in Section 5.2.4.

Alternative 1 for mitigation of the Samish/Edison/Joe Leary Area looked at the installation of a new tide gate structure at the Bayview-Edison North site location. The structure consists of four 48-inch culverts with side hinged gates, represented in the model as zero negative-flow flap gates. Modeling output shows that the project, as designed, reduces inundation duration in the Samish River left overbank (see Appendix D). Modeling showed this project resulted average improvement of 1.1 days to over-road duration along all of Bayview Edison Road, with nominal improvement along other egress routes.

Alternative 2 modeled the improvement design to the existing Bayview Edison South structure, including the addition of eight 60-inch culverts with side hinged gates. Modeling results show a similar improvement pattern to Alternative 1 in terms of reducing the duration of Bayview Edison Road flooding.

Alternative 3 modeled the improvement project where Farm to Market Road crosses the Samish River. Model simulation results show an improvement along Farm to Market Road of only 0.1 days, with nominal improvement elsewhere. However, modeling also shows a minor negative impact to the right bank floodplain centered around Farm to Market Road and Sunset Road, resulting in an increase of average duration of flooding over Sunset Road of approximately 0.1 days, and as much as 0.1-feet of increase in flood depth. Investigation of the model conditions show that these increases in flood levels are due to "worst-case" flow condition assumed in the model, with a Skagit River breach occurring at approximately the same time as the Samish River peak flow. The proposed tide gates act to route additional flood water from the left (south) overbank upstream of Farm to Market Road into the Samish river, which is already flowing at capacity. As a result, the added flow increases water-levels within the Samish River which then overtop the right bank of the river and flow north toward the Sunset Road vicinity. Modeling of a slightly smaller flow event (25 percent of peak Samish River discharge and 50 percent of the 100-year Skagit breach flow) resulted in overall improvement to the left (south) overbank while avoiding impacts to the right (north) overbank. These results indicate that under typical rainfall and flow conditions the alternative performs as anticipated, however capacity flow in the Samish can result in increased inundation duration on the right overbank. Additional mitigation options such as increasing the elevation of the Samish River right bank dike could potentially mitigate this increase, but these variations on the design have not yet been tested with the flood model.

Alternative 4 investigated an improved structure at Alice Bay (near the Samish Bay Sports Club). The proposed design includes an 8 x 4.5-foot box culvert set to replace the existing circular culvert structure as per the TFI guidelines (e.g., must maintain existing opening area). While total conveyance is not modified, the invert elevation of the structure is lowered to 0 feet NAVD88 (existing structure invert varies from 0.8 to 1.8 feet.). As expected, this design results in minor improvement to the left overbank, as well as a reduction in flood duration of 0.3 days at Bayview Edison Road. Additional modeling was performed to test both lowering of the gate invert and expanding conveyance area while maintaining the design invert. Lowering of gate invert results in minor additional improvement, with approximately one-tenth a day of additional reduction for each foot of drop (up to -2 feet), ignoring any potential for increased maintenance needs with a lower structure invert elevation. Increased conveyance results in a more appreciable benefit, resulting in 1.7 and 2.3 inundation days of improvement along Bayview Edison Road for double and triple conveyance respectively. Inundation duration difference maps for the Alice Bay tide gate replacement can be found in Appendix D.

A table of depth difference values was intentionally omitted. This was due to the initial flood wave backing up water against the landward side of the sea dike at Samish Bay resulting in effectively zero difference in maximum flood depth over primary egress routes in that area. As noted above, when looking at the whole length of an egress route, much of the roadway remains bare through the duration of the flood event, with localized regions more highly impacted. When assessing depth along the egress route, much of these minor differences are averaged out, again contributing to the resultant effective zero depth difference. Localized improvements can be assessed from the duration difference plots found in Appendix D.

In addition to modeling each alternative independently, a composite model was generated to develop an overview result for all projects currently in design. Model output duration inundation difference from exiting conditions is presented in Figure 5.8. As expected, the composite results indicate a roughly additive relationship with the individual alternative model outputs. Negative impacts seen on the right overbank in the composite results can be attributed to the Farm to Market findings described by Alternative 3.

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Table 5.5 Summary of Mitigation Measure Performance (100-year breach scenario) for Samish/Edison/Joe Leary Area. Values in parenthesis show percentage difference in inundation duration.

Roadway Name/Location	Average inundation duration (days)	Average difference in inundation duration (days)				
	Base (existing condition)	Alternatives				Composite Alternative
		1	2	3	4	
Bayview Edison Road (From Samish Island Road intersection, south to Leary)	7.1	-1.1 (-16%)	-1.1 (-16%)	-0.1 (-1.7%)	-0.3 (-3.6%)	-2.1 (-29%)
Bayview Edison Road (From Samish Island Road, east to Farm to Market Road	6.3	-0.9 (-14%)	-0.8 (-13%)	-0.1 (-1.3%)	-0.2 (-2.4%)	-1.5 (-24%)
Farm to Market Road (From Edison, south to high ground south of Allen West Road)	2.5	0.0 (0.0%)	> -0.05 (0.3%)	-0.1 (-2.9%)	0.0 (0.0%)	-0.1 (-3.5%)
Chuckanut Drive (From Bow Hill Road, south to Interstate-5	1.3	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	> -0.05 (-0.3%)	0.0 (0.0%)
Allen West Road (From Farm to Market Road to Chuckanut Drive)	1.5	> -0.05 (-0.1%)	> -0.05 (-0.1%)	0.0 (-0.1%)	0.0 (0.0%)	> -0.05 (-0.2%)
Sunset Road (From Farm to Market Road to Chuckanut Drive)	0.7	0.0 (0.0%)	< +0.05 (1.1%)	+0.2 (24%)	< +0.05 (0.2%)	+0.2 (24%)

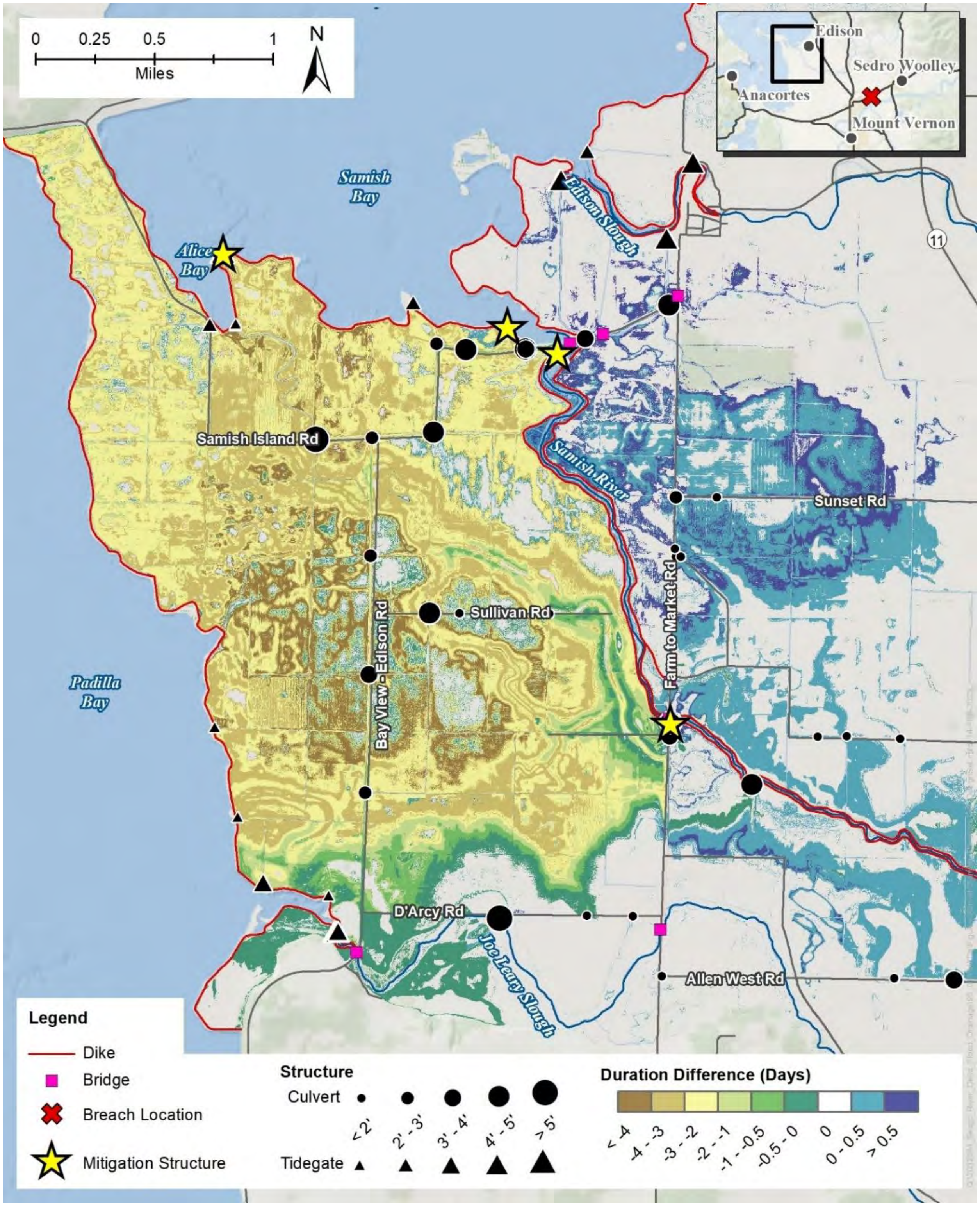

Figure 5.8 Inundation duration difference for all projects currently in design for the Samish/Edison/Joe Leary Area.

5.2.2 La Conner/Sullivan/No Name Area

Based on review of the existing conditions results and discussions with County staff, two mitigation alternatives were identified and evaluated for flood risk performance: (1) new levee at north end of town (Ring Levee project), and (2) relocation of the Sullivan Slough Bypass gates. A summary of performance for each alternative is provided in tabular form via and Table 5.7 and visually via Figure 5.9. Alternative 1 applied the design geometry from the Ring Levee project concept design drawings (CHS, 2016). The design considered a combination of levee and floodwall along the left bank of Sullivan Slough, extending from approximately North 3rd Street to Chilberg Road, with a height allowing for approximately 0.5 feet of freeboard at the 100-year design WSEL (breach scenario). Model results indicate significant reduction in inundation durations within the town, with increases in durations landward of the levee are likely attributed to ponding via local rainfall, indicating areas where drainage design is likely required. Although this alternative results in increased flood durations along La Conner-Whitney Road and Chilberg Road, roadway flooding is removed along Maple Avenue, allowing for egress via this roadway during large flood events (see Appendix D). It should also be noted that this alternative appears to result in flood impacts to adjacent properties, particularly those to the north of the town.

Alternative 2 evaluated considered relocation of Sullivan Slough Bypass gates approximately 200 feet upstream of 3rd Street (current location). This modification was requested by Drainage and Irrigation District 15 to facilitate better maintenance of the gates and reduced liability of impacts to the 3rd Street egress route. The conveyance capacity was not changed from the existing condition; however, invert elevations were matched to the existing channel elevation at the proposed location. This alternative was shown to result in no meaningful reduction or increase in water levels within the study area. Average simulated flood depths along all understood egress routes showed negligible change, with no road experiencing more than a 1 percent reduction in depth. The modeled gate geometry maximizes the available channel width, therefore, additional model simulations increasing conveyance capacity were not evaluated.

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Table 5.6 Summary of Mitigation Measure Performance (100-year breach scenario) for La Conner/Sullivan/No Name Area. Values in parenthesis show percentage difference in maximum inundation depth.

Road/Feature	Average depth (feet)	Average difference in depth (feet)		
	Base (existing) condition	Alternative 1	Alternative 2	Composite Alternative
Town of La Conner	3.0	-3.0 (-98%)	0.0 (-0.7%)	-3.0 (-98%)
Chilberg Road (From La Conner to Best Road)	2.4	+0.2 (8.1%)	0.0 (-0.9%)	+0.2 (8.2%)
Maple Avenue	3.3	-3.3 (-100%)	0.0 (-0.8%)	-3.3 (-100%)
La Conner-Whitney Road (From La Conner to Hwy 20)	2.7	+0.2 (7.9%)	0.0 (-0.8%)	+0.2 (8.0%)
Best Road (from Chilberg Road to Hwy 20)	1.2	+0.2 (14%)	0.0 (-1.4%)	+0.2 (14%)

Table 5.7 Summary of Mitigation Measure Performance (100-year breach scenario) for La Conner/Sullivan/No Name Area. Values in parenthesis show percentage difference in days of inundation duration.

Road/Feature	Average duration (days)	Average difference in duration (days)		
	Base (existing) condition	Alternative 1	Alternative 2	Composite
Town of La Conner	10.4	-6.8 (-65%)	+0.1 (0.6%)	-6.8 (-65%)
Chilberg Road (From La Conner to Best Road)	7.8	+0.8 (9.7%)	< +0.05 (0.2%)	+0.8 (10.4%)
Maple Avenue	10.0	-10.0 (-100%)	+0.1 (0.7%)	-10.0 (-100%)
La Conner-Whitney Road (From La Conner to Hwy 20)	7.5	+0.7 (9.5%)	< +0.05 (0.4%)	+0.8 (10.4%)
Best Road (from Chilberg Road to Hwy 20)	4.5	+0.7 (15.7%)	< +0.05 (0.4%)	+0.7 (16.4%)

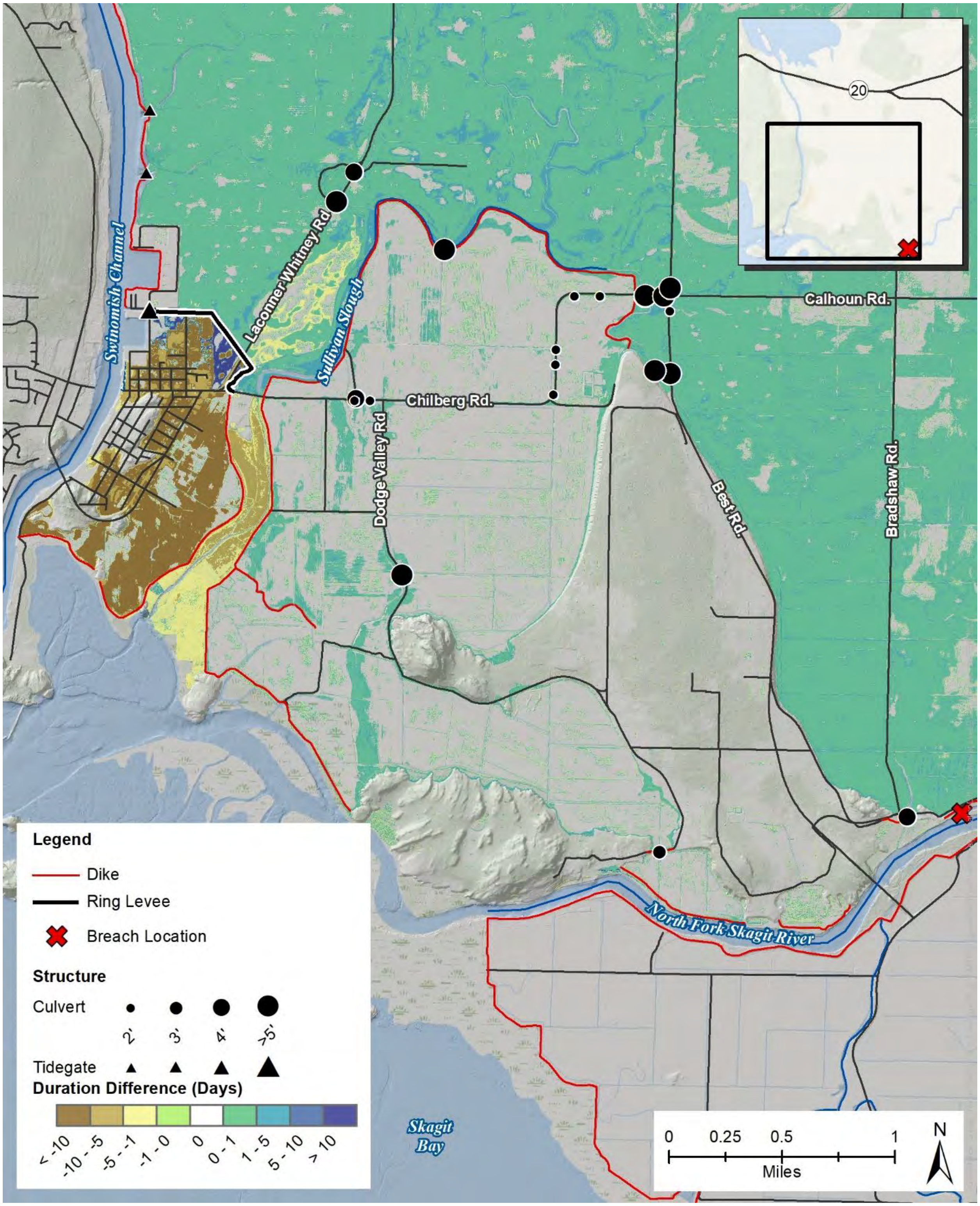

Figure 5.9 Maximum Inundation duration difference for composite proposed projects for the La Conner/Sullivan/No Name Area.

5.2.3 Fir Island Area

Based on examination of the existing condition maximum flood depth and inundation duration, it appears that Regions I and II (Figure 5.6) may be reasonable candidates for adding mitigation solutions within the dike to improve the drainage based on relatively significant inundation duration and flood depth in the surrounding regions. Three alternative solutions are proposed to improve drainage in these areas.

Alternative 1 focuses on the drainage of Region I. It includes adding 8-10 feet x 8 feet tide gates to the east of Dry Slough tide gate[1]. A scenario with only two gates was also investigated but showed significantly lower effectiveness in terms of reduction in inundation duration. Additionally, increasing the rise of tide gates was also assessed but did not show any significant improvement in conveyance. This solution decreased the inundation duration by around 2 days in the majority of the studied area with a more noticeable decrease in Region I.

Alternatives 2 focuses on the drainage of Region II. It includes increasing the capacity of the Hall Slough pump. In this solution, the capacity of the Hall Slough pump was increased from 2,500 to 8,000 gpm (matching the most powerful currently in use within the area). This solution provided a slight reduction in the inundation duration west of Fir Island Road.

Alternative 3 focuses on the drainage of Region II and includes upgrading Rawlins Road gate to two 10 feet x 8 feet box tide gates. In order to provide adequate width for the proposed gates, the downstream channel was also widened to have a bottom width of 25 feet. Similar to Alternative 2, this alternative also provided the most benefit to the area west of Fir Island Road but the average reduction in the inundation duration was more significant.

As shown in Table 5.8 and Table 5.9, inundation durations and depths were assessed for several key roads in the area. Composite alternative maximized the reduction in inundation duration, as expected. Among the other alternatives, Alternative 1 resulted in the greatest reduction in inundation duration while Alternative 2 had the least influence on the key roads. Although Alternative 2 and 3 had insignificant effects on the inundation duration reduction in roads within Region I, Alternative 1 noticeably reduced inundation duration even in roads in Region II. In terms of maximum flood depth, Alternative 1 and the composite alternative resulted in higher, similar average reductions while the reduction resulted from Alternative 2 and 3 was insignificant (0-2 percent).

Inundation duration difference maps for Alternatives 1-3 have been provided in Appendix D. A combination of Alternatives 1 to 3 was also investigated, and as expected resulted in superior performance in terms of reduction in inundation duration over the majority of study region. Figure 5.10 shows the inundation duration difference map for the composite alternative. This solution decreased

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[1] A scenario with only two new flood gates east of Dry Slough was also investigated but showed significantly lower effectiveness in terms of reduction in inundation duration. Additionally, increasing the rise of tide gates was also assessed but did not show any significant improvement in conveyance.

the inundation duration by 2.5 days in the majority of the studied area with a more noticeable decrease (around 4-6 days) in Regions I and II. Inundation duration difference maps for Alternatives 1-3 have been provided in Appendix D.

Table 5.8 Maximum Depth Summary of Mitigation Measure Performance (100-year breach scenario) for Fir Island in Key Roads. Values in parenthesis show percentage difference in inundation duration.

Road	Average maximum flood depth (ft)	Average difference in maximum flood depth (ft)			
	Base (existing) condition	Alternative 1	Alternative 2	Alternative 3	Composite Alternative
Fir Island (east west)	3.15	-0.24 (-8%)	0 (0%)	-0.1 (-2%)	-0.27 (-9%)
Wylie Road (north south)	5.30	-0.25 (-5%)	0 (0%)	> -0.05 (-1%)	-0.31 (-6%)
Fir Island (north south)	2.19	-0.23 (-11%)	0 (0%)	> -0.05 (-2%)	-0.29 (-13%)
Rawlins Road	4.20	-0.24 (-6%)	0 (0%)	-0.1 (-1%)	-0.31 (-7%)
Blake Resort Road	5.82	-0.24 (-4%)	0 (0%)	-0.1 (-1%)	-0.31 (-5%)

Table 5.9 Maximum Inundation Duration Summary of Mitigation Measure Performance (100-year breach scenario) for Fir Island in Key Roads. Values in parenthesis show percentage difference in inundation duration.

Road	Average inundation duration (days)	Average difference in inundation duration (days)			
	Base (existing) condition	Alternative 1	Alternative 2	Alternative 3	Composite alternative
Fir Island (east west)	7.2	-1.6 (-22%)	0.0 (0%)	-0.4 (-6%)	-1.7 (-24%)
Wylie Road (north south)	10.2	-2.8 (-28%)	0.0 (0%)	-0.5 (-5%)	-3.0 (-29%)
Fir Island (north south)	6.0	-1.4 (-23%)	0.0 (0%)	-0.3 (-5%)	-1.6 (-27%)
Rawlins Road	9.2	-1.9 (-20%)	-0.2 (-2%)	-0.9 (-10%)	-2.5 (-27%)
Blake Resort Road	15.5	-1.8 (-12%)	-0.9 (-6%)	-2.8 (-18%)	-4.6 (-30%)

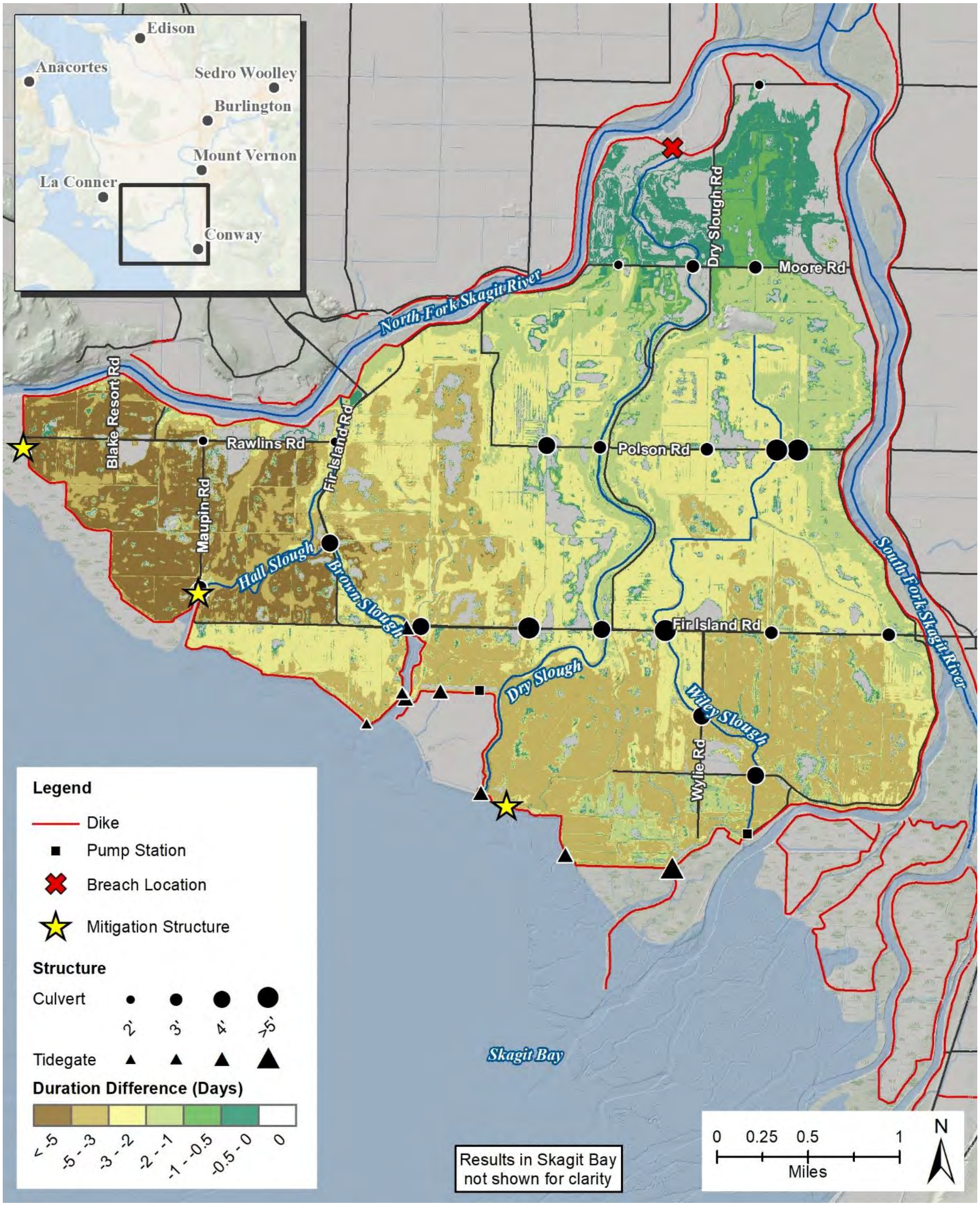

Figure 5.10 Inundation duration difference for the composite alternative, Fir Island.

5.2.4 Joe Leary Slough Drainage Assessment

Alternative solutions, ranging from standard channel maintenance to increased conveyance capacity were evaluated at the request of the Skagit Consortium and Drainage and Irrigation Improvement District 14 with planning of channel maintenance actions of Joe Leary Slough. The four channel improvement scenarios listed in Table 5.10 were evaluated for the Joe Leary Slough channel reach extending from the Farm to Market Road crossing to the Joe Leary Slough tide gate downstream of Bay-View Edison Road (see reach highlighted yellow in Figure 5.11). Due to focus on mitigating more common flood impacts a 10-year return period flood was used as the input hydrology for the assessment rather than the extreme Skagit River dike breach input hydrograph that was used for the other project sub area assessments. These results are identical to those that were originally generated and shared in May 2019.

Table 5.10 Summary of mitigation measures evaluated for Joe Leary Slough.

Alternative	Channel Condition	Tide Gate Configuration
Existing	No maintenance (existing channel)	2 side hinged tide gates (existing)
Alternative 1	Maintained channel – 20’ channel bottom, 2:1 side slopes	2 side hinged tide gates (existing)
Alternative 2	Maintained channel – 25’ channel bottom, 2:1 side slopes	2 side hinged tide gates (existing)
Alternative 3	Maintained channel – 30’ channel bottom	2 side hinged tide gates (existing)
Alternative 4	No maintenance (existing channel)	4 side hinged tide gates (double existing opening area)

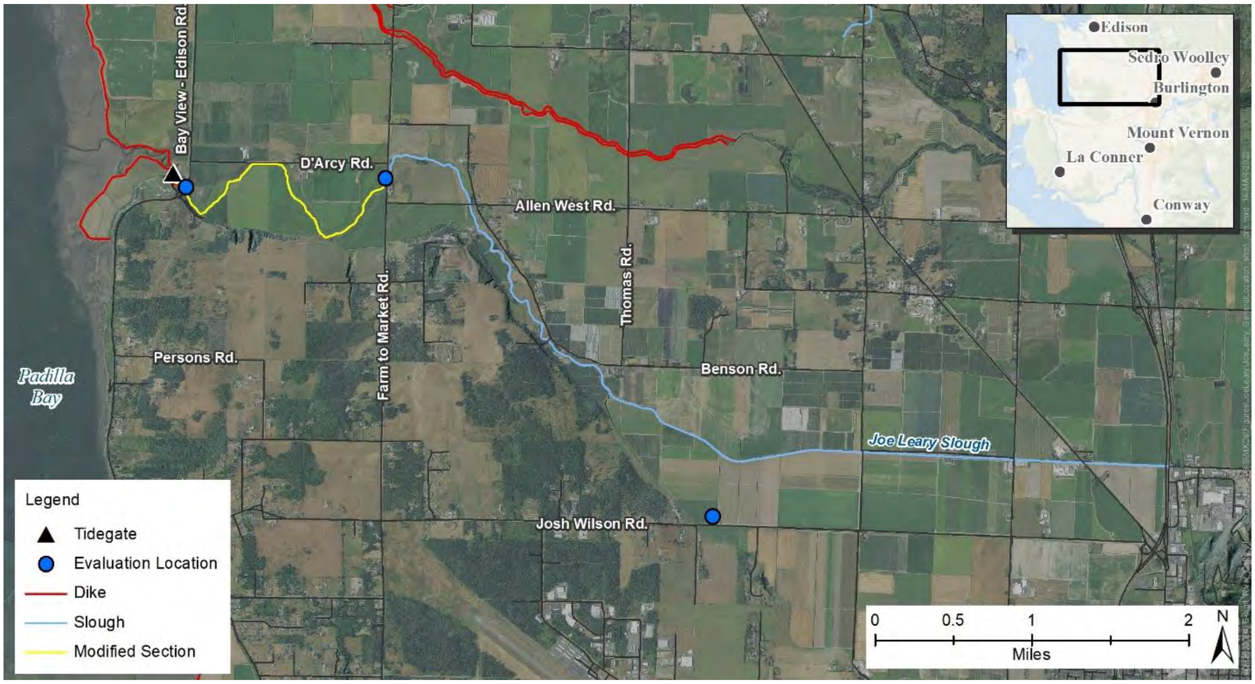

Figure 5.11 Overview of Joe Leary Slough area.

Figure 5.12 and Figure 5.13 show the calculated reduction in simulated flood duration resulting from channel maintenance/modification scenarios Alternatives 1 and 3 respectively (20’ and 30’ channel bottom widths) relative to the existing condition. Alternative 2 output was not included in the report due to its similarity to the output from Alternatives 1 and 3. As one would expect, the most significant improvements from channel maintenance occur at the upstream end of the channel improvements. For Alternative 3, the simulated flood duration is reduced by more than 48 hours in areas along the reach (i.e., areas colored brown in Figure 5.13). Shorter improvements in flood inundation duration are obtained by Alternatives 1 (Figure 5.12) and 2 (not shown). Reductions in peak water level resulting from the channel maintenance alternatives were most significant at the Farm to Market Road crossing with up to 1.3 feet of flood reduction in Alternative 3.

An evaluation of Alternative 4, doubling the size of the Joe Leary Slough tide-gate, did not identify a meaningful improvement in flood conditions under the evaluated 10-year flood. Flood levels were reduced by approximately 0.4 feet at the Bayview Edison Road crossing, with less reduction further upstream.

In general, channel modifications seem to be a more effective flood risk reduction solution compared to additional increases in tide gate conveyance area. However, both types of alternatives have negligible benefit further upstream in Josh Wilson area.

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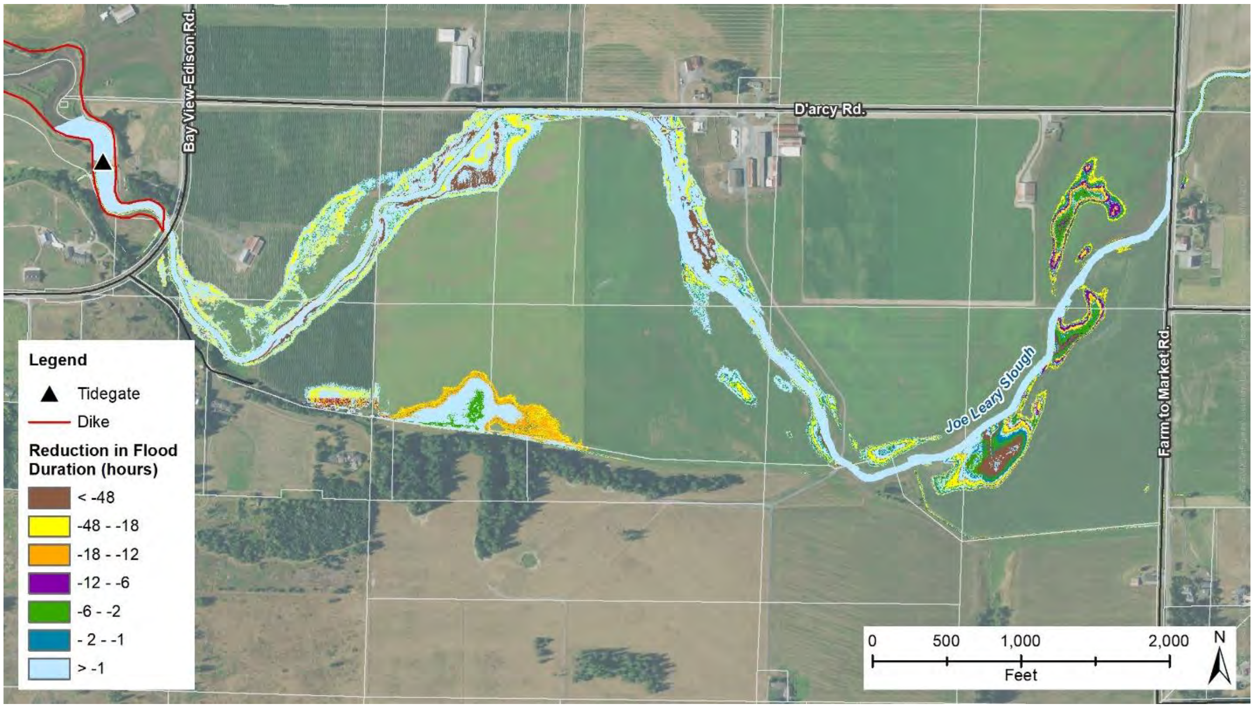

Figure 5.12 Reduction in flood duration between existing (not maintained) and maintained channel with 20 feet bottom width (Alternative 1).

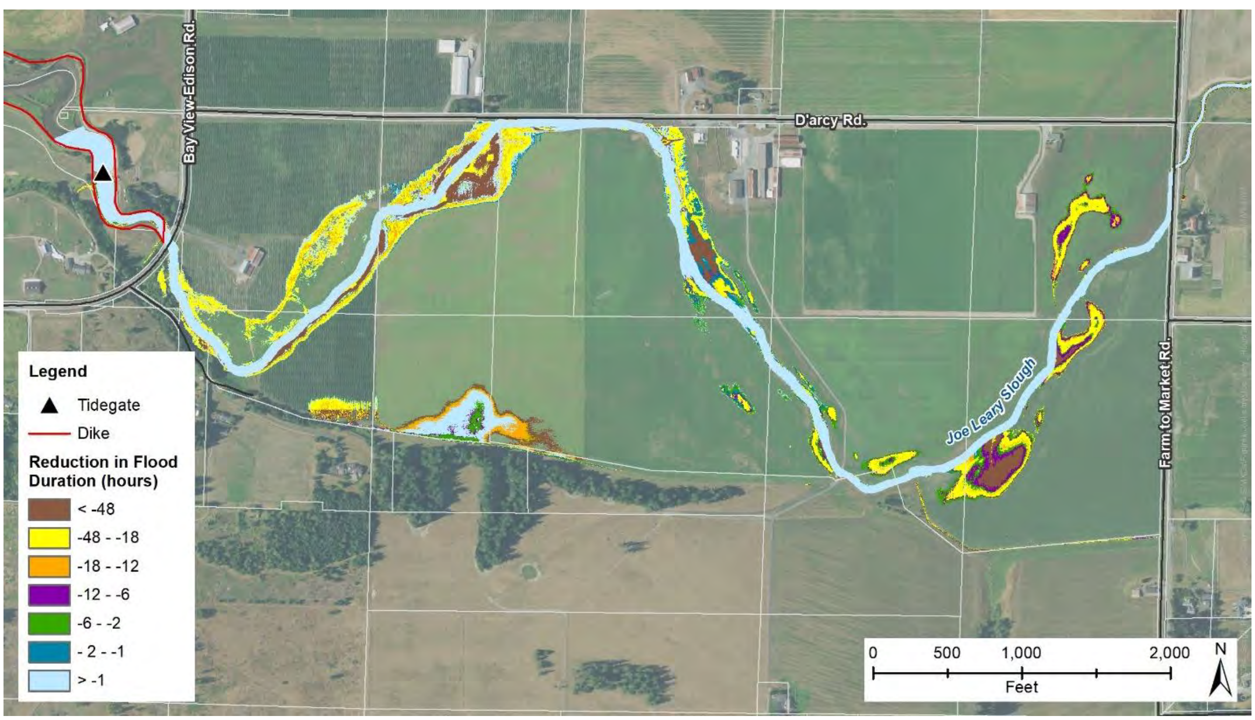

Figure 5.13 Reduction in flood duration between existing (not maintained) and maintained channel with 30 feet bottom width (Alternative 3).

6 CONCLUSION AND RECOMMENDATIONS

Mitigation solutions for the Samish/Edison/Joe Leary area, both in design and proposed as potential futures alternatives, show the potential for some reduction in the amount of time that water is over key egress routes. Installation of a new tide gate structure (four 48-inch culverts) at the Bayview-Edison North site location (Alternative 1) resulted in a similar benefit as a new tide gate structure (eight (60-inch culverts) at the Bayview-Edison South site location in terms of reductions in average inundation duration, both showing up to a 16 percent reduction (from 7.1 to 6.0 days) along Bayview Edison Road. Individually these two options both provided more reduction than Alternatives 3 or 4. The composite alternative scenario shows best performance along Bayview Edison Road, allowing for reductions of up to 29 percent inundation duration, which is beneficial given its key egress use for many residents on Samish Island and relatively worse hazards (with respect to inundation duration) during flood conditions. Limited ability of overall floodplain drainage generally limits the ability of solutions to affect maximum (peak) flood depths. Alternative 3 shows a minor increase in inundation duration, but not peak water levels, over Sunset Road. It is recommended design modifications be considered to mitigate these potential impacts.

The most effective mitigation solution for the La Conner/Sullivan/No Name area is the proposed ring levee project design (Alternative 1). This alternative shows the potential for significant reductions in depths within the town of La Conner (about 98 percent [from 3.0 to less than 0.1 feet]) and elimination of flooding over Maple Avenue, allowing for safe egress via this roadway during flood conditions. However, this alternative also results in increased depths (up to about 14 percent [from 1.1 to 1.3 feet]) and inundation duration (up to about 16 percent [from 4.5 to 5.2 days] over Chilberg Road, La Conner-Whitney Road, and Best Road. It is recommended that Alternative 1 consider design modifications, allowing for mitigation of these impacts, at a future design phase. Modifications to the Sullivan Slough Bypass gates (Alternative 2) do not show a flood reduction benefit or detriment that should prevent it from being considered for maintenance considerations.

Mitigation solutions for the Fir Island area show the potential for some reduction in the amount of time that water is over key egress routes. Additional conveyance (eight 10 x 8-foot culverts) at the Dry Slough tide gate location (Alternative 1) resulted in the greatest relative benefit, with reductions in average inundation duration of up to 28 percent (from 10.2 to 7.4 days) along Wylie Road. Appreciable reductions in inundation duration (up to 23 percent [from 6.0 to 4.6 days]) are also shown for Fir Island Road, which is beneficial given its key egress use for many residents during flood conditions. Similar to the Samish/Edison/Joe Leary area, limitations on overall floodplain drainage generally constrain the ability of solutions to affect maximum (peak) flood depths. Alternatives 2 and 3 both show some reduction in inundation durations, but with generally localized effects that are similar in magnitude to that of Alternative 1, even within these localized areas.

Mitigation solutions were identified and evaluated based on flood risk reduction performance only. It is recommended that further evaluation of the solutions, considering permitting and implementation costs, be conducted prior to selecting solutions to move forward into design.

Anecdotal flood records (i.e., high water marks, aerial imagery) are generally lacking within the La Conner/Sullivan/No Name and Fir Island area. It is recommended that the County consider having resources available to make flood observation and establish field records to enhance the quality of water level estimates and overall level of confidence in the flood models. Additional survey of existing hydraulic structures in also recommended, with structures within the sea dike considered primary, and floodplain conveyances as secondary. This will further increase the accuracy in representation of baseline flood hydraulics and evaluation of mitigation solution performance.

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APPENDIX A

2018 AND 2021 FLOOD OBSERVATIONS AND OTHER PHOTOGRAPHS

February 2018 Flooding in the Samish Area

- Photo Set 1 Samish River Corridor
- Photo Set 2 Samish River Dike Breach
- Photo Set 3 Sam Bell Road and Interstate-5 Vicinity Flooding
- Photo Set 4 Allen Road and Chuckanut Road Vicinity Flooding
- Photo Set 5 Thomas Rd Flooding
- Photo Set 6 Farm to Market Road and Boe Road Flooding
- Photo Set 7 Alice Bay, Bayview Edison North Design Site, Samish Bay Vicinity
- Photo Set 8 Padilla Bay
- Photo Set 9 Edison Vicinity

November 2021 Flooding in the Samish Area and Lower Skagit River

- Photo Set 10 Samish Area
- Photo Set 11 Skagit River between Mt. Vernon and Sedro-Woolley

Photo Set 1 Samish River Corridor (February 2018 Flood)


Photo A1.1 Looking south across Samish River toward T Loop Road and Joe Leary Slough from a location near Farm to Market Road and Edison Lutheran Church, taken February 8, 2018 (left)
Photo A1.2 Looking southeast along Samish River and across Farm to Market Road from a location near Boe Road, taken February 8, 2018 (right)


Photo A1.3 Looking west across Church Road Farm to Market Road Samish River from from above Sunset Road and a location west of Thomas Road, taken February 8, 2018 (left)
Photo A1.4 Looking west along Sunset Road across Farm to Market Road Samish River from a location west of Thomas Road, taken February 8, 2018 (right)


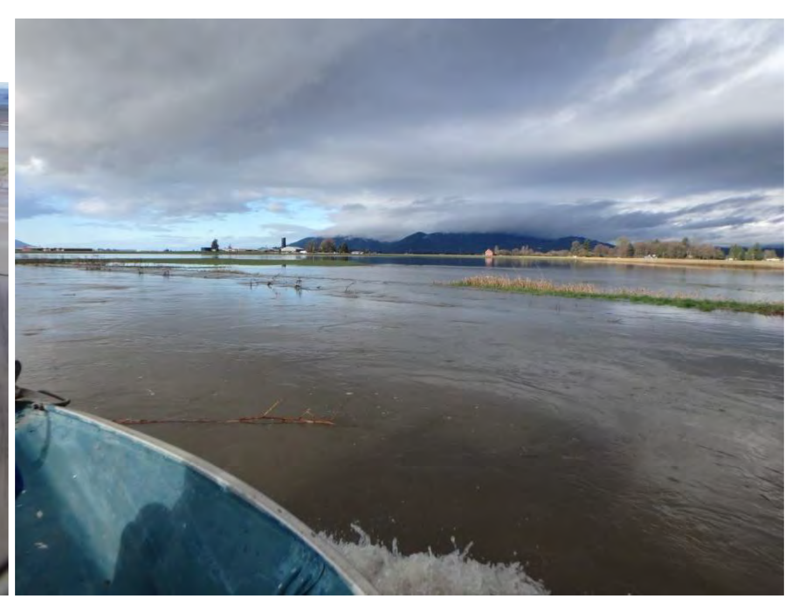

Photo A1.5 Looking west along Samish River toward Thomas Road bridge from a location near Chuckanut Road, taken February 8, 2018 (left)
Photo A1.6 Samish River west of Thomas Road, taken February 4, 2018 (right)

 

Photo A1.7 Photo from UAV looking west along Samish River and T Loop Road toward Farm to Market from above a location near 15014 Field Road, taken February 6, 2018 – courtesty of Austin Breckenridge. (left)
Photo A1.8 Samish River west of Thomas Road, taken February 6, 2018 – courtesty of Austin Breckenridge. (right)

 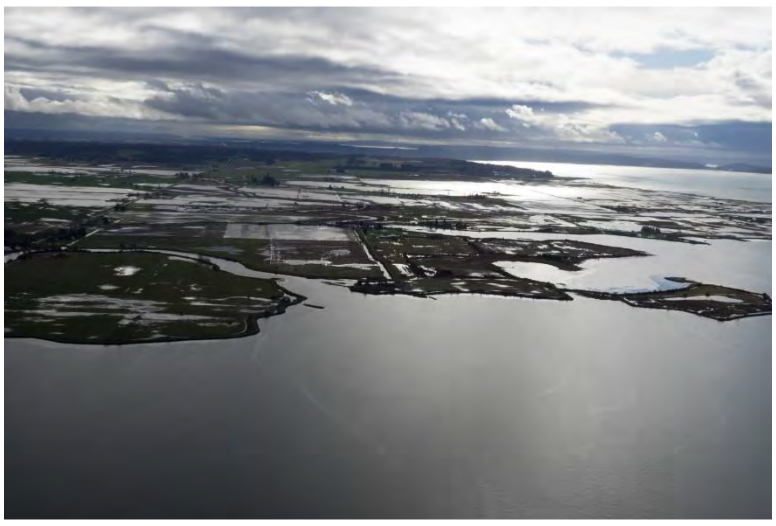

Photo A1.9 Looking southwest toward Padilla Bay and intersection of Sullivan Road and Boe Roads from above a location near the intersection of Farm to Market and Sunset Roads, taken February 8, 2018 (left)
Photo A1.10 Looking south from Samish Bay towards Edison Slough and Samish River outlets, taken February 8, 2018 (right)

Photo Set 2 Samish River Dike Breach (February 2018 Flood)

Photo A2.1 Looking south across at Samish River dike breach from above a location near 15014 Field Road February 8, 2018, during flood (left)

Photo A2.2 Looking southwest at Samish River dike breach from above a location near 15014 Field Road Road February 8, 2018, during flood (right)

Photo A2.3 Post flood photo of Samish River dike breach, looking toward river, taken February 15, 2018 following flood recession (left)

Photo A2.4 Post flood photo of Samish River dike breach, looking twoward through breach toward floodplain, taken February 15, 2018 following flood recession (left)

Photo A2.5 Photo from UAV looking at Samish River dike breach, taken February 6, 2018 – courtesty of Austin Breckenridge. (left)

Photo A2.6 Photo from UAV looking at Samish River dike breach, taken February 6, 2018 – courtesty of Austin Breckenridge. (right)

Photo Set 3 Sam Bell Road and Interstate-5 Vicinity Flooding (February 2018 Flood)

Photo A3.1 Looking southwest at Interstate-5 Samish River Crossing and Sam Bell Road from a location above Old Highway 99, taken February 8, 2018 (left)

Photo A3.2 Looking south along Interstate-5 at Samish River crossing towards Sam Bell Road from a location above Interstate-5, taken February 8, 2018 (right)

Photo A3.3 Looking south across Samish River railroad crossing towards Sam Bell Road from a location above I-5, taken February 8, 2018 (left)

Photo A3.4 Looking south from gravel pit along PulverRoad near Sam Bell Road, taken February 8, 2018 (right)

Photo A3.5 Sam Bell Road from location east of Chuchanut Drive, taken February 5, 2018 (left)

Photo A3.6 Sam Bell Road from location east of Chuchanut Drive, taken February 5, 2018 (right)

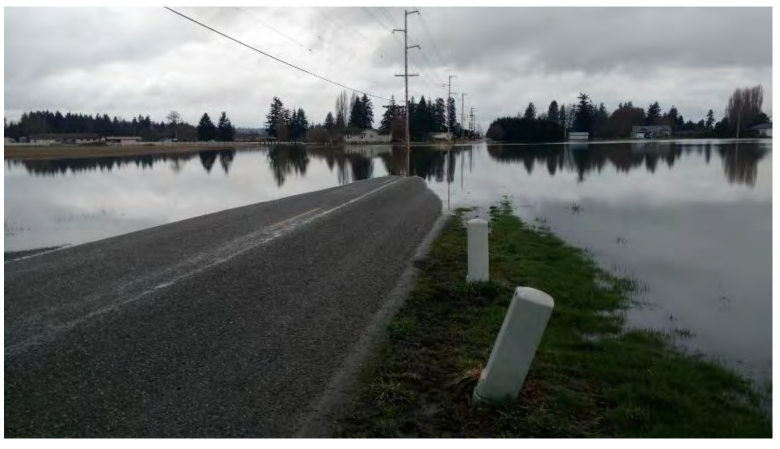

Photo A3.7 Sam Bell Road looking east from 18272 block toward east deadend near Interstate-5, taken February 6, 2018 (left)

Photo A3.8 Sam Bell Road looking west from 17246 block east of Chuckanut Road, taken February 6, 2018 (right)

Photo Set 4 Allen Road and Chuckanut Road Vicinity Flooding (February 2018 Flood)

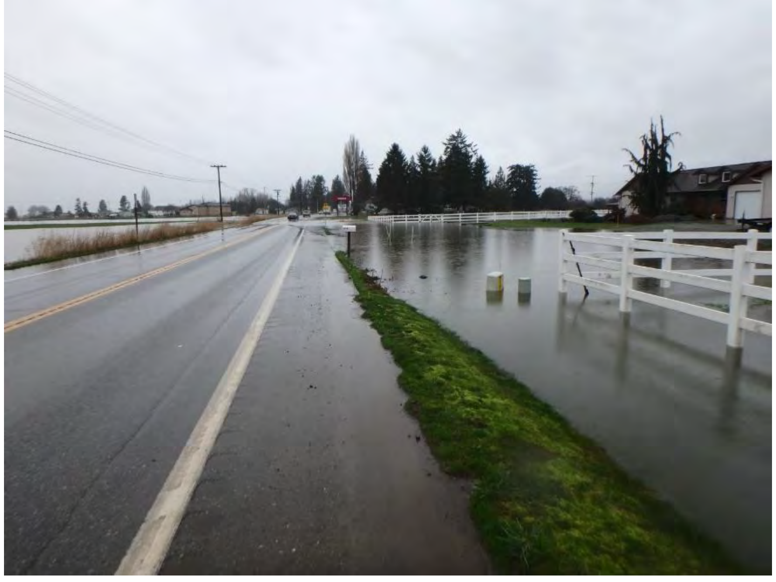


Photo A4.1 Sam Bell Road Looking West from 17246 block east of Chuckanut Road, taken February 5, 2018 (left)
Photo A4.2 ChuckanutDrive south of Sam Bell Road, taken February 4, 2018 (right)


Photo A4.3 Looking southwest across Farm2Market and Samish River from a location near intersection of Bow Hill Road and Chuckanut Road, taken February 8, 2018
Photo A4.4 Flooding at Omdahl Road, taken February 5, 2018 (right)

Photo A4.5 Samish River at Chuckanut Road looking east, taken February 3, 2018

Photo Set 5 Thomas Road Flooding (February 2018 Flood)

Photo A5.1 Looking southeast across Samish Rver and along Thomas Road, taken February 8, 2018 (left)
Photo A5.2 Thomas Road at Samish River north of Allen Road, taken February 4, 2018 (right)

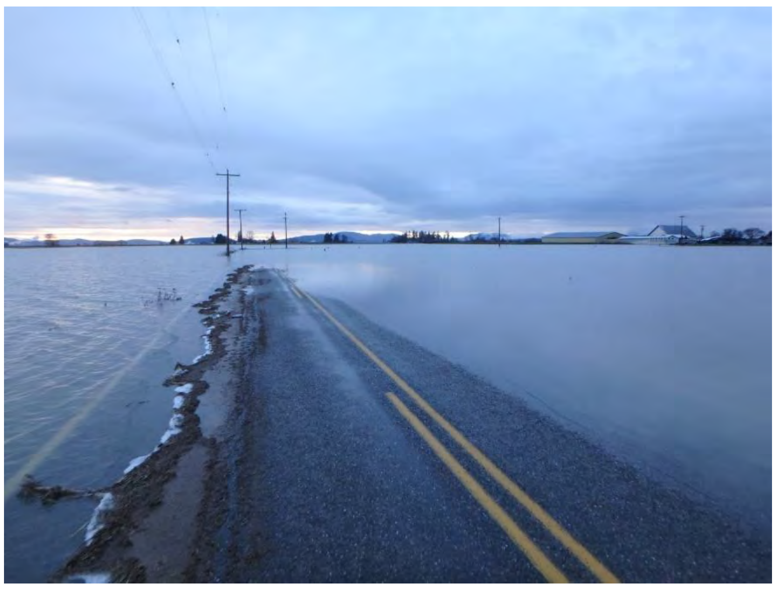

Photo A5.3 Thomas Road at Samish River north of Allen, taken February 6, 2018 (left)
Photo A5.4 Field Road looking east toward Thomas Road from location east of Church Road, taken February 5, 2018 (right)

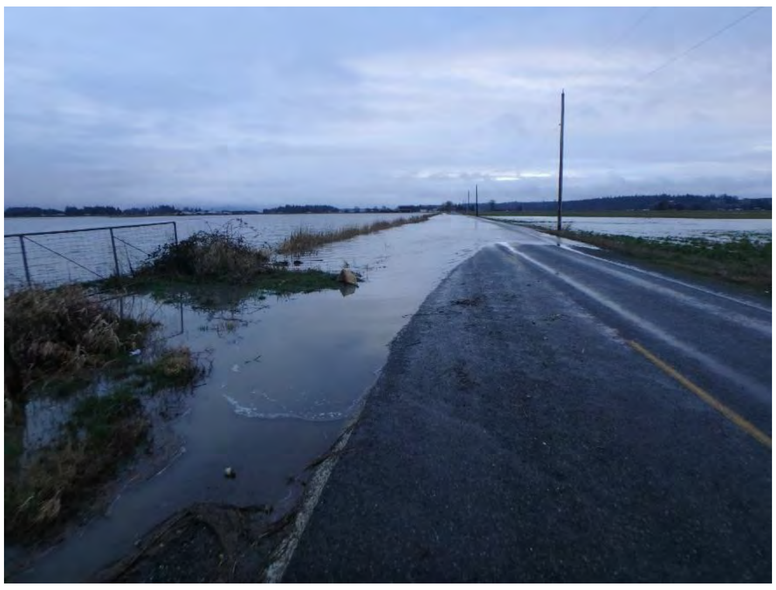

Photo A5.5 Thomas Road looking south from 8000 block of Field Road, taken February 5, 2018 (left)
Photo A5.6 Thomas Road north of Allen, taken February 4, 2018 (right)


Photo A5.7 Thomas Road north of Allen, taken February 4, 2018 (left)
Photo A5.8 Thomas Road north of Allen, taken February 5, 2018 (right)

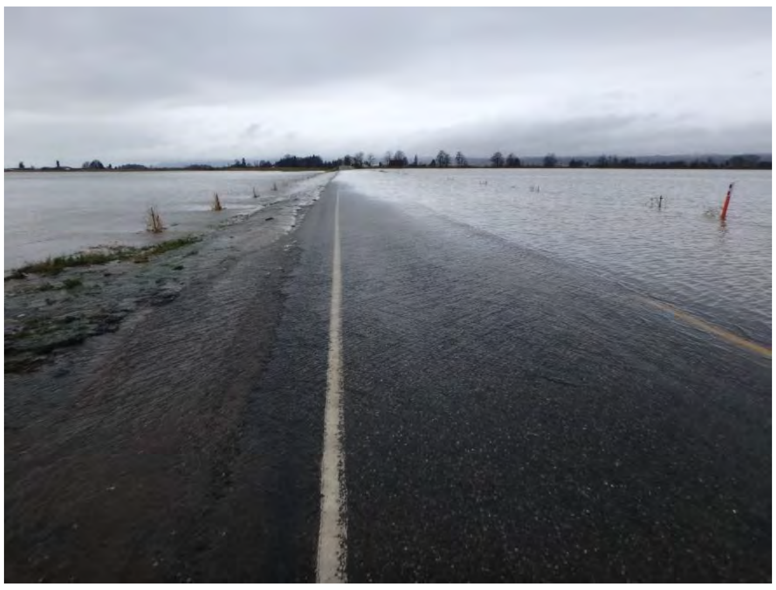


Photo A5.9 Thomas Road north of Allen, taken February 5, 2018 (left)
Photo A5.10 Thomas Road north of Allen, taken February 5, 2018 (right)

Photo Set 6 Farm to Market Road and Boe Road Flooding (February 2018 Flood)

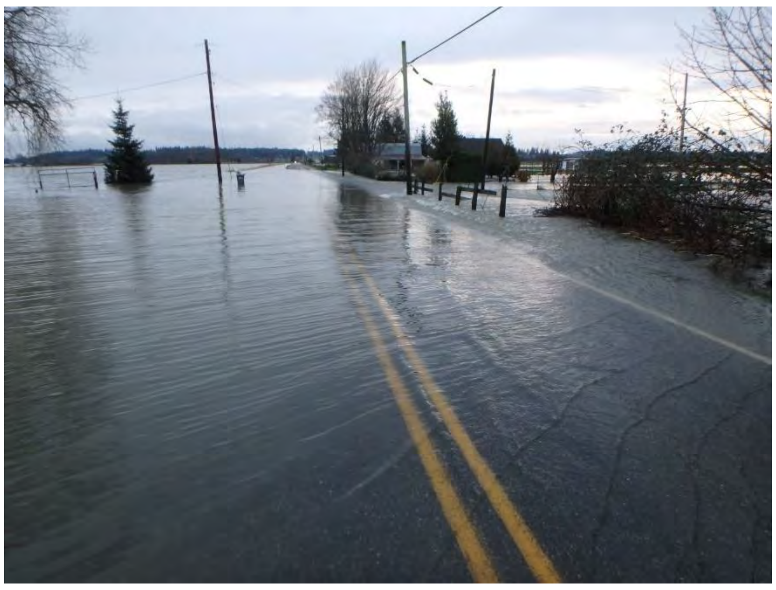

Photo A6.1 Flooding at Farm to Market Road and Boe Road, taken February 5, 2018 (left)
Photo A6.2 Flooding at Farm to Market Road and Boe Road, taken February 5, 2018 (right)

Photo A6.3 Swirling current at culvert inlet at Farm to Market and Boe Road, taken February 5, 2018 (left)
Photo A6.4 Flooding at Farm to Market and Boe Road, taken February 6, 2018 (right)

Photo A6.5 Flooding at Farm to Market and Boe Road, taken February 5, 2018 (left)
Photo A6.6 Flooding of residenec on Farm to Market near intersection of Field Road, taken February 6, 2018 (right)

Photo Set 7 Alice Bay, Bayview Edison North flood mitigation design site, and Samish Bay Vicinity (February 2018 Flood)


Photo A7.1 Looking west along Bayview Edison Road across Farm to Market Road and Samish River, taken February 8, 2018 (left)
Photo A7.2 Looking north toward Samish Bay along Farm to Market Road from above a location near Sunset Road T-intersection , taken February 8, 2018 (right)


Photo A7.3 Looking west along Bayview Edison Road across Farm to Market Road and Samish River, taken February 8, 2018 (left)
Photo A7.4 Looking north toward Samish Bay, Bayview Edison North flood mitigation design site, and Bayview Edison Road, taken February 8, 2018 (right)


Photo A7.5 Looking northwest toward Samish Bay, Bayview Edison North flood mitigation design site, and Bayview Edison Road, taken February 8, 2018 (left)
Photo A7.6 Looking west toward Padilla Bay, Samish Bay, and Samish Island Road, taken February 8, 2018 (right)


Photo A7.7 Looking north toward Alice Bay and Padilla Bay from a location above Samish Island Road, taken February 8, 2018 (left)
Photo A7.8 Looking northwest toward AliceBay and Samish Island, taken February 8, 2018 (right)

Photo A7.9 Looking northwest toward Samish Island, taken February 8, 2018

Photo Set 8 Padilla Bay (February 2018 Flood)


Photo A8.1 Looking west toward Padilla Bay and Samish Island Road across Bayview Edison Road from above a location near the Samish River and Sullivan Road, taken February 8, 2018 (left)
Photo A8.2 Looking west toward Padilla Bay and Samish Island Road across Bayview Edison Road from above a location near the Samish River and Sullivan Road, taken February 8, 2018 (right)


Photo A8.3 Looking west toward Padilla Bay Samish Island Road across Bayview Edison Road from above a location near the Samish River and Sullivan Road, taken February 8, 2018 (left)
Photo A8.4 Looking west toward Padilla Bay along Sullivan Road from above a location near the Samish River and Farm to Market Road, taken February 8, 2018 (right)


Photo A8.5 Looking south along Bayview Edison Road toward Padilla Bay from above a location near Sullivan Road, taken February 8, 2018 (left)
Photo A8.6 Looking south from near a location west of Bayview Edison Road and above Samish Island Road, taken February 8, 2018 (right)


Photo A8.7 Looking south along Bayview Edison Road toward Padilla Bay from above a location near Sullivan Road, taken February 8, 2018 (left)

Photo A8.8 Looking southwest toward Padilla Bay across Bayview Edison Road from above a location near Sullivan Road, taken February 8, 2018 (right)

Photo A8.9 Looking southwest toward Padilla Bay across Bayview Edison Road from above a location near Sullivan Road, taken February 8, 2018

Photo Set 9 Edison Vicinity (February 2018 Flood)


Photo A9.1 Downtown Edison, taken February 8, 2018 (left)
Photo A9.2 Downtown Edison, taken February 8, 2018 (right)

Photo A9.3 Looking west along Edison Slough and Bow Hill Road, taken February 8, 2018

Photo Set 10 Samish Area (November 2021 Flood)


Photo A10.1 Samish River flooding at Allen, taken November 16, 2021 (left)
Photo A10.2 Samish River flooding at Allen, taken November 16, 2021 (right)


Photo A10.3 Looking west toward Sam Bell Road and Interstate-5 from location above Old Highway 99, taken November 16, 2021 (left)
Photo A10.4 Looking south along Farm to Market Road near Field Road, taken November 16, 2021 (right)


Photo A10.5 Looking southwest across Samish River from Samish Bay toward Padilla Bay, taken November 16, 2021 (left)
Photo A10.6 Looking southwest across Samish River from Samish Bay toward Padilla Bay, taken November 16, 2021 (right)

Photo Set 11 Skagit River between Mt. Vernon and Sedro-Woolley (November 2021 Flood)


Photo A11.1 Skagit River flooding near Francis Road and Nookachamps Creek (left)
Photo A11.2 Skagit River flooding looking south near Stirling Highway 20 and District Line Road (right)


Photo A11.3 Skagit River flooding east of Stirling (left)
Photo A11.4 Skagit River flooding near Stirling and Highway 20 and District Line Road (right)

Photo A11.5 Skagit River flooding looking west from Burlington (left)

APPENDIX B

HIGH WATER MARK INVENTORY FOLLOWING NOVEMBER 2021 FLOOD MEMORANDUM

12787 Gateway Drive South | Seattle, WA 98168 | 206.241.6000 | www.nhcweb.com

nhc
northwest hydraulic consultants

MEMORANDUM

To:	Michael See Skagit County 1800 Continental Place Mount Vernon, WA 98273	Date:	March 10, 2022
From:	Chad Drake, PhD, EIT Derek Stuart, P.E.	NHC Ref. No.	2002084
Re:	**Post-November 2021 Flood High Water Mark (HWM) Inventory** **Skagit River Downstream of Rockport**		

1 INTRODUCTION

In support of an ongoing Skagit River Delta Flood Drainage project with Skagit County, Northwest Hydraulic Consultants (NHC) was requested to conducted high-water measurements along the Lower Skagit River between the Sauk River confluence (near Rockport) and Mount Vernon after a high flow event on November 15-16, 2021. The event produced the 2nd, 16th, and 8th largest peak discharges on record at the USGS stations at Marblemount, Concrete, and Mount Vernon, respectively. The peak discharge and water surface elevation records at each of these USGS stations are summarized in Table 1.1, and the hydrographs are shown in Figure 1.1. This memorandum describes the methods employed and summarizes the high-water mark survey data collected by NHC as part of this effort. All water surface elevations are reported in feet, using the North American Vertical Datum of 1988 (NAVD 1988), unless noted otherwise.

Table 1.1 Peak discharge and water surface elevations recorded along the Skagit River at the Marblemount, Concrete, and Mount Vernon USGS stations

USGS Gage	Peak Discharge (cfs)	Peak Water Surface Level (feet)	Date/Time of Peak [1]	Gage Record Length (years)	Peak Rank
Skagit River at Marblemount (12181000)	63,400[A]	323.31[A,2]	11/15/2021 03:20 PST	58	2nd largest
Skagit River near Concrete (12194000)	134,000[P]	38.93[P,1]	11/15/2021 10:45 PST	104	16th largest
Skagit River near Mount Vernon (12200500)	127,000[A]	40.79[A,2]	11/16/2021 03:43 PST	82	8th largest

[A]Approved data by USGS; [P]Provisional data subject to revision by USGS; [1]Gage height, not water surface elevation, reported since no vertical shift provided by USGS. [2] Referenced to NAVD 1988 vertical datum

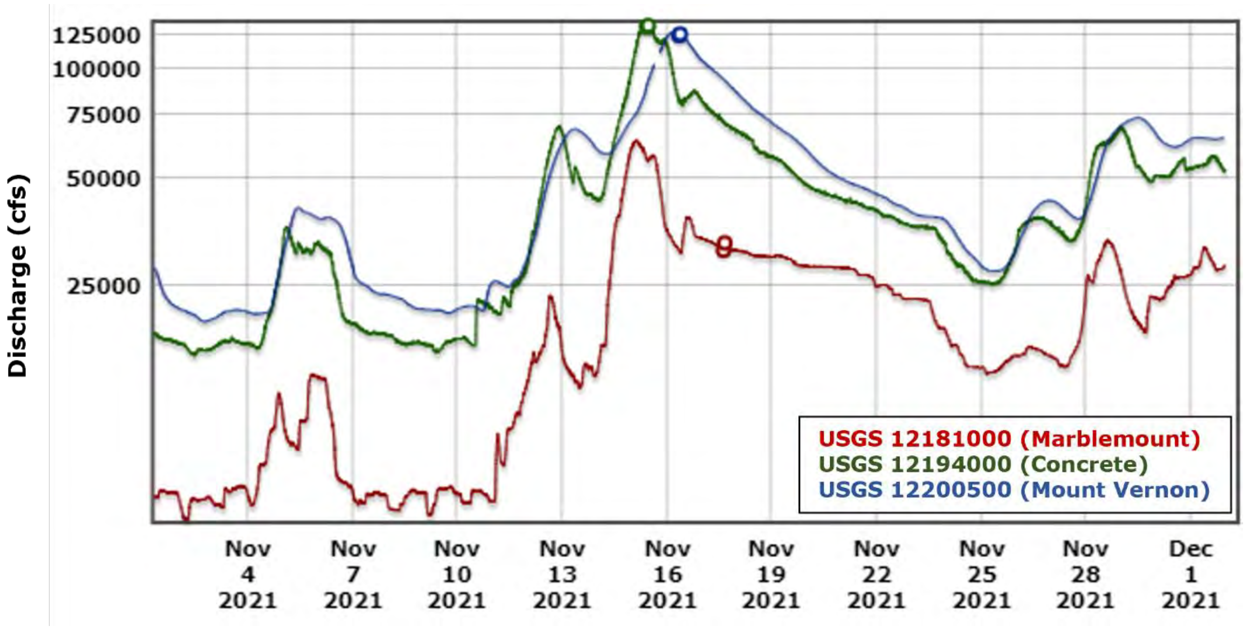

Figure 1.1 Hydrographs observed along the Skagit River at the Marblemount, Concrete, and Mount Vernon USGS stations encompassing the November 15-16, 2021, high flow event

2 METHODOLOGY

Peak water surface elevations from the November 15-16, 2021, high-flow event were collected along the Skagit River between the Sauk River confluence (near Rockport) and Mount Vernon by identifying high-water marks on several field visits following the event. High-water marks (HWMs) are post-flood evidence of the highest elevation reached by floodwaters. Evidence collected for this study included:

- Debris lines of small organic material left behind as the water recedes
- Wash lines indicating the maximum elevation that loose material was removed from the ground surface by floodwaters
- Mud lines of fine sediment deposited up to the peak flood elevation

Upon identification, each high-water mark was evaluated for how precisely it defined the peak flow elevation using the USGS high-water mark uncertainty rating system (Table 2.1). This rating system assigns a level of confidence as to the degree which the mark reflects the highest elevation reached by the floodwaters (Koenig et al., 2016).

Each high-water mark was flagged, photographed, and surveyed with real-time kinematic (RTK) GPS which received corrections via the Washington State Reference Network (WSRN). Surveyed marks with excessive vertical uncertainty (generally greater than 0.5 feet) because of poor connection with GPS satellites due to overhanging and/or dense tree canopy were excluded from the HWM survey dataset.

Vertical datum quality control was established by checking into WSDOT Survey Monument GP29020-55 near Burlington with the RTK and comparing the calculated elevation to the published reference elevation for the site. A good match was achieved, as the surveyed elevation (40.354 feet) was only 0.072 feet lower than the published reference elevation (40.426).

Table 2.1 USGS HWM Uncertainty Rating System (Koenig et al., 2016)

Vertical Uncertainty in Identifying High Water Elevation	Uncertainty Rating
Within ±0.05 foot	Excellent (E)
Within ±0.10 foot	Good (G)
Within ±0.20 foot	Fair (F)
Within ±0.40 foot	Poor (P)
More than ±0.40 foot	Very Poor (V)
High-water mark defines the minimum height of the peak, but peak may have been higher to an unknown extent	At least this high (ALTH)

3 SUMMARY OF DATA COLLECTED

As mentioned above, a total of 75 high-water marks were collected at approximately two dozen distinct locations along the Skagit River between Rockport and Mount Vernon for the November 15-16, 2021, high flow event. Of the 75 marks, 50 (67%) were assigned a USGS rating of “excellent” or “good”, 18 (24%) were assigned a rating of “fair”, five (6%) were assigned a rating of “poor”, and two (3%) identified the flood peak elevation as “at least this high.”

Three high water marks collected near the Mount Vernon USGS gage (12200500) were compared to the peak water surface elevations reported by the USGS. This data is summarized in Table 3.1. Two high water marks surveyed by NHC near the USGS gage on the north side of the river were within 0.2 feet of the USGS approved peak water surface elevation of 40.79 feet (one NHC survey mark was 0.16 feet lower and the other was 0.03 feet higher than that reported by the USGS). The third NHC high water mark, a stake placed by Skagit County on the Dike District 17 boat ramp located on the south side of the river 890 feet downstream of the USGS gage, was 0.37 feet lower than the USGS approved elevation, but is not inconsistent with the other observations given the longitudinal distance separating the HWMs.

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Table 3.1 Peak water surface elevations surveyed near the Skagit River near Mount Vernon USGS Gage (12200500) as compared to the USGS and National Weather Service (NWS) reported values.

NHC	USGS
40.63 (debris line near USGS gage on north side of river) 40.82 (wash line near USGS gage on north side of river) 40.42 (stake on Dike District 17 boat ramp on south side of river, 890 feet downstream of the USGS gage)	40.79[A]

[A]Approved; [P]Preliminary

On the same day that the high-water mark stake on the Dike District 17 boat ramp was surveyed, NHC also surveyed the current water surface elevation on the south side of the river opposite the Mount Vernon USGS gage. The water surface elevation shot was collected on February 25, 2022 at 09:45 PST. The surveyed elevation of 17.75 feet was very close to the current USGS preliminary estimate of 17.78 feet. Although not a high-water mark, this water surface mark provides another verification that the USGS water-levels and those collected by the RTK GPS based on WSRN provided corrections are consistent with one another when adjusted to the NAVD 1988 vertical datum.

4 CONCLUSIONS

Field measurements of peak water surface elevations were collected along the Skagit River between the Sauk River confluence (near Rockport) and Mount Vernon after the November 15-16, 2021, high flow event. The quality ratings of the HWMs included in the inventory range from 'Fair' to 'Excellent' at 68 of the 75 (91%) high-water marks based on the USGS HWM rating system. The two high-water marks surveyed adjacent to the Mount Vernon USGS gage were within 0.16 feet of the USGS approved elevation. This high-water mark dataset provides valuable information for quantifying the spatial extent of flooding and is an important resource for future hydraulic model calibration/validation to be performed by the County, its consultants, or partners in the Skagit River basin.

5 REFERENCES

Koenig, T.A., J.L. Bruce, J.E O'Connor, B.D. McGee, R.R. Holmes, Jr., Ryan Hollins, B.T. Forbes, M.S. Kohn, M.F., Schellekens, Z.W. Martin, and M.C. Peppler. (2016.) Identifying and preserving high-water mark data (No.3-A24). U.S. Geological Survey. DOI: http://dx.doi.org/10.3133/tm3A24

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ATTACHMENTS

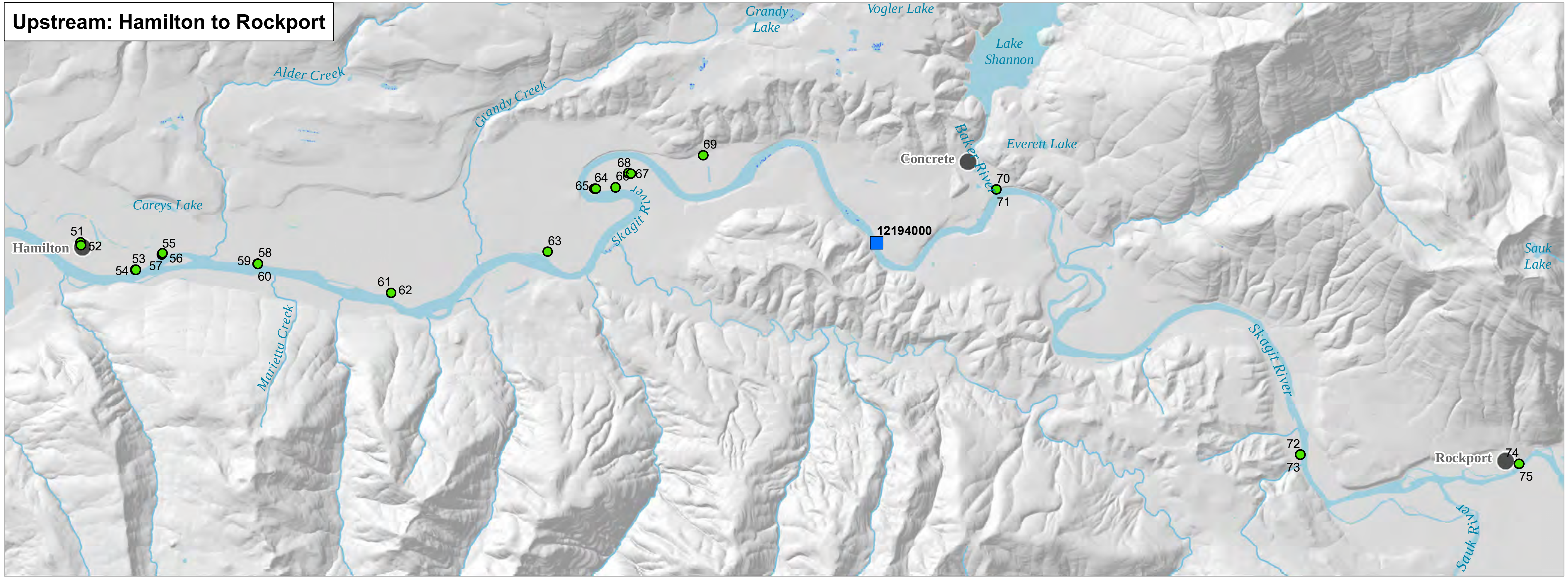
- Table of November 2021 Flood Skagit River High Water Marks, Downstream of Sauk River Confluence
- High-Water Mark Map
- ESRI Point Shapefile of Surveyed High-Water Marks (Digital Transmittal)

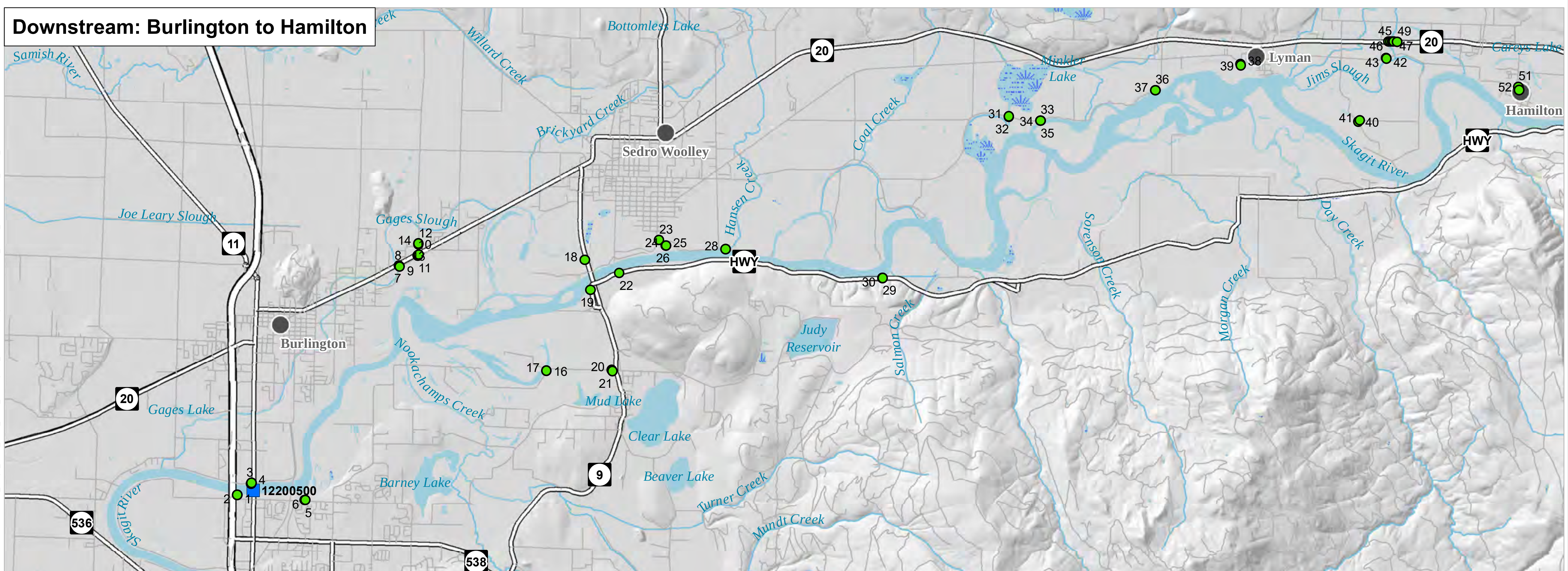
Table of November 2021 Flood Skagit River High Water Marks, Downstream of Sauk River Confluence

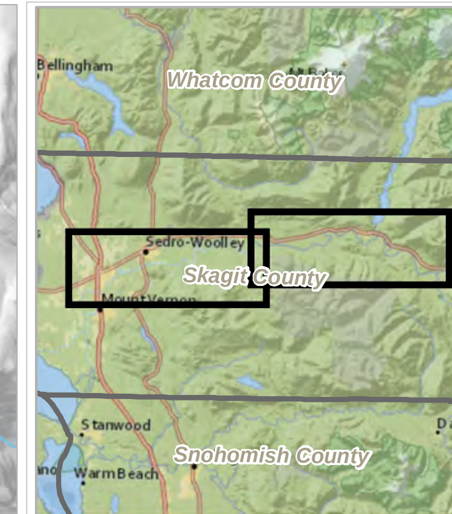
NHC ID	Northing	Easting	Elevation (Feet NAVD88)	HWM Line Description[B]	Rating
1	530255.880	1274812.089	40.42	STAKED AT PEAK	E
2	530255.831	1274812.100	40.41	STAKED AT PEAK	E
3	531014.110	1275751.176	40.82	WASH	G
4	531059.794	1275776.990	40.63	DEB	G
5	529901.064	1279311.766	41.68	DEB	F
6	529910.935	1279376.472	41.75	DEB	F
7	545523.041	1285602.155	45.07	DEB	F
8	545473.014	1285636.145	45.39	MUD	G
9	545466.022	1285644.699	45.31	DEB	F
10	546193.327	1286852.890	45.39	DEB	G
11	546205.210	1286872.454	45.28	DEB	G
12	546955.714	1286889.767	45.29	DEB	F
13	547002.669	1286896.106	44.90	DEB	F
14	547002.588	1286896.226	44.90	DEB	F
15	546247.173	1286907.946	44.06	DEB	G
16	538533.392	1295426.269	44.61	DEB	ALTH
17	538532.170	1295426.554	44.48	DEB	ALTH
18	545911.481	1297967.020	45.84	DEB	G
19	543903.263	1298343.427	46.36	DEB	G
20	538580.810	1299758.176	44.72	DEB	G
21	538506.015	1299821.852	43.22	DEB	P
22	545028.077	1300276.171	48.63	DEB	F
23	547219.736	1302925.144	49.30	DEB	F
24	546853.027	1303368.525	49.60	DEB	E-G
25	546853.750	1303375.480	49.70	DEB	E-G
26	546856.580	1303384.054	49.76	DEB	E-G
27	546862.170	1303394.046	49.90	DEB	E-G
28	546625.250	1307339.943	51.53	DEB	G
29	544717.112	1317783.532	57.38	DEB	G
30	544717.358	1317813.414	56.90	WASH	G
31[A]	555464.193	1326211.666	66.36	DEB	G
32[A]	555468.059	1326224.905	66.51	SEED	G
33[A]	555180.419	1328306.719	67.91	SEED	G
34[A]	555180.928	1328307.051	67.97	DEB	G
35[A]	555180.611	1328307.339	67.99	SEED	G
36[A]	557201.104	1335963.198	66.63	DEB	G
37[A]	557201.073	1335963.247	66.70	DEB	G
38	558966.590	1341649.533	76.36	DEB	G
39	558885.019	1341654.166	80.51	WASH	F
40	555134.891	1349479.704	84.55	DEB	G
41	555193.522	1349597.177	84.97	DEB	G
42	559349.110	1351343.719	90.41	DEB	G
43	559349.108	1351343.770	90.39	DEB	G

NHC ID	Northing	Easting	Elevation (Feet NAVD88)	HWM Line Description[B]	Rating
44	559329.564	1351359.622	90.20	DEB	G
45	560444.612	1351491.452	92.24	DEB	G
46	560447.459	1351620.522	93.00	MUD	G
47	560446.865	1351735.816	93.38	MUD	G
48	560444.589	1351839.773	93.45	WASH MUD	G
49	560423.427	1352078.423	93.91	DEB MUD	G
50	560423.418	1352078.539	93.96	DEB MUD	G
51	557432.906	1360147.600	102.49	MUD	G
52	557223.730	1360184.782	102.44	MUD	G
53	555604.491	1363804.679	106.38	DEB	F
54	555607.252	1363850.606	106.97	DEB	F
55	556634.107	1365578.662	107.14	DEB	G
56	556652.467	1365592.110	107.05	DEB	G
57	556712.728	1365638.329	105.70	MUD	F
58	556007.240	1371965.103	112.61	MUD	P
59	556007.183	1371965.137	112.60	MUD	P
60	556007.223	1371965.144	112.57	MUD	P
61	554060.815	1380852.628	121.10	SEED	G
62	554060.851	1380852.702	121.07	SEED	G
63	556795.110	1391266.577	132.71	WASH	F
64	561011.206	1394372.094	146.74	DEB	G
65	561010.344	1394487.042	145.90	DEB	G
66	561098.147	1395794.362	145.59	WASH	G
67	562051.115	1396646.349	150.66	DEB	P
68	562013.147	1396839.362	151.62	WASH	F
69	563225.310	1401632.201	156.55	DEB	F
70	560955.991	1421163.063	183.48	WASH	G
71	560954.287	1421172.337	183.85	WASH	G
72	543270.578	1441392.812	222.65	DEB	F
73	543270.552	1441392.812	222.64	DEB	F
74	542658.840	1455989.324	232.71	DEB	G
75	542658.921	1455989.382	232.70	DEB	G

[A] Post collection data review identified that the water-levels observed at HWM IDs 36 and 37 are lower than would be expected given the water-levels at HWM IDs 31-35, approximately 2 miles downstream. Subsequent review did not identify obvious causes for the deviation.
B WASH = wash line; DEB = debris line; MUD = mud line; ALTH = "at least this high"; and "STAKED AT PEAK" points were staked by Dike District 17 staff that were visually monitoring the flood peak (two GPS observations were taken on the same HWM).







Miles
0 0.5 1

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N

Coordinate System: NAD 1983 HARN
STATEPLANE WASHINGTON NORTH FIPS 4601

Legend

- High Water Mark (NHC)
- USGS Gage

USGS Data Summary:
Skagit River at Marblemount (12181000): Approved
Peak Discharge: 63,400 cfs (11/15/2021 03:20 PST)
Peak WSE: 323.31 ft-NAVD88

Skagit River near Concrete (12194000): Provisional
Peak Discharge: 134,000 cfs (11/15/2021 10:45 PST)
Peak Gage Height: 38.93 ft

Skagit River near Mount Vernon (12200500): Approved
Peak Discharge: 127,000 cfs (11/16/2021 03:43 PST)
Peak WSE: 40.79 ft-NAVD88

nhc northwest hydraulic consultants

SKAGIT COUNTY WASHINGTON

SKAGIT RIVER DELTA
FLOOD DRAINAGE PROJECT

High Water Mark Survey
November 15-16, 2021
High Flow Event

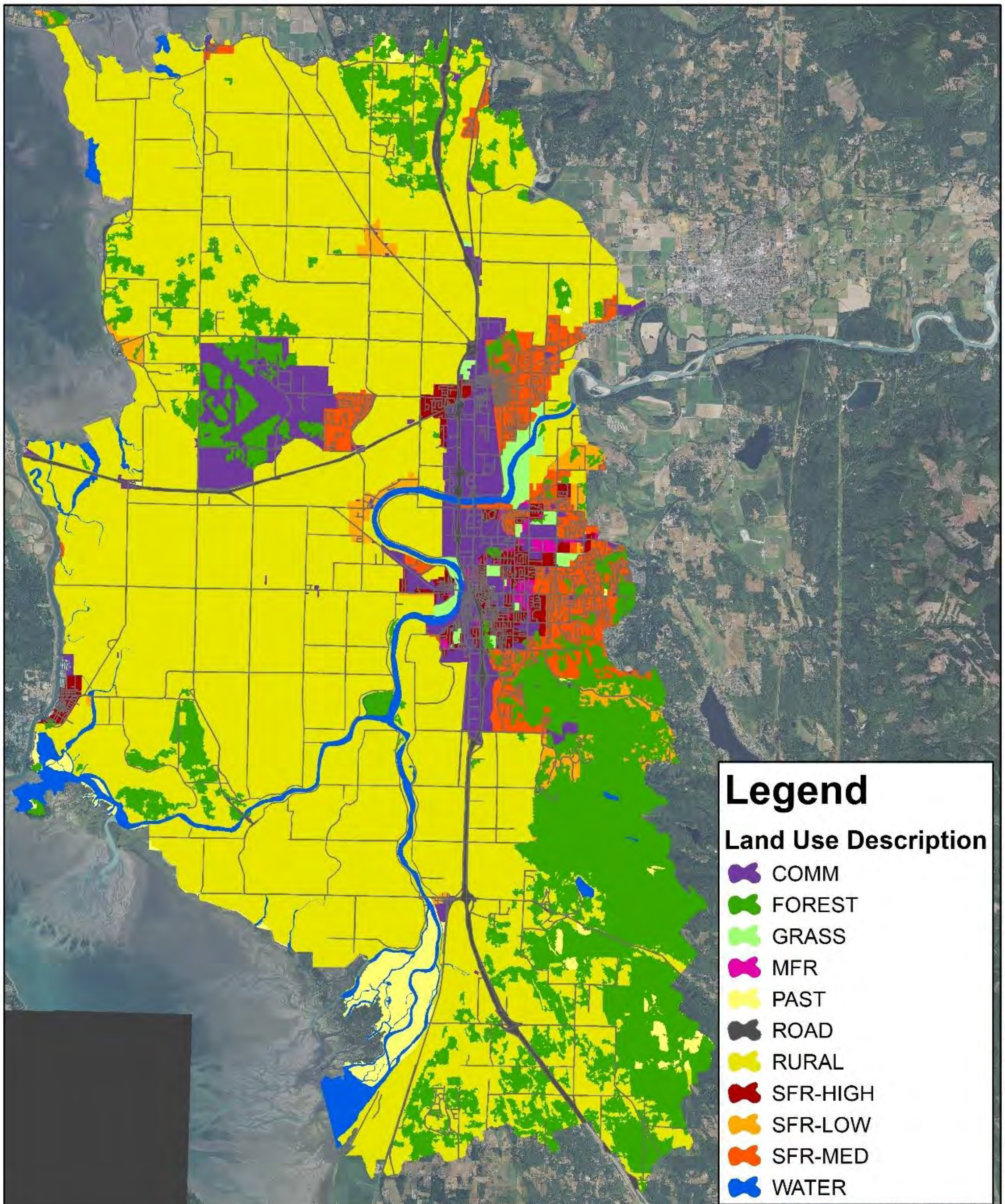
DRAFT

Date: 04-Mar-2022
Job: 2002084

EXHIBIT 1

APPENDIX C

MAPS OF SKAGIT DELTA HSPF MODEL INPUTS



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Skagit River Delta
Flood Drainage Project

Land Use Map

Coordinate System: NAD 1983 HARN STATEPLANE WASHINGTON NORTH FIPS 4601 FEET

nhc
northwest hydraulic consultants

Job: 2002084 | Date: 05-DEC-2019

FIGURE C-1

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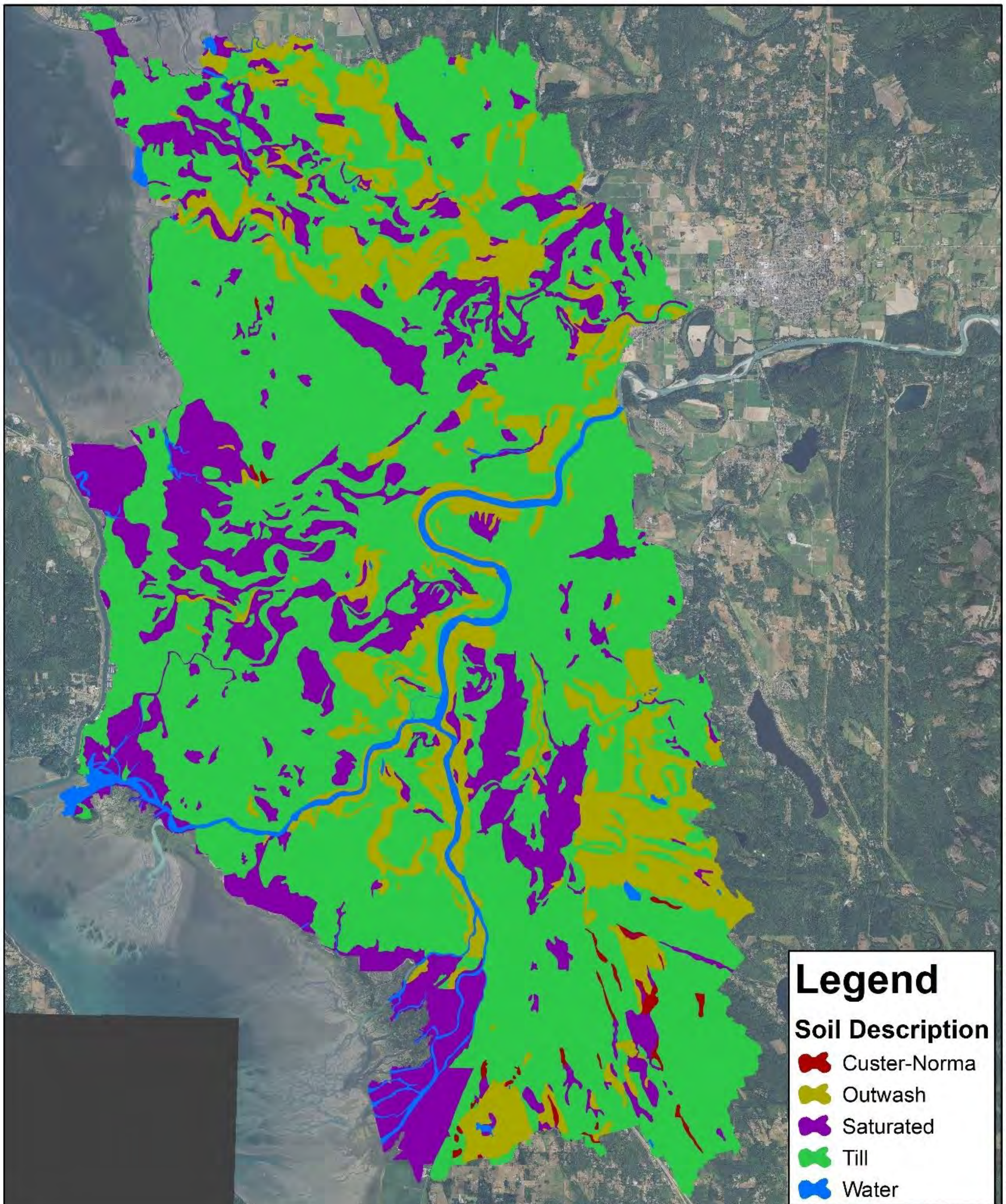

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Skagit River Delta Flood Drainage Project

Soils Map

nhc
northwest hydraulic consultants

Coordinate System: NAD 1983 HARN STATEPLANE WASHINGTON NORTH FIPS 4601 FEET

Job: 2002084 | *Date: 05-DEC-2019*

FIGURE C-2

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Table C-1, Model Parameters Applied to Skagit Delta HSPF Model

Copied directly from Table 10 from Snohomish County (2002)

Table 10
Generalized HSPF Model Parameters (adapted from Dinicola, 1990)

	HSPF Model Parameter																
Land Segment	LZSN (in.)	INFILT (in/hr)	LSUR (ft.)	SLSUR	KVARY (1/in.)	AGWRC (1/day)	INFEXP	INFILD	BASETP	AGWETP	CEPSC (in)	UZSN (in)	NSUR	INTFW	IRC (1/day)	LZETP	RETSC (in)
TFF	4.5	0.08	400	0.05	0.5	0.996	2.0	2.0	0.0	0.0	0.2	1.00	0.35	3.0	0.7	0.70	n/a
TFM	4.5	0.08	400	0.10	0.5	0.996	2.0	2.0	0.0	0.0	0.2	0.50	0.35	6.0	0.5	0.70	n/a
TFS	4.5	0.08	200	0.20	0.5	0.996	2.0	2.0	0.0	0.0	0.2	0.30	0.35	7.0	0.3	0.70	n/a
TPF	4.5	0.06	400	0.05	0.5	0.996	2.0	2.0	0.0	0.0	0.1	0.60	0.30	3.0	0.7	0.25	n/a
TPM	4.5	0.06	400	0.10	0.5	0.996	2.0	2.0	0.0	0.0	0.1	0.30	0.30	6.0	0.5	0.25	n/a
TPS	4.5	0.06	200	0.20	0.5	0.996	2.0	2.0	0.0	0.0	0.1	0.20	0.30	7.0	0.3	0.25	n/a
TGF	4.5	0.03	400	0.05	0.5	0.996	2.0	2.0	0.0	0.0	0.1	0.50	0.25	3.0	0.7	0.25	n/a
TGM	4.5	0.03	400	0.10	0.5	0.996	2.0	2.0	0.0	0.0	0.1	0.25	0.25	6.0	0.5	0.25	n/a
TGS	4.5	0.03	200	0.20	0.5	0.996	2.0	2.0	0.0	0.0	0.1	0.15	0.25	7.0	0.3	0.25	n/a
OF	5.0	2.00	400	0.05	0.3	0.996	2.0	2.0	0.0	0.0	0.2	0.50	0.35	0.0	0.7	0.70	n/a
OP	5.0	1.40	400	0.05	0.3	0.996	2.0	2.0	0.0	0.0	0.1	0.50	0.30	0.0	0.7	0.25	n/a
OG	5.0	0.80	400	0.05	0.3	0.996	2.0	2.0	0.0	0.0	0.1	0.50	0.25	0.0	0.7	0.25	n/a
CNF	2.0	0.40	400	0.01	4.0	0.990	3.5	2.0	0.0	0.0	0.2	1.00	0.35	4.0	0.8	0.90	n/a
CNP	2.0	0.30	400	0.01	4.0	0.990	3.5	2.0	0.0	0.0	0.1	0.70	0.30	4.0	0.8	0.90	n/a
CNG	2.0	0.16	400	0.01	4.0	0.990	3.5	2.0	0.0	0.0	0.1	0.50	0.25	4.0	0.8	0.90	n/a
SATF	4.0	2.00	100	0.001	0.5	0.996	10.0	2.0	0.0	0.7	0.2	3.00	0.50	1.0	0.7	0.80	n/a
SATP	4.0	1.80	100	0.001	0.5	0.996	10.0	2.0	0.0	0.7	0.1	3.00	0.50	1.0	0.7	0.80	n/a
SATG	4.0	1.00	100	0.001	0.5	0.996	10.0	2.0	0.0	0.7	0.1	3.00	0.50	1.0	0.7	0.80	n/a
EIA	n/a	n/a	100	0.010	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.10	n/a	n/a	n/a	0.10

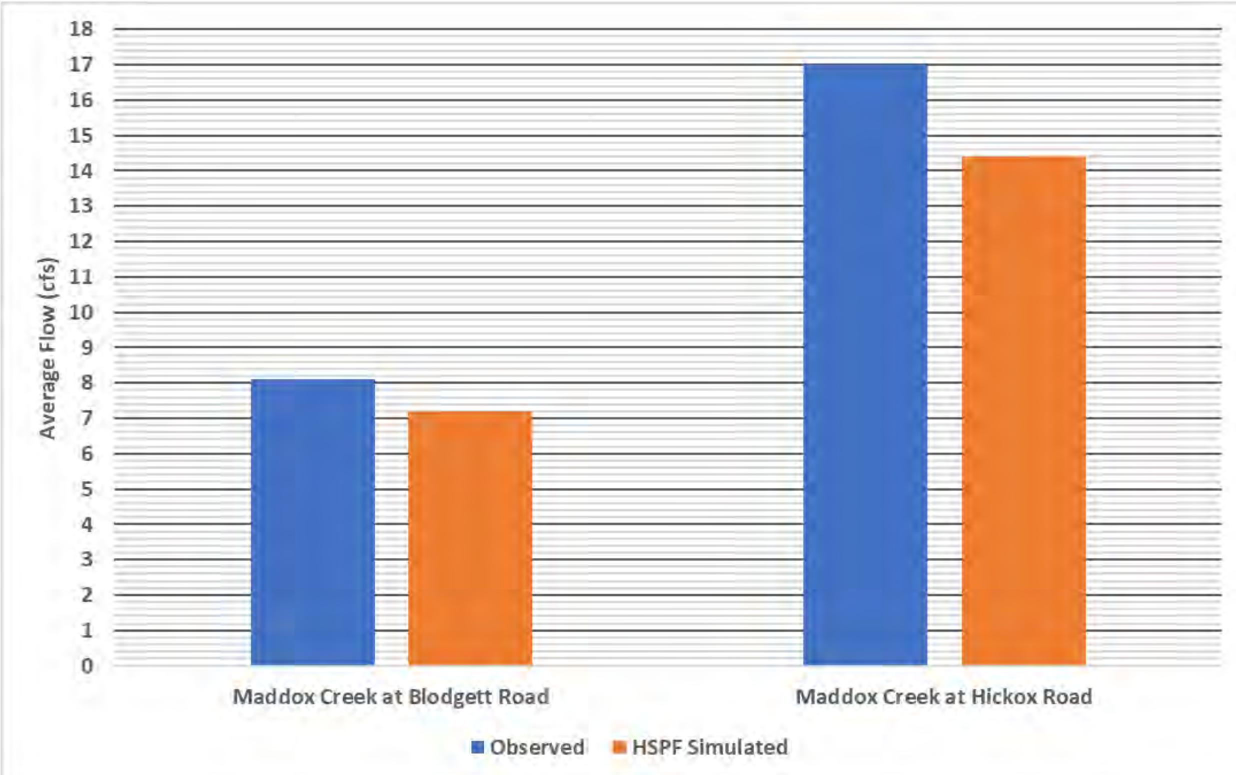


Figure C-3 Average flow comparison between HSPF simulated and observed Maddox Creek flow data at Blodgett Road and Hickox Road for December 28-30, 2018 event.

Note: Figure copied from NHC (2019) HSP model validation discussion. The December 28-30, 2018 event was the largest during the observed flow record at Maddox Creek: Blodget Road included December 5, 2018 through May 29, 2019, and Hickox Road included November 28, 2018 through January 8, 2019.

APPENDIX D

SUPPLEMENTAL FIGURES OF SIMULATED FLOODING

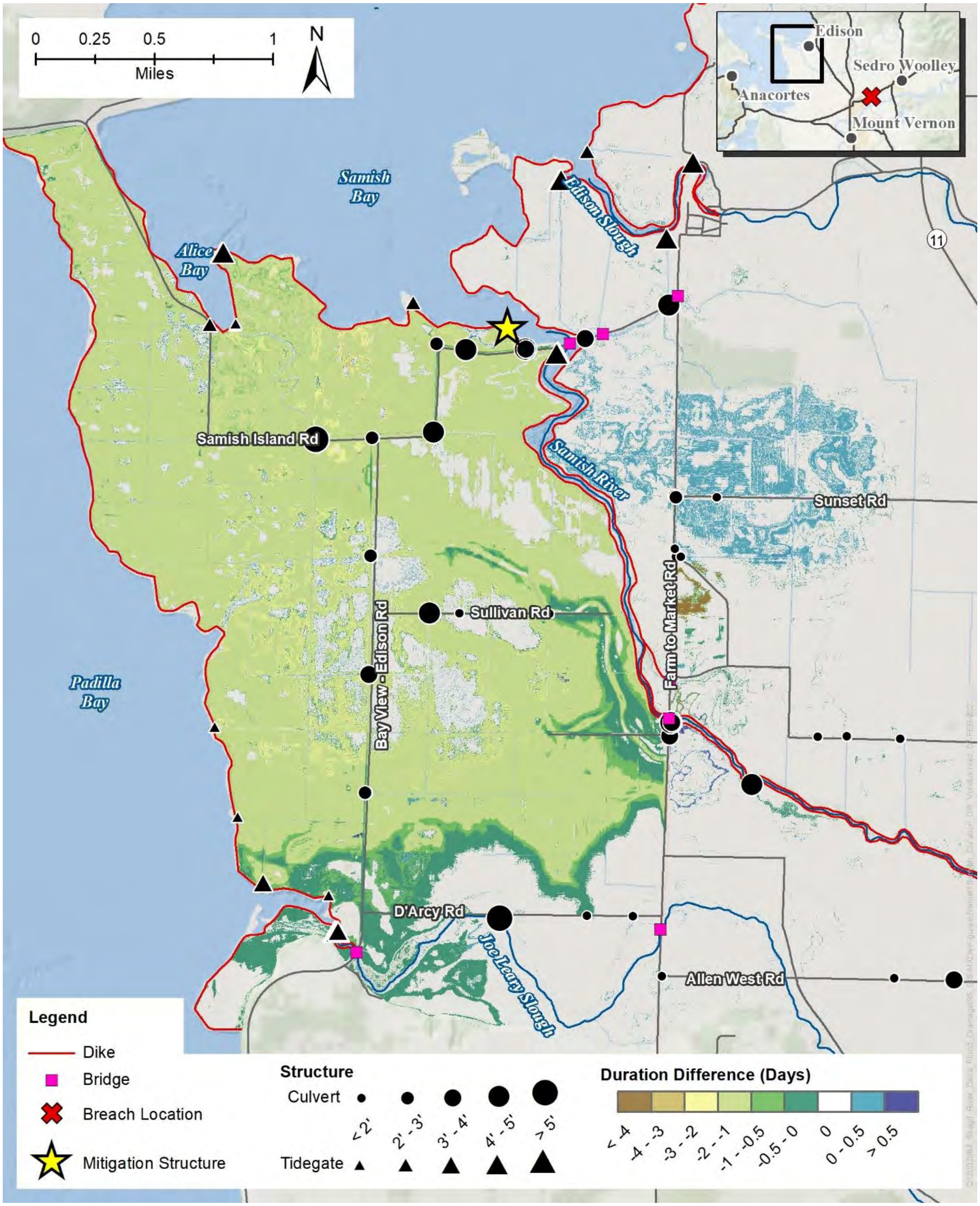


Figure D.1 Reduction in inundation duration – Alternative 1, Bayview Edison North– Samish Area

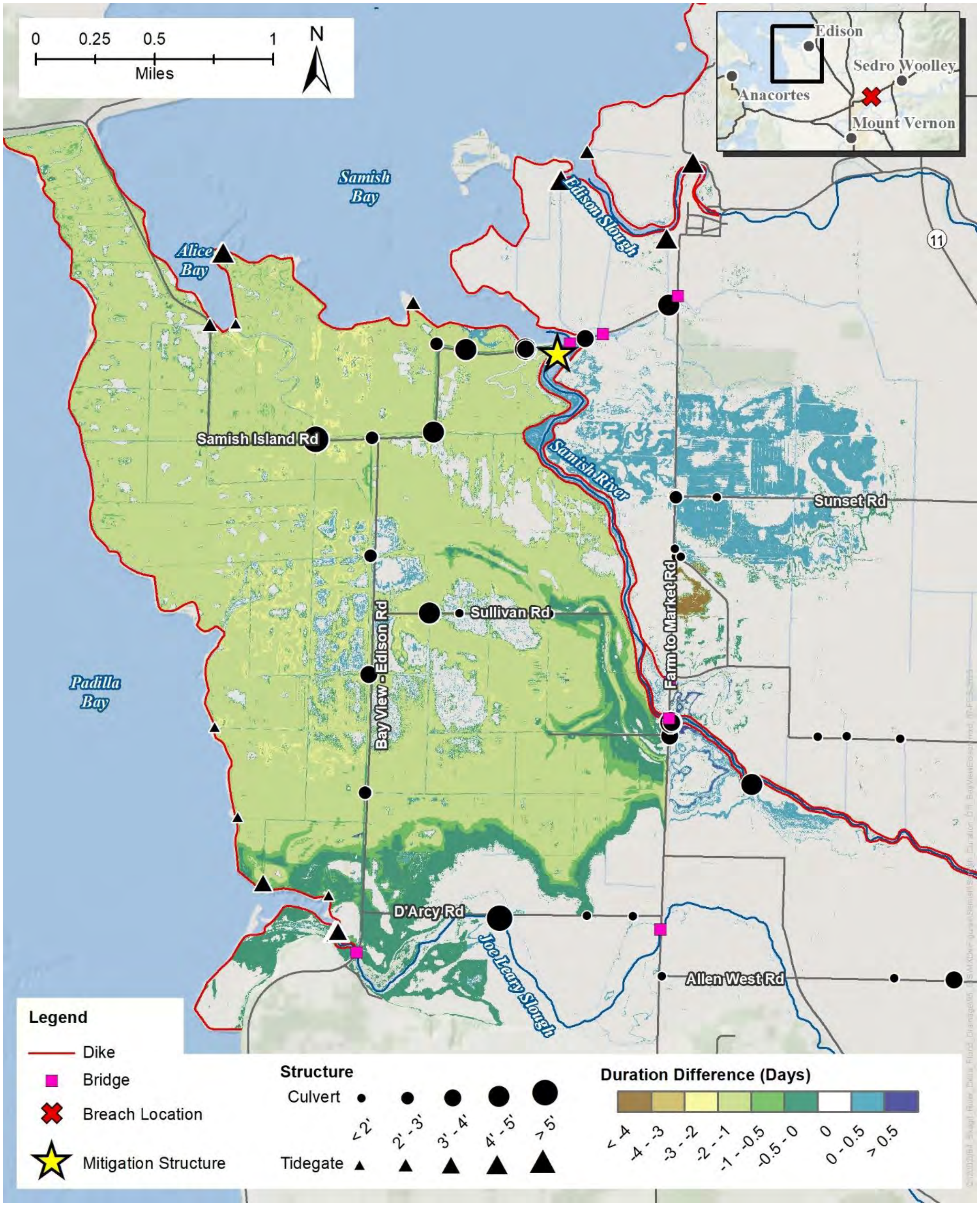


Figure D.2 Reduction in inundation duration – Alternative 2, Bayview Edison South – Samish Area

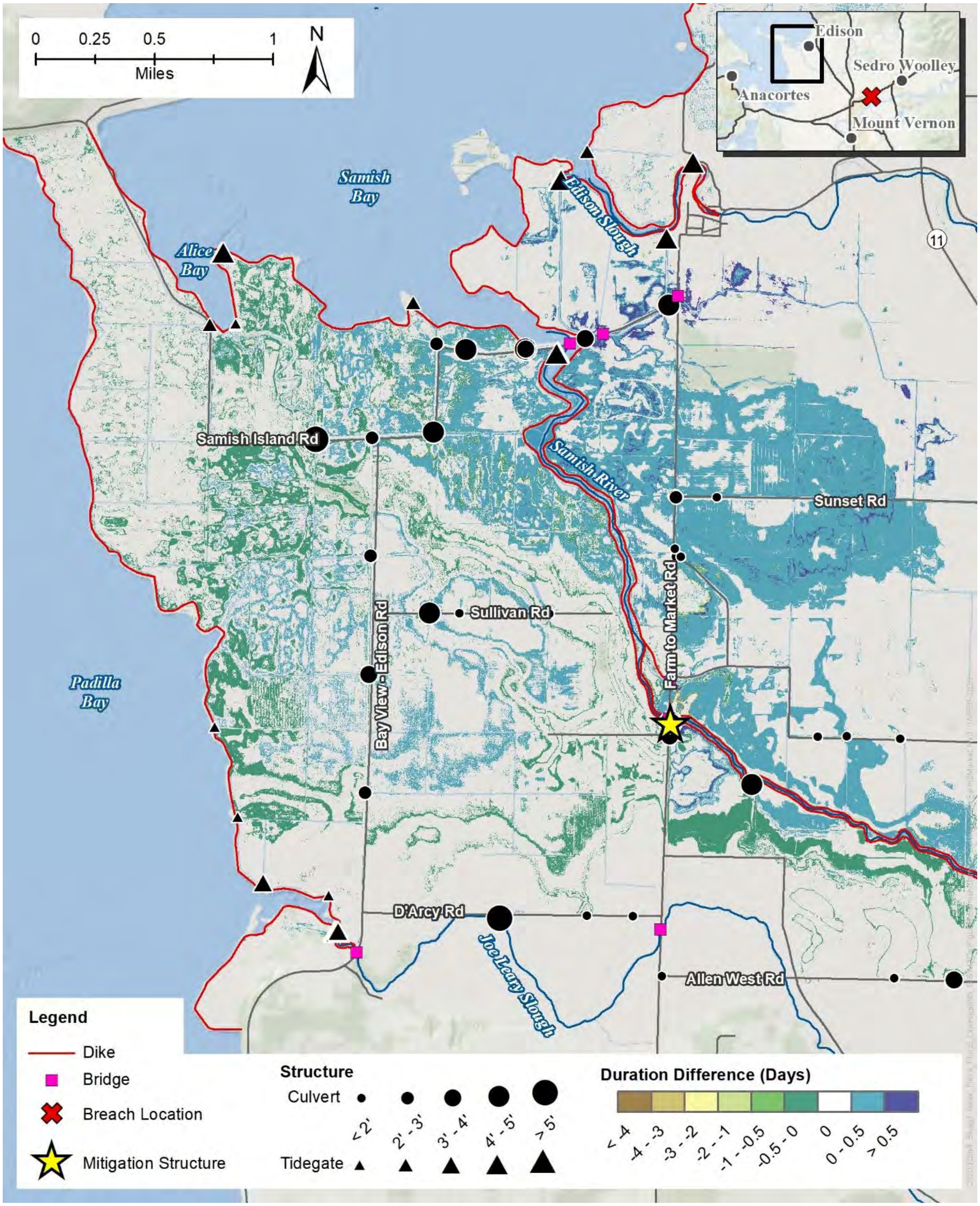


Figure D.3 Reduction in inundation duration – Alternative 3, Farm to Market – Samish Area

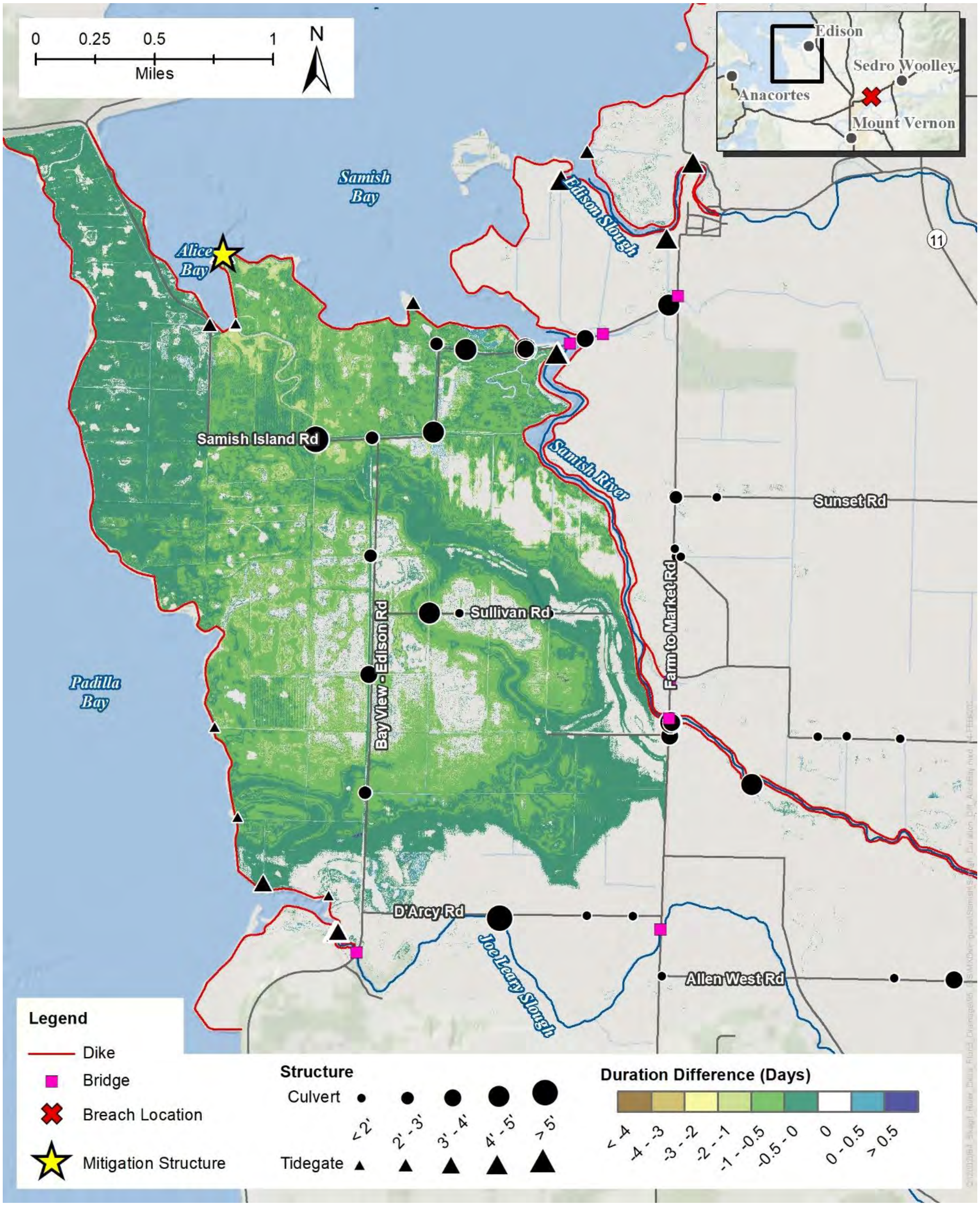


Figure D.4 Reduction in inundation duration – Alternative 4A, Alice Bay TFI – Samish Area

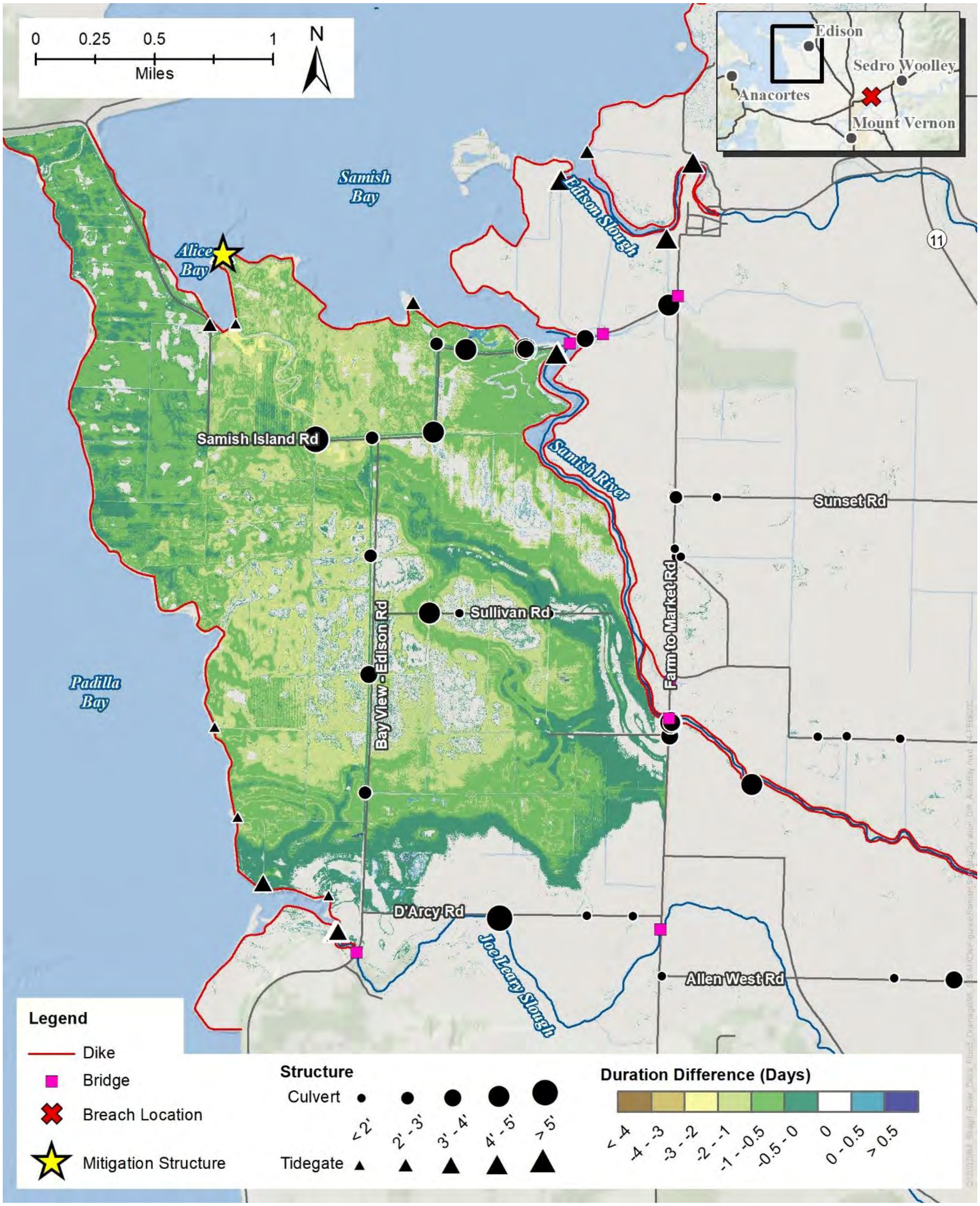


Figure D.5 Reduction in inundation duration – Alternative 4B, Alice Bay with lower invert (-1 ft) – Samish Area

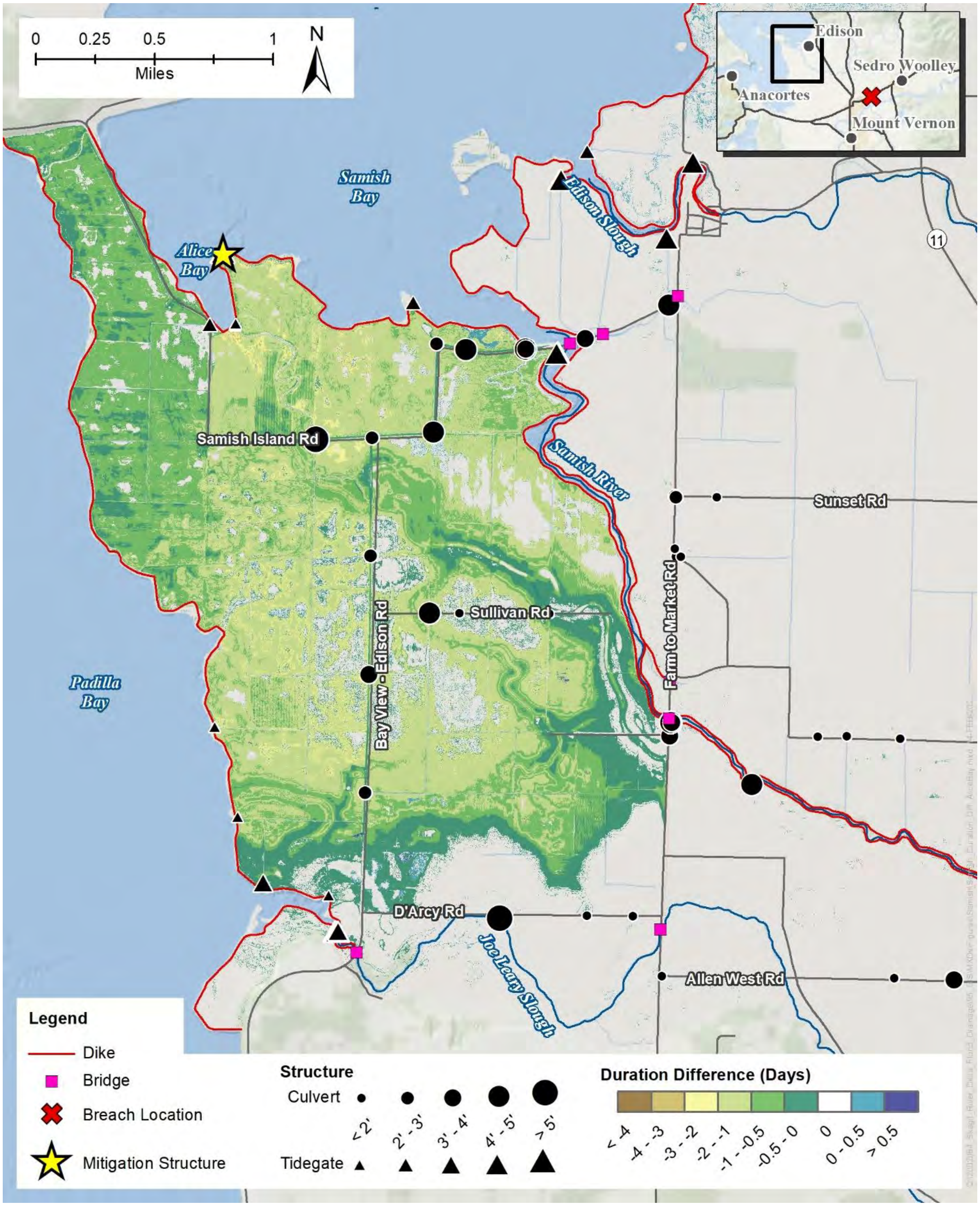


Figure D.6 Reduction in inundation duration – Alternative 4C, Alice Bay with lower invert (-2 ft) – Samish Area

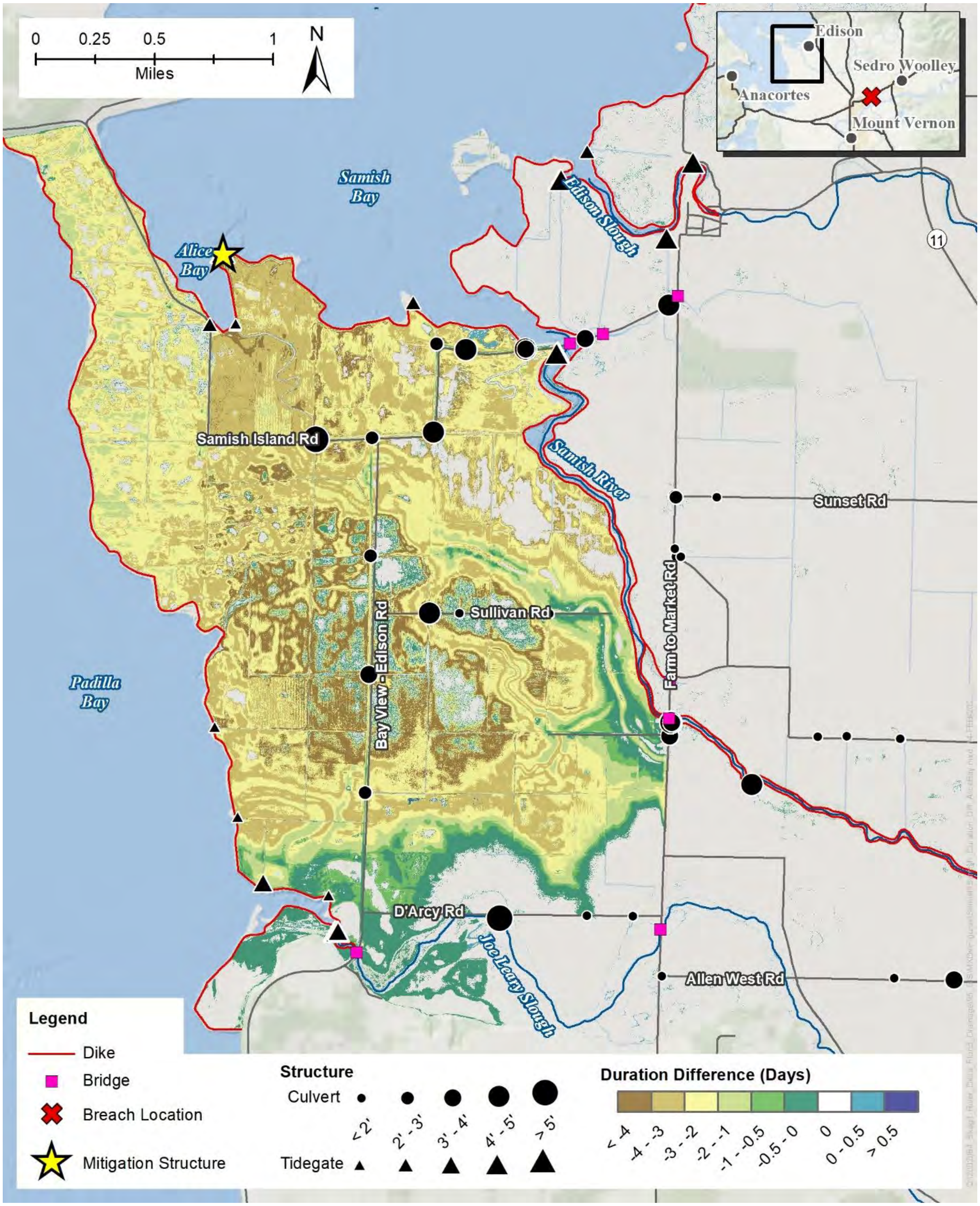


Figure D.7 Reduction in inundation duration – Alternative 4D, Alice Bay with 2x TFI conveyance – Samish Area

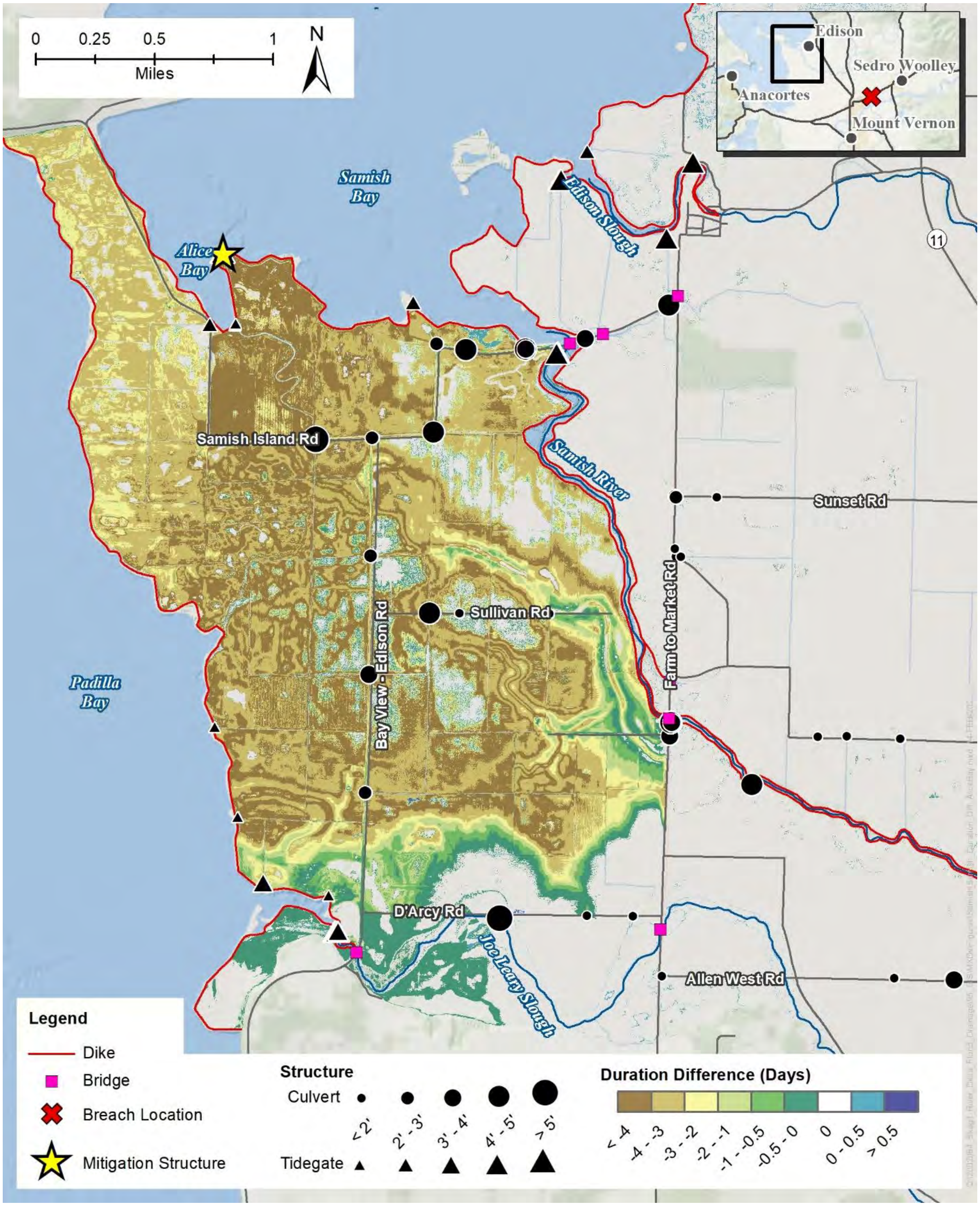


Figure D.8 Reduction in inundation duration – Alternative 4D, Alice Bay with 3x TFI conveyance – Samish Area

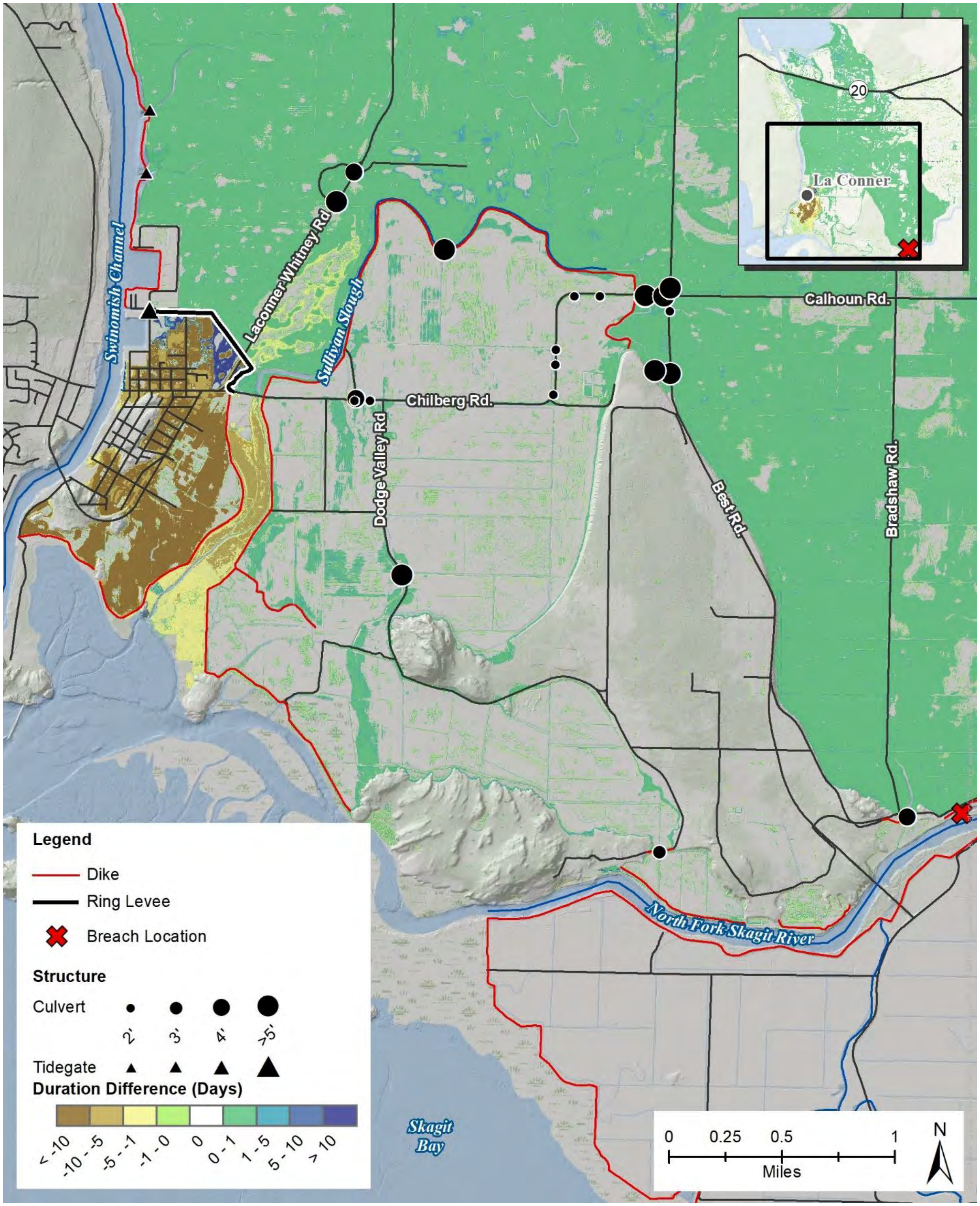


Figure D.9 Reduction in inundation duration – Alternative 1, Ring Levee project – La Conner Area

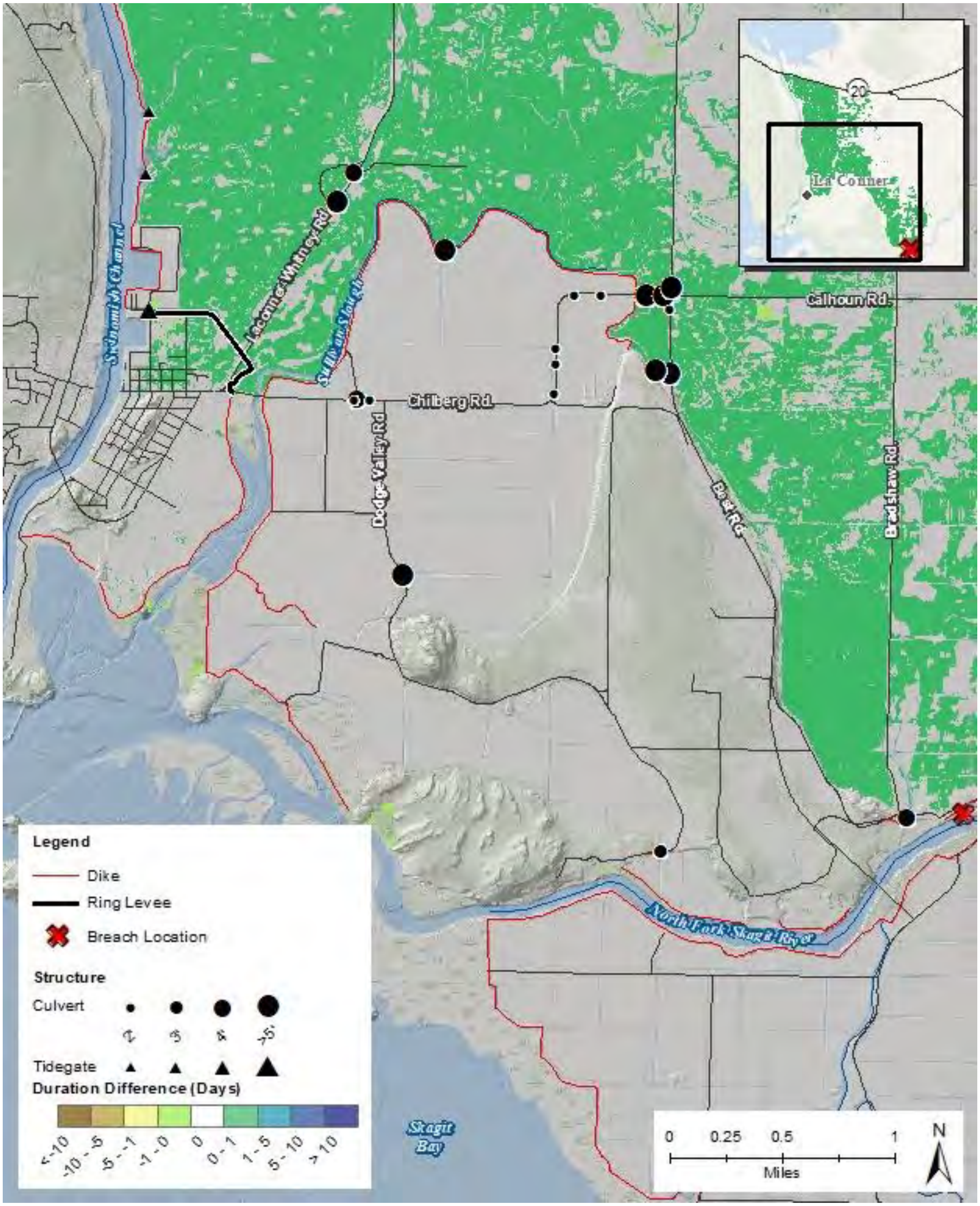


Figure D.10 Reduction in inundation duration – Alternative 2, relocate gates – La Conner Area

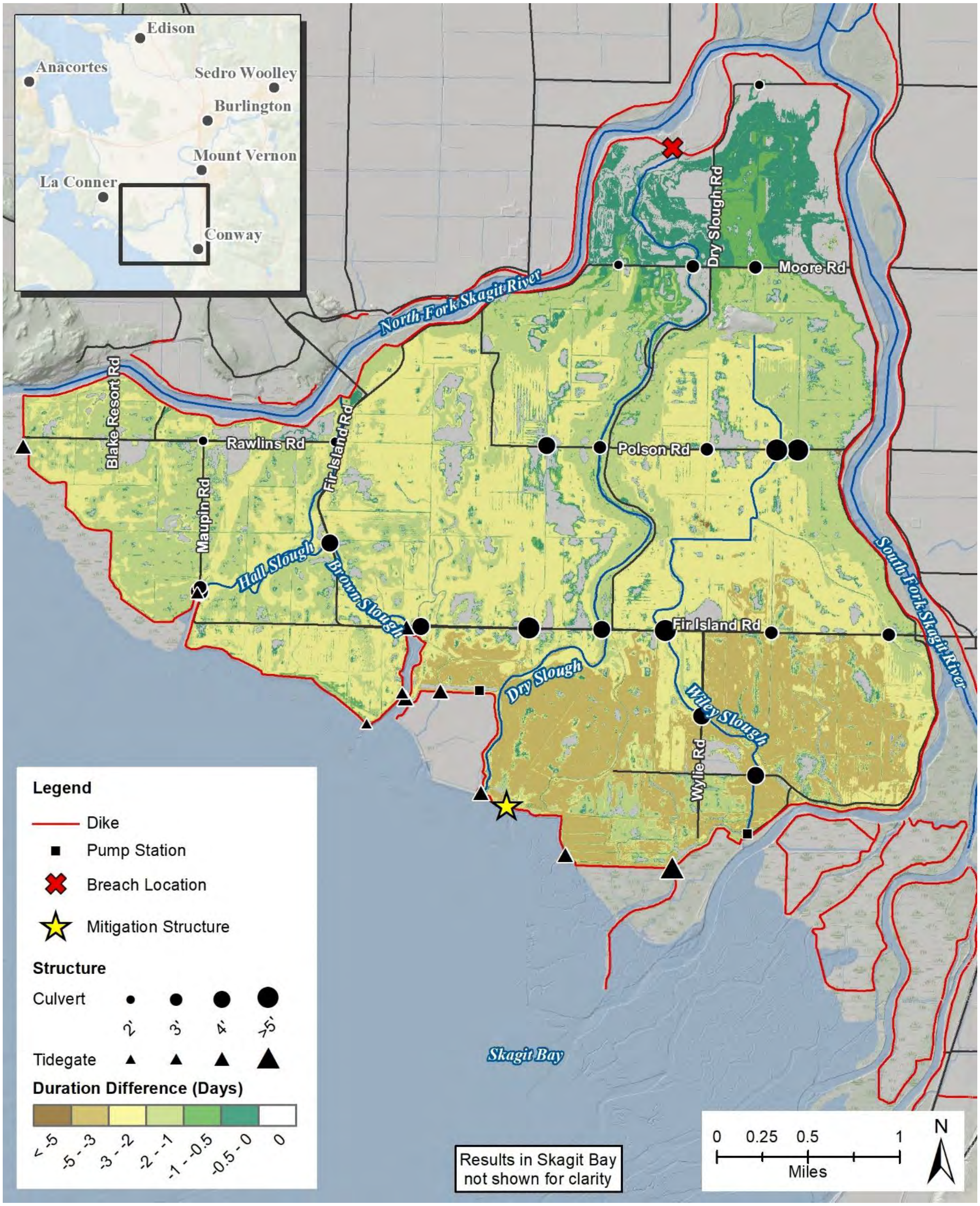


Figure D.11 Reduction in inundation duration – Alternative 1, eight gates east of Dry Slough – Fir Island

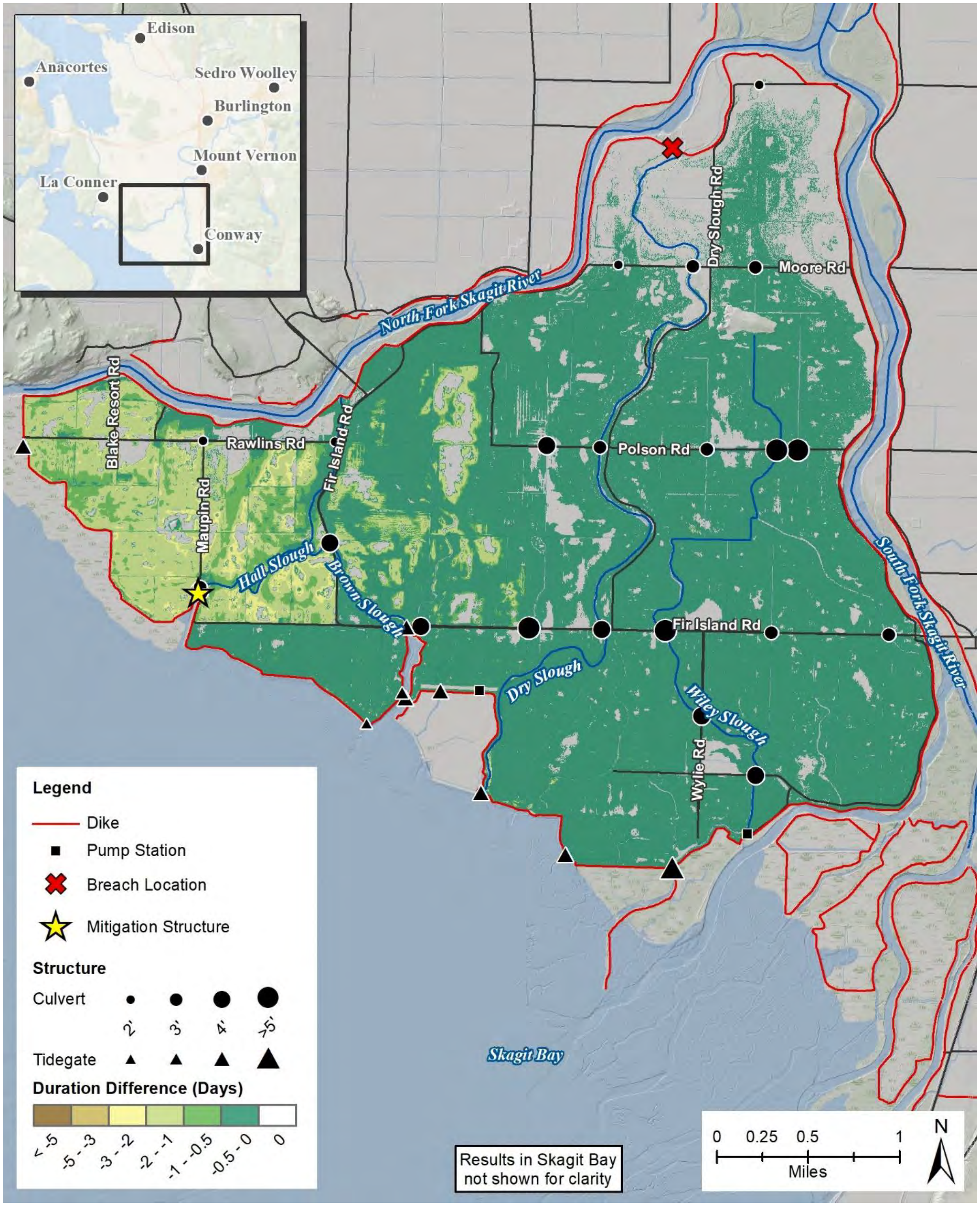


Figure D.12 Reduction in inundation duration – Alternative 2, Hall Slough pump – Fir Island

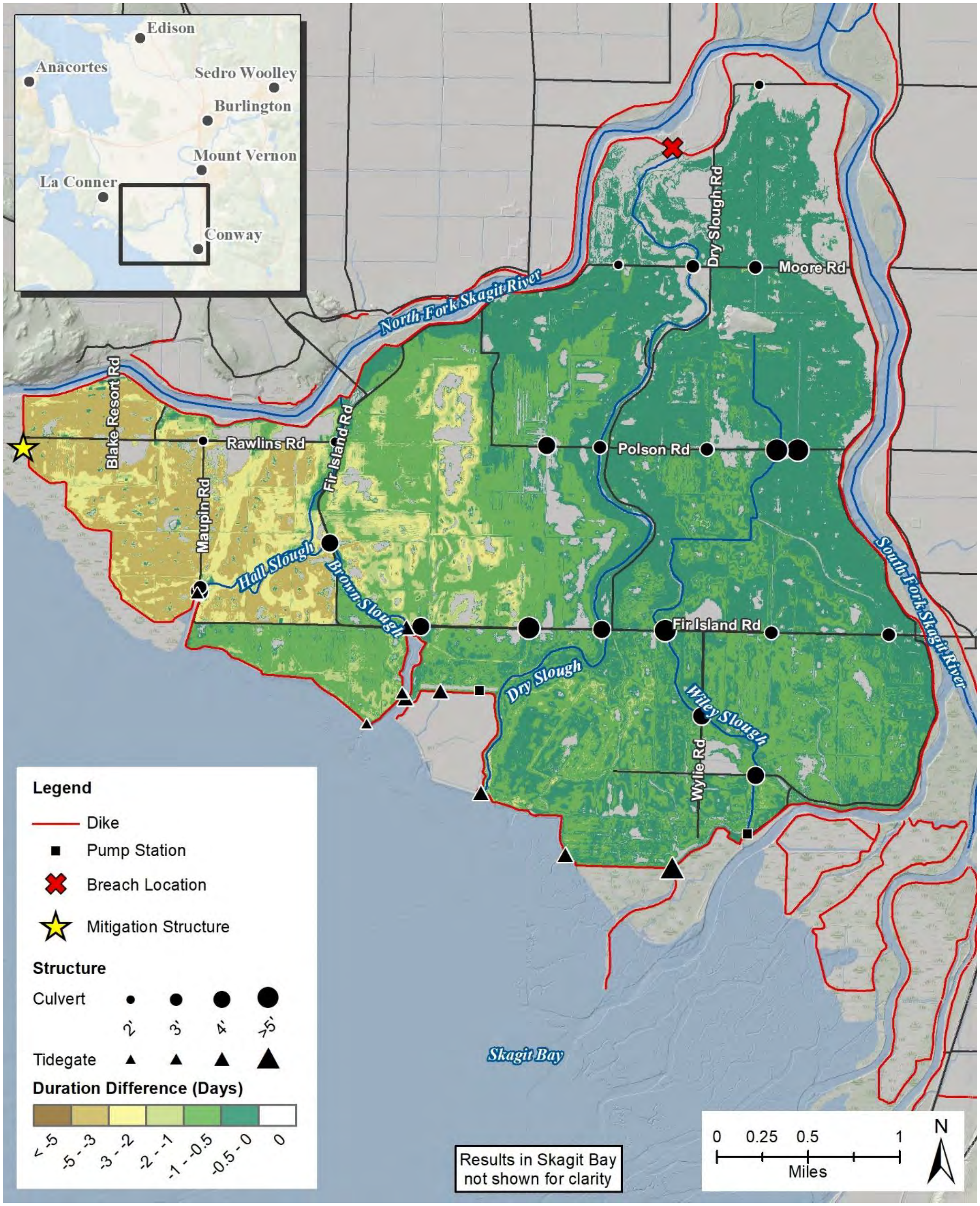


Figure D.13 Reduction in inundation duration – Alternative 3, upgrading Rawlins Road gates – Fir Island

APPENDIX E

SAMISH AREA FLOOD MITIGATION BASIS OF DESIGN REPORT

Northwest Hydraulic Consultants Inc.
301 W Holly Street #U03
Bellingham, WA 98225
Tel: 206.241.6000
www.nhcweb.com

NHC Reference 2002084

May 10, 2023

Skagit County Drainage and Irrigation Consortium
1800 Continental Place
Mount Vernon, WA 98273

Attention: CJ Jones, Project Manager
Via email: cjjones@co.skagit.wa.us

Re: **Skagit River Delta Flood Drainage Project**
Samish Area High Priority Design Sites Basis of Design

1 INTRODUCTION

This document presents Skagit County and its partner the Skagit County Drainage and Irrigation District Consortium (SDIDC) with the design basis to add new flood relief structures to improve flood drainage to the Samish River at three sites near Edison, WA, including one at Farm to Market Road and two at Bay View Edison Road. These three flood relief structure locations were prescribed as priority locations by County staff and local drainage district commissioners prior to executing a consultant contract with Northwest Hydraulic Consultants Inc. (NHC). The County requested that NHC develop design concepts and evaluate the proposed structure effectiveness for each of the sites. While the existing dike network within the delta keeps waters from inundating agricultural lands during frequent riverine floods, the dike systems also play a role in prolonging flooding by preventing drainage from precipitation that falls within the Delta from running off to the sea or into a river or slough. The purpose of the proposed flood drainage structures is to improve the flow of runoff and floodwaters from the interior side of the dikes to the riverward or seaward side. More broadly, the design objectives for the new flood relief structures are to:

1) Reduce the duration of flooding if a Skagit River dike breach were to occur following a 100-year return period Skagit River flood.
2) Improve drainage from frequent storm events.
3) Reduce leakage and gate maintenance related issues.

The model evaluation of the structures is documented in detail separately in the 'Skagit River Delta Flood Drainage Project Flood Modeling, Mapping, and Mitigation Analysis' Report.

1.1 Project Team

The project was initiated by Skagit County incoordination with the SDIDC. NHC was the prime consultant and provided hydraulic design and project coordination to a multi-disciplined project team that included: Pacific Survey and Engineering (PSE), GeoEngineers Inc. (GeoEngineers), and Nehalem Marine (Nehalem).

Table 1-1. Samish Area High Priority Design Sites Project Team

Organization	Name	Role
Skagit County	CJ Jones	Water Resources Project Manager
	Michael See	Water Resources Section Manager
SCDIC	Jenna Friebel	Executive Director
District 5 and 25	Commissioners (multiple)	Owner of Dikes
NHC	Derek Stuart	Project Manager
	Vaughn Collins	Sr. Design Lead
	Victor Lam	Engineer
	Alex Wittmershaus	Junior Engineer
	Evan Heitman	Hydraulic Modeler
	Dan Heckendorf	Sr. Model Review
GeoEngineers	Mark Rose	Geotechnical Engineer
	Sean Cool	Sr. Geotechnical Engineer
	Adam Wright	Biologist (Wetland and Stream Delineation Report)
	Joseph Callaghan	Sr. Biologist (Wetland and Stream Delineation Report)
	Emily Hurn	Biologist (Biological Evaluation)
	Fiona McNair	Sr. Biologist (Biological Evaluation)
PSE	Adam Morrow	Geomatics Survey
Nehalem Marine	Leo Kuntz	Tide Gate Design and Supplier

1.2 Scope of Work

The following scope of work was developed to complete the flood relief structure designs at the three priority Samish area project sites:

- Complete site surveys of the project sites (Pacific Survey and Engineering)
- Complete a geotechnical investigation at the site, including borehole drilling (GeoEngineers)
- Develop a geometric configuration for the replacement flood relief structures and analyze the hydraulics to verify design criteria and performance objectives are achieved. (NHC)
- Develop engineering plans and construction cost estimates for the priority flood relief structures (NHC with support from Nehalem Marine)

- Perform critical areas delineation and document findings in a Wetland and Stream Delineation Report (GeoEngineers)
- Develop a Biological Evaluation Report to support permit submittal requirements (GeoEngineers)

Permitting: The County took the lead role on coordination and submittal of the project permit applications. This approach, rather than having the consultant team handle project permitting, was required due to constraints attached to the WSDOT Local Programs funding source originally utilized by the County for this work. As of the date of this report, the project permit application remains in agency review. In late 2022 when it became apparent that agency review comments would not be available prior to the expiration date of the consultant contract, the County directed NHC to complete this BOD report as a record of the status of the design. Additional effort to finalize the design and develop a bid package will be required following receipt of agency comments on the design.

Replacement of Existing Flood Drainage Pipes at Farm to Market Site: The design concept at the Farm to Market site changed significantly in December 2020. As the result of failing pipes that created an emergency condition the County requested that NHC develop a separate set of design plans for that site which included only replacement of existing flood drainage pipes. That design was constructed by the drainage district in 2021. The JARPA drawings and other supporting documentations for that work have been excluded from this BOD report. Only the design of the remaining new flood drainage structures at that site are documented in herein.

1.3 Design Timeline

Key events occurring in the development of the design included:

- June 2018: Base survey (draft) issued by PSE. Final issued July 2018.
- July 2018: Wetland and Stream Delineation Report (Draft) issued by GeoEngineers.
- August 2018: Geotechnical Engineering Services Report (Draft) issued by GeoEngineers. NHC issues 30% design package and construction cost estimates for County comment. County provides comments on 30% Design submittal.
- October 2018: NHC submits 60% Design submittal to County staff for review.
- December 2018: County submits 60% and JARPA format drawings to WSDOT Local Programs for review. WSDOT Local Programs requests County perform a Biological Evaluation.
- April 2019: County requests GeoEngineers develop Biological Evaluation report.
- June 2019: NHC submits erosion and sediment control sheets to County for review.
- October 2019: Revised BE Report issued by GeoEngineers.
- November 2019: Site visit with WSDOT Local Programs on November 20, 2019. County submits design concepts with BE Report to WSDOT Local Programs for review.
- June 2020: WSDOT Local Programs recommends that the County find a different funding pathway to get project constructed. Project funding shifts to Drainage Utility Funding source and County plans to submit permit applications without WSDOT involvement.

- December 2020: As the result of failing pipes that created an emergency condition at the Farm to Market site, the County requests that NHC develop separate set of design plans for that site which include only replacement of existing flood drainage pipes. The replacement is to be performed in accordance with the STFI.
- January 2021: NHC issues JARPA drawings for replacement of only the existing Farm to Market drainage pipes that will be replaced under the STFI.
- February 2021: County requests that NHC reissue Farm to Market site design to exclude the upgrades to existing flood drainage pipes that were replaced in summer 2020.
- March 2021: NHC revises project construction sequence to minimize fish handling requirements and refine coffer dam configuration.
- April 2021: Revised Biological Evaluation and Essential Fish Habitat Evaluation Report issued by GeoEngineers to incorporate March 2021 design changes for County permit submittal.
- October 2022: NHC provides updated construction cost estimate to incorporate costs of inflation.
- December 2022: Final Wetland and Stream Delineation Report and Geotechncial Engineering Services reports issued by GeoEngineers.

2 Site Description and Existing Conditions

The project sites are in the lowlands of the Samish River floodplain to the south and west of Edison, WA and north of Bayview, WA. Topography among all three sites is similar with relatively level topography and prominent topographical features are primarily limited to drainage ditches and dike embankments. The existing dike top width ranges from 12 to 15 feet with side slopes of 1.5H:1V on the riverward side and 2H:1V on the landward side. The crest elevation varies from 12 feet at the Bayview Edison North site to an elevation of 15 ft. at the Farm to Market site. The sites are vegetated with grass and brush, including the dike.

The Bayview Edison North site does not currently have any flood relief structures that project through the dike. There are, however, existing culverts that connect low-lying storage areas within the floodplain. Dimensions of the culverts are provided in Table 2.1; photographs of the flood relief structures are included in **Attachment A.**

The flood relief structures at Bayview Edison South drain approximately diked land through four 48-inch Corrugated Plastic Pipe (CPP) culverts with mounted top hinge tide gates. The culverts project through the existing dike and the tide gates are designed to open when the upstream water level is greater than the downstream water level. Dimensions of the culverts are provided in Table 2-2; photographs of the flood relief structures are included in **Attachment A.**

The flood relief structures at Farm to Market drain diked land through two 48-inch CMP culverts with mounted top hinge tide gates and one 36-inch CMP culvert. The culverts project through the existing dike and the tide gates are designed to open when the upstream water level is greater than the downstream water level. Dimensions of the culverts are provided in Table 2.3; photographs of the flood relief structures are included in **Attachment A.**

Table 2.1 Bayview Edison North Culvert Data

Culvert	Length (feet)	Diameter (inches)	Inlet Invert El. (feet)	Outlet Invert El. (feet)
#1	32.0’	24”	2.6’	2.4’
#2	16.1’	18”	2.5’	2.5’
#3	28.4’	18”	3.4’	2.6’

1. Elevations are NAVD88.
2. Diameters as per PSE.
3. Culvert number increases from north to south.
4. Existing culverts connect storage areas within the floodplain and do NOT provide flood relief through the dike.

Table 2-2. Bayview Edison South Culvert Data

Culvert	Length (feet)	Diameter (inches)	Inlet Invert El. (feet)	Outlet Invert El. (feet)
#1	50.2	48”	4.9’	4.9’
#2	51.0	48”	5.0’	5.0’
#3	50.9’	48”	4.7’	4.7’
#4	51.3’	48”	4.8’	4.8’

1. Elevations are NAVD88.
2. Diameters as per PSE.
3. Culvert number increases from north to south.

Table 2.3 Farm to Market Culvert Data

Culvert	Length (feet)	Diameter (inches)	Inlet Invert El. (feet)	Outlet Invert El. (feet)
#1	40.4’	48”	7.2	7.2’
#2	34.4’	48”	8.7’	8.6’
#3	40.1’	36”	4.0’	3.6’

1. Elevations are NAVD88.
2. Diameters as per PSE.
3. Culvert number increases from west to east.

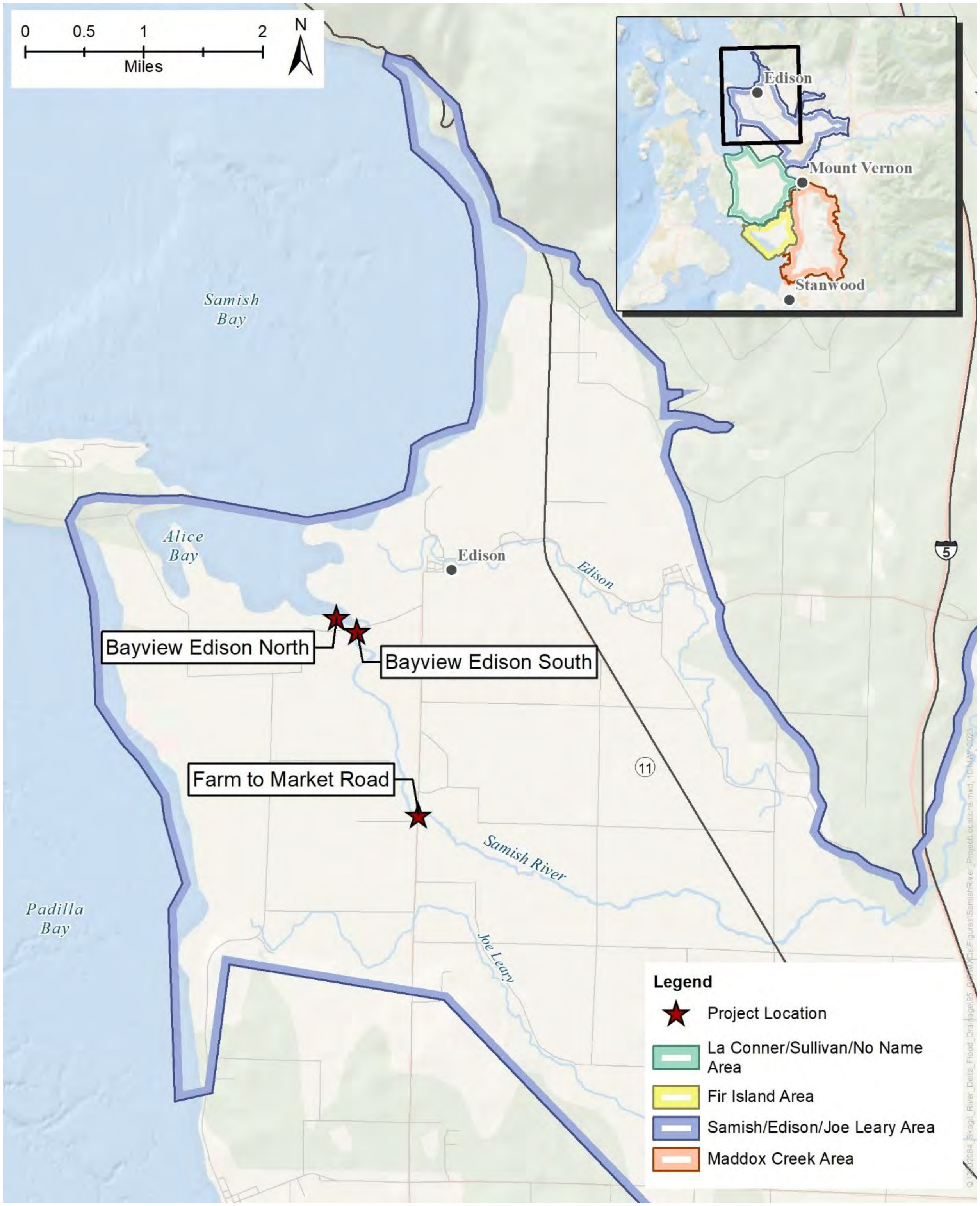


Figure 2-1 Farm to Market and Bay View Edison North and South Flood Relief Structure Location

3 DESIGN

As stated in the introduction, the primary design objective is to increase flood relief in the Skagit River Delta by adding new structures at the proposed project sites. Details of the design development for the control structure are provided in the sections below.

3.1 Guides, Standards and Codes

Design guides, standard methods, and codes used include:

- USACE Design and Construction of Levees Manual No. 1110-2-1913

3.2 Reference Materials

Previous studies, documentation, drawings, and communications referenced as part of the design include:

- PSE Survey
  - DWG “2018075_Samish_River_Flood_Phase-2.dwg”. Received June 15, 2018
  - PDF “2018075_svX_TB_signed.pdf”. Received by NHC on 5 July 2018. (**Attachment B**).
- GeoEngineers Samish River Floodgates Geotechnical Report File No. 0220-097-00 (**Attachment C**).
- GeoEngineers Wetland and Stream Delineation Report File No. 0220-097-00 (**Attachment D**).
- NHC ‘Skagit River Delta Flood Drainage Project Flood Modeling, Mapping, and Mitigation Analysis’ Report and associated hydraulic model. Dated May 10, 2023.

3.3 Criteria and Considerations

Criteria developed and adopted for the design include:

- The crest width shall be a minimum 15.0’ wide.
- The water surface profile in the upstream channel should not be adversely affected.
- Match existing dike elevations in proposed condition.
- 3:1 side slopes where allowed by site conditions.

The design and layout must also consider construction equipment weights and operational limitations during construction.

3.4 Hydraulics

The design procedure adopted the following approach:

1. Model the existing conditions to determine the baseline hydraulic performance.
2. Develop a preliminary proposed geometric configuration for the flood relief structures
3. Evaluate hydraulic performance of the proposed configuration for 100-year Skagit River Dike Breach condition.

3.4.1 Discharge

A specific design discharge was not developed as part of the design for the flood relief structures. There is no existing flow through the dike at these sites so any additional conveyance capacity is expected to improve drainage from the floodplain into the river or Samish Bay (the case only for the Bayview-Edison North site).

3.4.2 HEC-RAS Model

The US Army Corps of Engineers (USACE) HEC-RAS 2D numerical modeling software program was used to evaluate the design. Details of the model development, including the assumptions and limitations of the model are provided in the Skagit River Delta Flood Drainage Project Flood Modeling, Mapping, and Mitigation Analysis Report. A summary of the modeled results for a dike breach that is considered likely during a 100-year Skagit River flood is provided as

Modeling results for the Farm to Market site only show 0.1 days of reduction in the simulated inundation duration along Farm to Market Road, with nominal improvement elsewhere. However, modeling also shows a minor negative impact to the right bank floodplain centered around Farm to Market Road and Sunset Road, resulting in an increase of average duration of flooding over Sunset Road of approximately 0.1 days, and as much as 0.1-feet of increase in flood depth. Investigation of the model conditions show that these increases in flood levels are due to “worst-case” flow condition assumed in the model, with a Skagit River breach occurring at approximately the same time as the Samish River peak flow. The proposed tide gates act to route additional flood water from the left (south) overbank upstream of Farm to Market Road into the Samish river, which is already flowing at capacity. As a result, the added flow increases water-levels within the Samish River which then overtop the right bank of the river and flow north toward the Sunset Road vicinity. Modeling of a slightly smaller flow event (25 percent of peak Samish River discharge and 50 percent of the 100-year Skagit breach flow) resulted in overall improvement to the left (south) overbank while avoiding impacts to the right (north) overbank. These results suggest that under typical rainfall and flow conditions the alternative performs as anticipated, however conditions where flow capacity is severely limited in the Samish can result in increased inundation duration on the right overbank. Additional mitigation options such as increasing the elevation of the Samish River right bank dike could potentially mitigate this increase, but these variations on the design have not yet been tested with the flood model.

Table 3.1. Full details of the hydraulic analysis, including inundation mapping, are provided in the modeling report.

Mitigation solutions for the Samish/Edison/Joe Leary area show the potential for some reduction in the amount of time that water is over key egress routes. Installation of a new tide gate structure (four 48-inch culverts) at the Bayview-Edison North site location resulted in a similar benefit as a new tide gate structure (eight (60-inch culverts) at the Bayview-Edison South site location in terms of reductions in average inundation duration, both showing up to a 16 percent reduction (from 7.1 to 6.0 days) along Bayview Edison Road.

Modeling results for the Farm to Market site only show 0.1 days of reduction in the simulated inundation duration along Farm to Market Road, with nominal improvement elsewhere. However, modeling also shows a minor negative impact to the right bank floodplain centered around Farm to Market Road and Sunset Road, resulting in an increase of average duration of flooding over Sunset Road of approximately 0.1 days, and as much as 0.1-feet of increase in flood depth. Investigation of the model conditions show that these increases in flood levels are due to "worst-case" flow condition assumed in the model, with a Skagit River breach occurring at approximately the same time as the Samish River peak flow. The proposed tide gates act to route additional flood water from the left (south) overbank upstream of Farm to Market Road into the Samish river, which is already flowing at capacity. As a result, the added flow increases water-levels within the Samish River which then overtop the right bank of the river and flow north toward the Sunset Road vicinity. Modeling of a slightly smaller flow event (25 percent of peak Samish River discharge and 50 percent of the 100-year Skagit breach flow) resulted in overall improvement to the left (south) overbank while avoiding impacts to the right (north) overbank. These results suggest that under typical rainfall and flow conditions the alternative performs as anticipated, however conditions where flow capacity is severely limited in the Samish can result in increased inundation duration on the right overbank. Additional mitigation options such as increasing the elevation of the Samish River right bank dike could potentially mitigate this increase, but these variations on the design have not yet been tested with the flood model.

Table 3.1 Summary of Mitigation Measure Performance (100-year breach scenario) for Samish/Edison/Joe Leary Area. Values in parenthesis show percentage difference in inundation duration relative to the base (existing condition). Negative and positive values represent reduction and increase in duration, respectively.

Roadway Location	Average inundation duration (days)	Average difference in inundation duration (days)		
	Base (existing condition)	Alternatives		
		Bayview-Edison North	Bayview-Edison South	Farm to Market Tide Gate Addition
Bayview Edison Road (From Samish Island Road intersection, south to Leary)	7.1	-1.1 (-16%)	-1.1 (-16%)	-0.1 (-1.7%)
Bayview Edison Road	6.3	-0.9 (-14%)	-0.8 (-13%)	-0.1 (-1.3%)

Roadway Location	Average inundation duration (days)	Average difference in inundation duration (days)		
	Base (existing condition)	Alternatives		
		Bayview-Edison North	Bayview-Edison South	Farm to Market Tide Gate Addition
(From Samish Island Road, east to Farm to Market Road				
Farm to Market Road (From Edison, south to high ground south of Allen West Road)	2.5	0.0 (0.0%)	> -0.05 (0.3%)	-0.1 (-2.9%)
Chuckanut Drive (From Bow Hill Road, south to Interstate-5	1.3	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)
Allen West Road (From Farm to Market Road to Chuckanut Drive)	1.5	> -0.05 (-0.1%)	> -0.05 (-0.1%)	0.0 (-0.1%)
Sunset Road (From Farm to Market Road to Chuckanut Drive)	0.7	0.0 (0.0%)	< +0.05 (1.1%)	+0.2 (24%)

3.5 Geometric Configuration

General arrangement plans, profiles and sections of the proposed control structure are included in **Attachment D**. The geometry is highlighted by the following:

- Similar for All Sites
  - Grade riverward face of dike to match existing slope, place minimum 2” thick light loose riprap with woven high survivability geotextile
  - Place 6” minimum thickness of 2-4” quarry spall with woven fabric for stabilization on top of dike
- Bayview Edison North
  - Four 48”x58.5’ ADS Sanitite pipe with side-hinged tide gates
  - Inlet and outlet inverts at El. 2.0’

  - Grade landward side of dike at 3H:1V from top of dike
- Bayview Edison South
  - Eight 60”x64’ ADS Sanitite pipe with tide gate system
  - Inlet and outlet inverts at El. 4.80’
  - Grade landward side of dike at 2H:1V from top of dike
- Farm to Market
  - Two 48”x50’ ADS Sanitite pipe with tide gate system
  - Two 48”x47’ ADS Sanitite pipe with tide gate system
  - Inlet and outlet inverts at El. 8.60’
  - Replace existing 36” CMP culvert
  - Grade landward side of dike at 2H:1V from top of dike
  - Two existing pipes were replaced in the summer of 2020 for emergency repair and were removed from the project design.

4 CONSTRUCTION

4.1 Materials

Material types, including cofferdam, fills, and concrete, are provided in GeoEngineers geotechnical document (**Attachment C**), and design drawings (**Attachments D and F**).

Nehalem Marine makes custom-order gates to suit each individual structure and has recommended NSG40a tide gates at Bayview Edison North and Farm to Market and NSG50a tide gates at Bayview Edison South. This should be confirmed prior to procurement.

4.2 Quantities

On-site soils consist primarily of soft to stiff silts and clays with variable amounts of sand and some loose medium dense silty sand. The high moisture content of these materials will make achieving compaction requirements difficult without significant moisture conditioning (drying [Attachment C]). Therefore, the current cost estimates assume no reuse of on-site materials. In total (all three sites), an estimated 2,100 cubic yards (CY) are anticipated to be excavated to facilitate removal of the existing structure, install the cofferdam, and construct the new flood relief structures.

Estimated quantities of key design elements are summarized in Table 4-1. Detailed quantities and cost estimate are included as **Attachment G**.

Table 4-1. Summary of Quantities for key design elements

Item	Quantity per Project Site		
	Bayview Edison North	Bayview Edison South	Farm to Market
Approximate Excavation	750 CY	1020 CY	340 CY
Supplemental Dike Fill	Dependent on contractor approach and re-use of existing materials on-site		
NSG4oa Tide Gate	4 units		4 units
NSG5oa Tide Gate		8 units	
36" ADS Sanitite Pipe			51 LF
48" ADS Sanitite Pipe	234 LF		194 LF
60" ADS Sanitite Pipe		512 LF	

1. Should be confirmed prior to purchase.

4.3 Logistics and Construction Considerations

General site access is proposed via stabilizing the entrance to the existing dike maintenance road. The areas to the south of the Bayview Edison North and Farm to Market sites provide space for equipment and material laydown, temporary stockpiling, and office and trailer staging.

Clearing and hazard tree removal are not anticipated with this work. Some stripping of organics, road mulch and riprap will be needed. These materials should be salvaged and temporarily stockpiled for re-use during construction.

The proposed construction sequence for the Bayview Edison and Farm to Market Sites, found in the Biological Assessment Report, is summarized below.

1. Site preparation
2. Install erosion and sedimentation control measures
3. Install a temporary cofferdam on the estuary/river side of the dike during low tide in the dry area at the Bayview Edison South and Farm to Market Sites. No de-fishing is necessary as work area isolation will occur during low tides in the dry area.
4. Install a cofferdam on the landward side of the dike at the Bayview Edison North site. The existing ditch disconnected from the Samish River and Samish River Estuary so de-fishing is not required.
5. Remove existing tide gate and culvert during low tide if required.
6. Install new tide gates and culverts
7. Regrade/restore the dike and riverbed within the temporary cofferdams and remove the temporary cofferdams at the Bayview Edison South and Farm to Market sites.
8. Site restoration and cleanup.

Construction activities that include excavation or equipment operation below high-water line are anticipated to be limited by permitting agencies from August 1 through October 15 (WWAA, 2008). The temporary cofferdam shall be installed prior to initiating any excavation activity below the high-water line to isolate the project site from the watercourse. Seaward high-tide water-levels at the Bayview Edison Road North site are estimated for the month of July to be 9.5 feet NAVD 1988 based on the highest observed tide elevation at the NOAA Cherry Point station. Higher water-levels will occur at other times of the year. Water-level monitoring and hydraulic modeling data were used to characterize water-levels at the Bayview Edison Road South and Farm to Market sites.

Areas that are disturbed by the work should be restored as per District operational and maintenance requirements and protocols.

4.4 Cost Estimate

An estimated construction cost based on estimated quantities is included in **Attachment G** The estimate is limited to probable construction costs are provided in current year dollars and does not include expenses such as reporting, engineering inspection or contract administration. The cost estimate does not include the costs to transport and place excess soils generated from the excavations off-site. As part of the estimate, the follow assumptions have been made:

- Construction would be performed over a 6-week period.
- Labor, equipment, and materials procured via local contractors and suppliers, limiting time of travel to approximately 1 hour.
- Salvage and disposal prices of waste material are included.
- The estimates assume that material quantities derived are within ±30%.

5 CLOSURE

We hope this report meets your requirements. Please feel free to contact me to discuss further for additional detail or information.

Report prepared by:

Alex Wittmershaus, EIT
Junior Engineer

Under the Direct Supervision of:

Vaughn Collins, PE
Principal

Enclosure:

- ATTACHMENT A, Photographs
- ATTACHMENT B, PSE Base Survey
- ATTACHMENT C, Geotechnical Report
- ATTACHMENT D, Project Drawings (60% detail sheet, see also JARPA permit drawings in ATTACHMENT F)
- ATTACHMENT E, Wetland Delineation Report
- ATTACHMENT F, BE Report
- ATTACHMENT G, Cost Estimate

DISCLAIMER

6 REFERENCES

GeoEngineers. 2018. Geotechnical Enigneering Services Report – Draft (File No. 0220-097-00).

GeoEngineers. 2021. Revised Biological Evaulation and Essential Fish Habitat Evaluation (File No. 0220-097-00).

Skagit River System Cooperative. 2020. Skagit Basin Barrier Culvert Analysis: Public and Private Stream Crossings.

Skagit River System Cooperative and Washington Department of Fish and Wildlife. 2005. Skagit Chinook Recovery Plan. La Conner, Washington.

Western Washington Agricultural Association. 2010. Skagit Delta Tidegates and Fish Initiative Implementation Agreement.

ATTACHMENT A

Photographs

Photo A.1 Bayview Edison North site (looking northwest along landward side of dike (May 11, 2018).

Photo A.2 Bayview Edison North site (looking northwest along seaward side of dike (May 11, 2018).

Photo A.3 Bayview Edison North site (looking southeast along landward side of dike (May 11, 2018).

Photo A.4 Bayview Edison North site (looking southeast along seaward side of dike (May 11, 2018).

Photo A.5 Existing Bayview Edison South Flood Relief Structure Outlets (viewing from the river towards the dike).

Photo A.6 Existing Bayview Edison South Flood Relief Structure Outlets

Photo A.8 Farm to Market Flood Relief Structure Inlets (viewing from landward side towards dike).

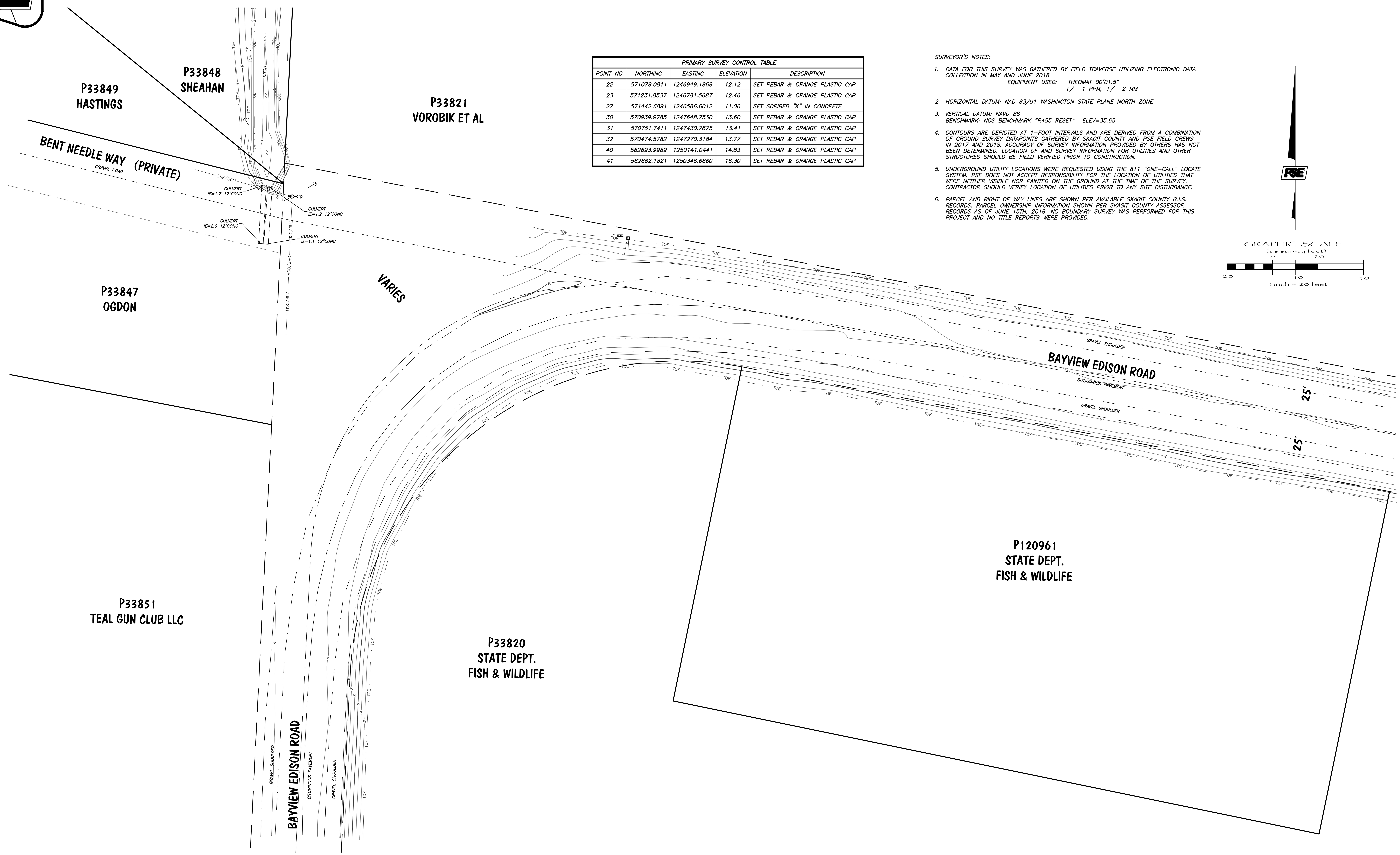
Photo A.8 Farm to Market Flood Relief Structure Outlets (viewing from the west side of the levy towards the structures).

ATTACHMENT B

PSE Base Survey

TOPOGRAPHIC SURVEY

SITUATE IN A PORTION OF THE N 1/2 OF SECTION 5, TOWNSHIP 35 NORTH,
RANGE 3 EAST, W.M., SKAGIT COUNTY, WASHINGTON



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27	571442.6891	1246586.6012	11.06	SET SCRIBED "X" IN CONCRETE
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41	562662.1821	1250346.6660	16.30	SET REBAR & ORANGE PLASTIC CAP

SURVEYOR'S NOTES:

1. DATA FOR THIS SURVEY WAS GATHERED BY FIELD TRAVERSE UTILIZING ELECTRONIC DATA COLLECTION IN MAY AND JUNE 2018.
   EQUIPMENT USED: THEOMAT 00'01.5"
   +/- 1 PPM, +/- 2 MM
2. HORIZONTAL DATUM: NAD 83/91 WASHINGTON STATE PLANE NORTH ZONE
3. VERTICAL DATUM: NAVD 88
   BENCHMARK: NGS BENCHMARK "R455 RESET" ELEV=35.65'
4. CONTOURS ARE DEPICTED AT 1-FOOT INTERVALS AND ARE DERIVED FROM A COMBINATION OF GROUND SURVEY DATAPOINTS GATHERED BY SKAGIT COUNTY AND PSE FIELD CREWS IN 2017 AND 2018. ACCURACY OF SURVEY INFORMATION PROVIDED BY OTHERS HAS NOT BEEN DETERMINED. LOCATION OF AND SURVEY INFORMATION FOR UTILITIES AND OTHER STRUCTURES SHOULD BE FIELD VERIFIED PRIOR TO CONSTRUCTION.
5. UNDERGROUND UTILITY LOCATIONS WERE REQUESTED USING THE 811 "ONE-CALL" LOCATE SYSTEM. PSE DOES NOT ACCEPT RESPONSIBILITY FOR THE LOCATION OF UTILITIES THAT WERE NEITHER VISIBLE NOR PAINTED ON THE GROUND AT THE TIME OF THE SURVEY. CONTRACTOR SHOULD VERIFY LOCATION OF UTILITIES PRIOR TO ANY SITE DISTURBANCE.
6. PARCEL AND RIGHT OF WAY LINES ARE SHOWN PER AVAILABLE SKAGIT COUNTY G.I.S. RECORDS. PARCEL OWNERSHIP INFORMATION SHOWN PER SKAGIT COUNTY ASSESSOR RECORDS AS OF JUNE 15TH, 2018. NO BOUNDARY SURVEY WAS PERFORMED FOR THIS PROJECT AND NO TITLE REPORTS WERE PROVIDED.

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FIELD BOOKS	TBM. NO.	LOCATION	ELEV.
DESIGN: 696.00			
STAKING:			
ASBUILT:			
SURVEY REFERENCE	VERTICAL DATUM		

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PLAN CHECK			

REV	DATE	DESCRIPTION	BY
REVISIONS			

No.		DATE
ISSUE		

NORTHWEST HYDRAULIC CONSULTANTS INC.

12787 GATEWAY DRIVE SOUTH
SEATTLE, WA 98168

TOPOGRAPHIC SURVEY

EXISTING CONDITIONS
SAMISH RIVER FLOOD RELIEF

JOB #: 2018075

SHEET 1 OF 9

7-5-2018
ADAM SCOTT MORROW
STATE OF WASHINGTON
REGISTERED
PROFESSIONAL LAND SURVEYOR

TOPOGRAPHIC SURVEY

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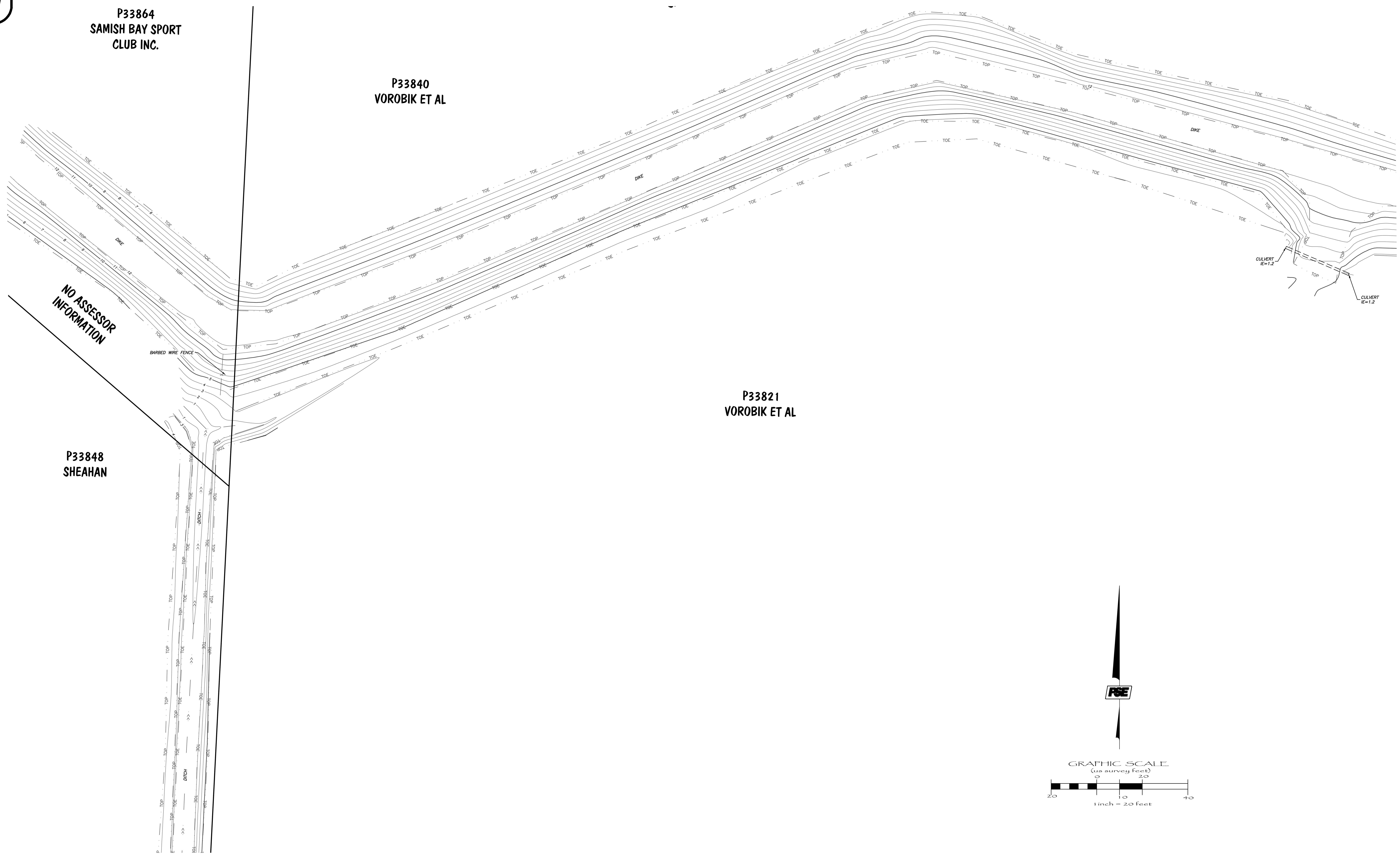

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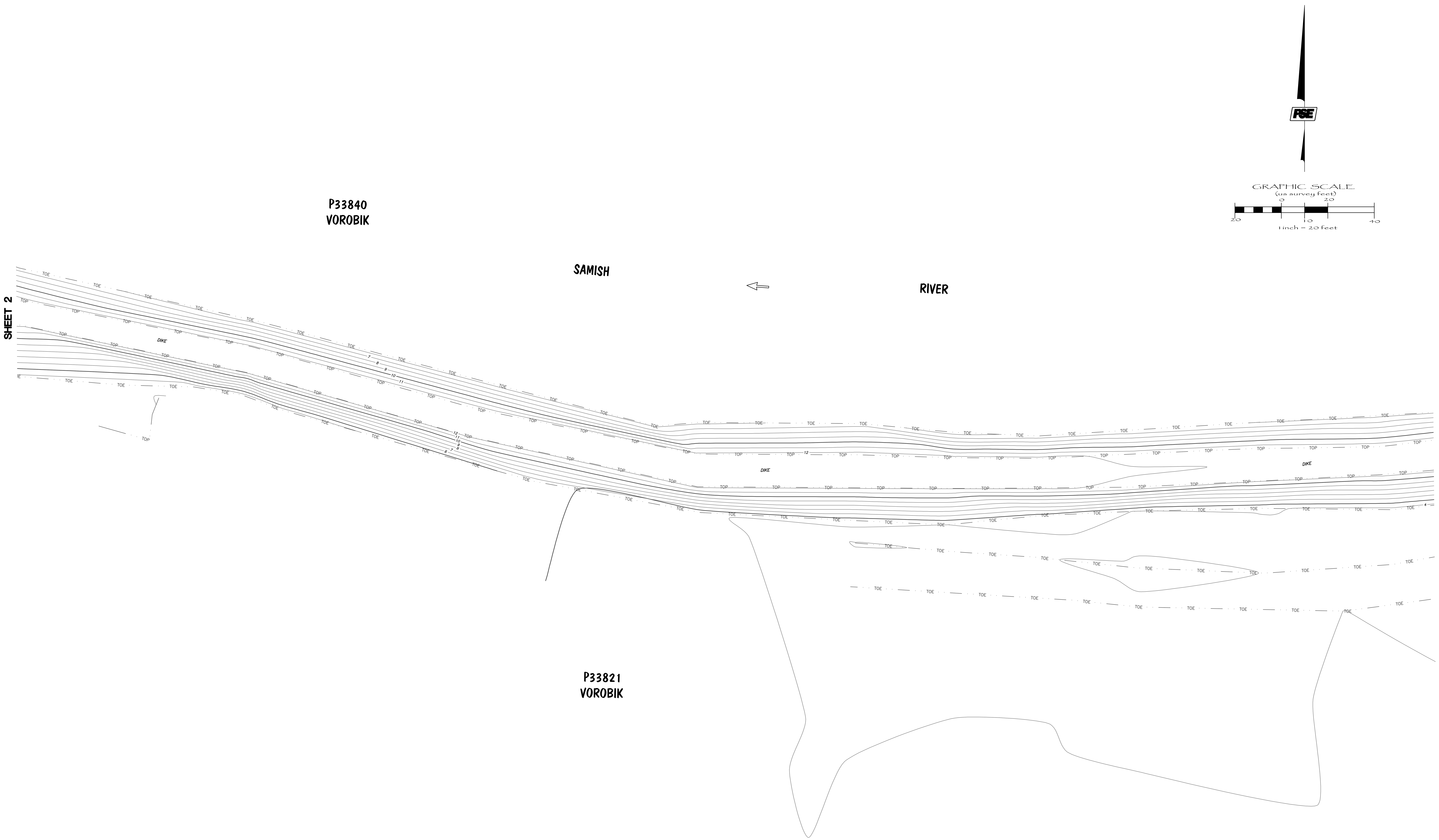

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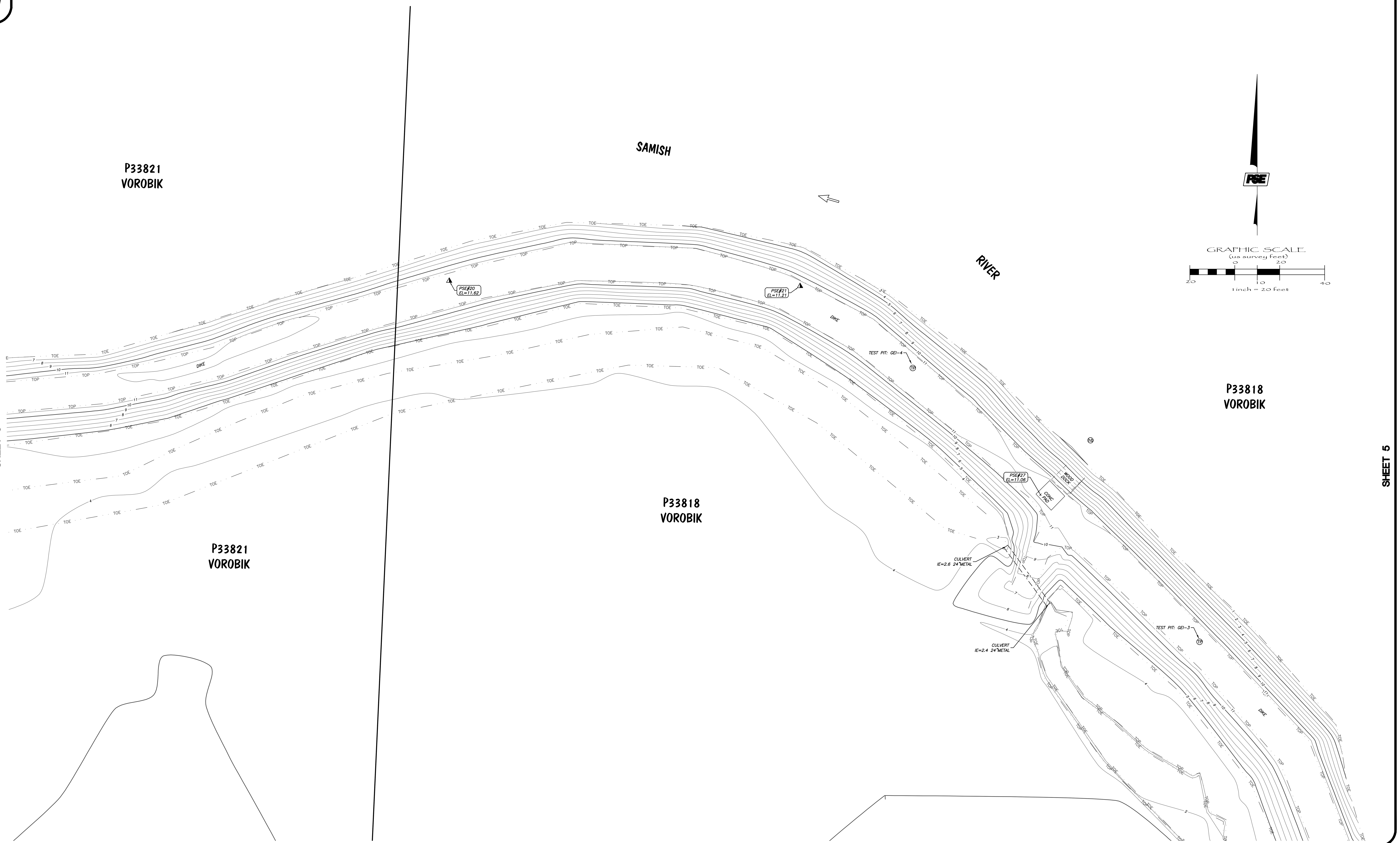

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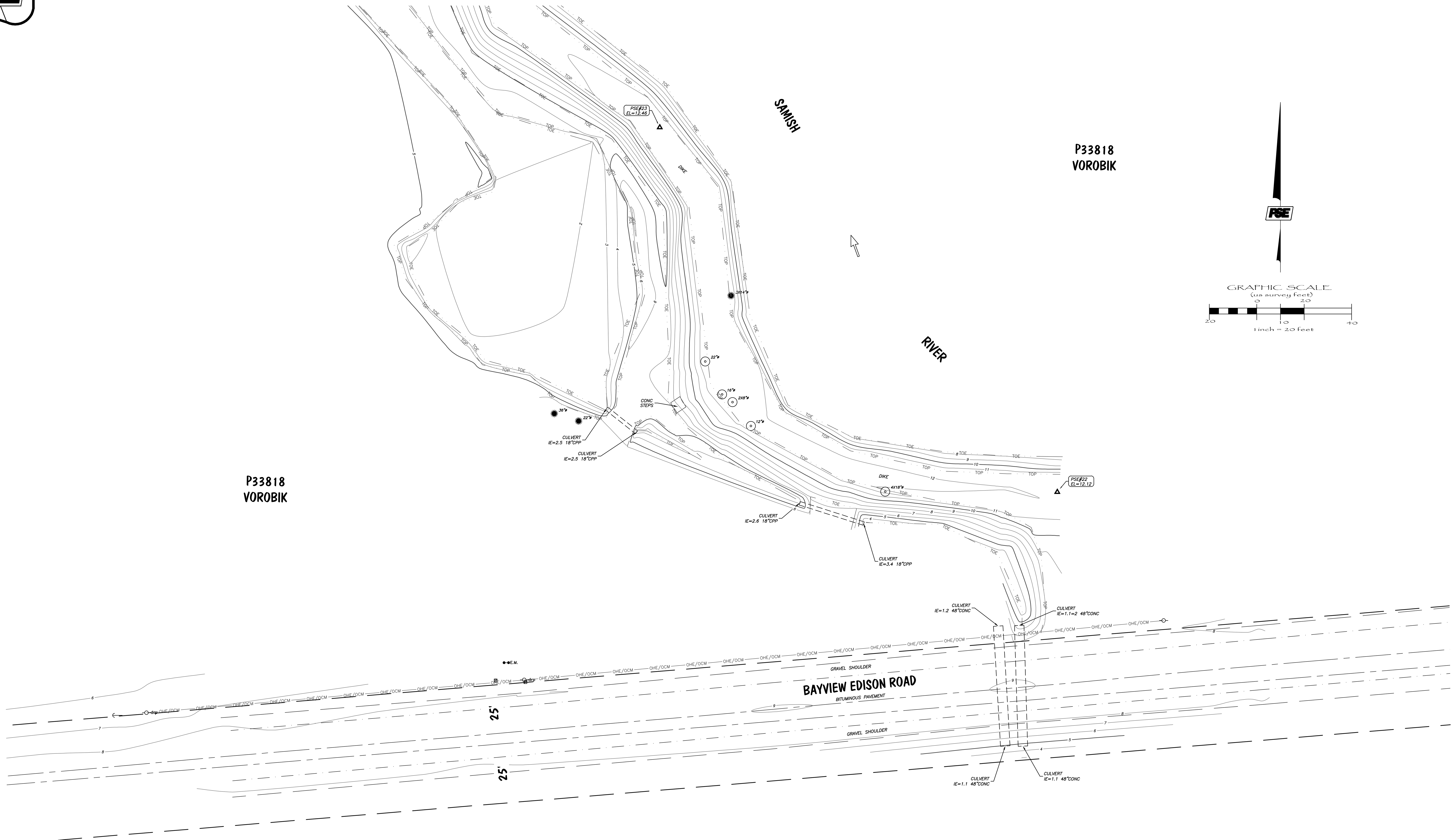

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TOPOGRAPHIC SURVEY

EXISTING CONDITIONS
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JOB #: 2018075

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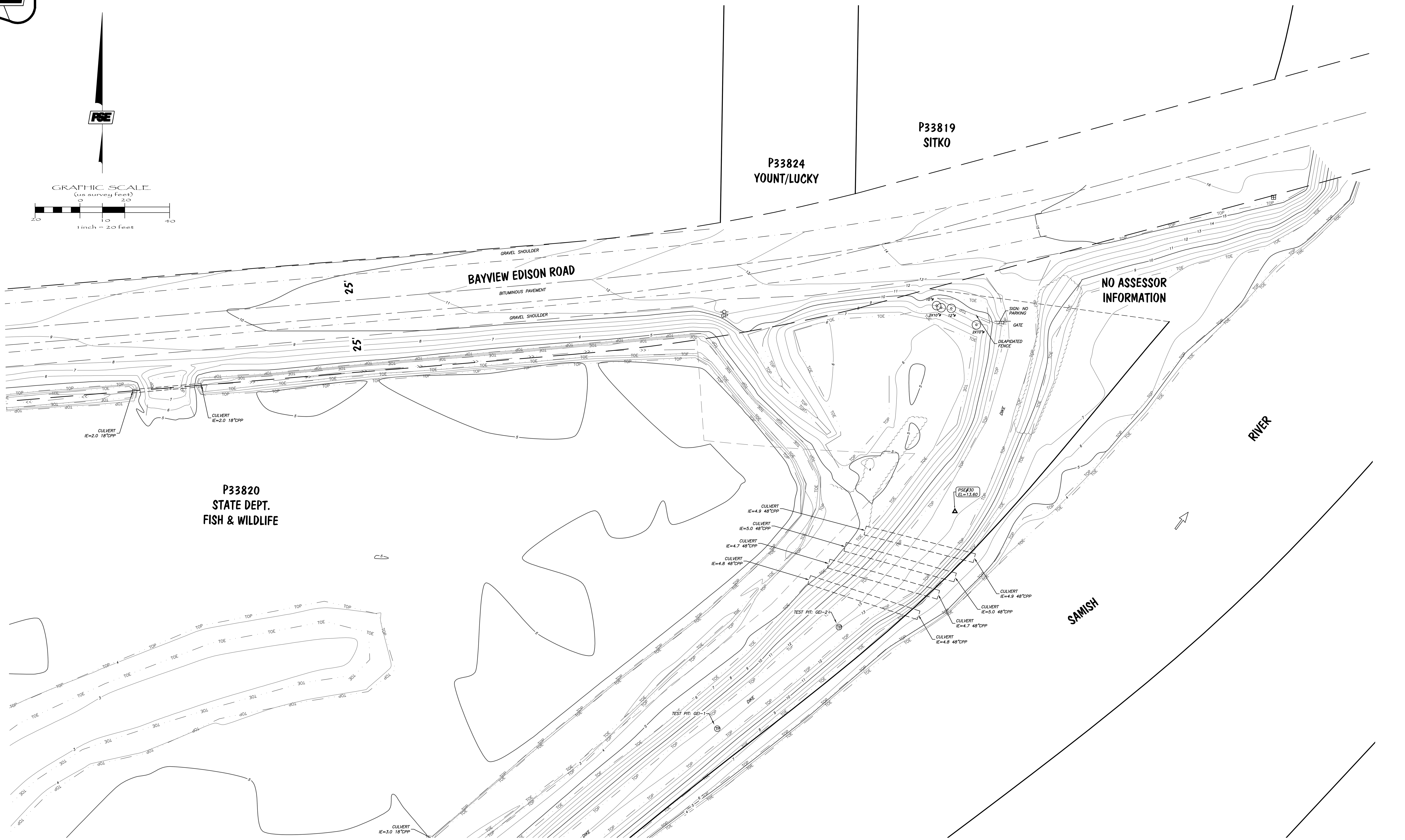

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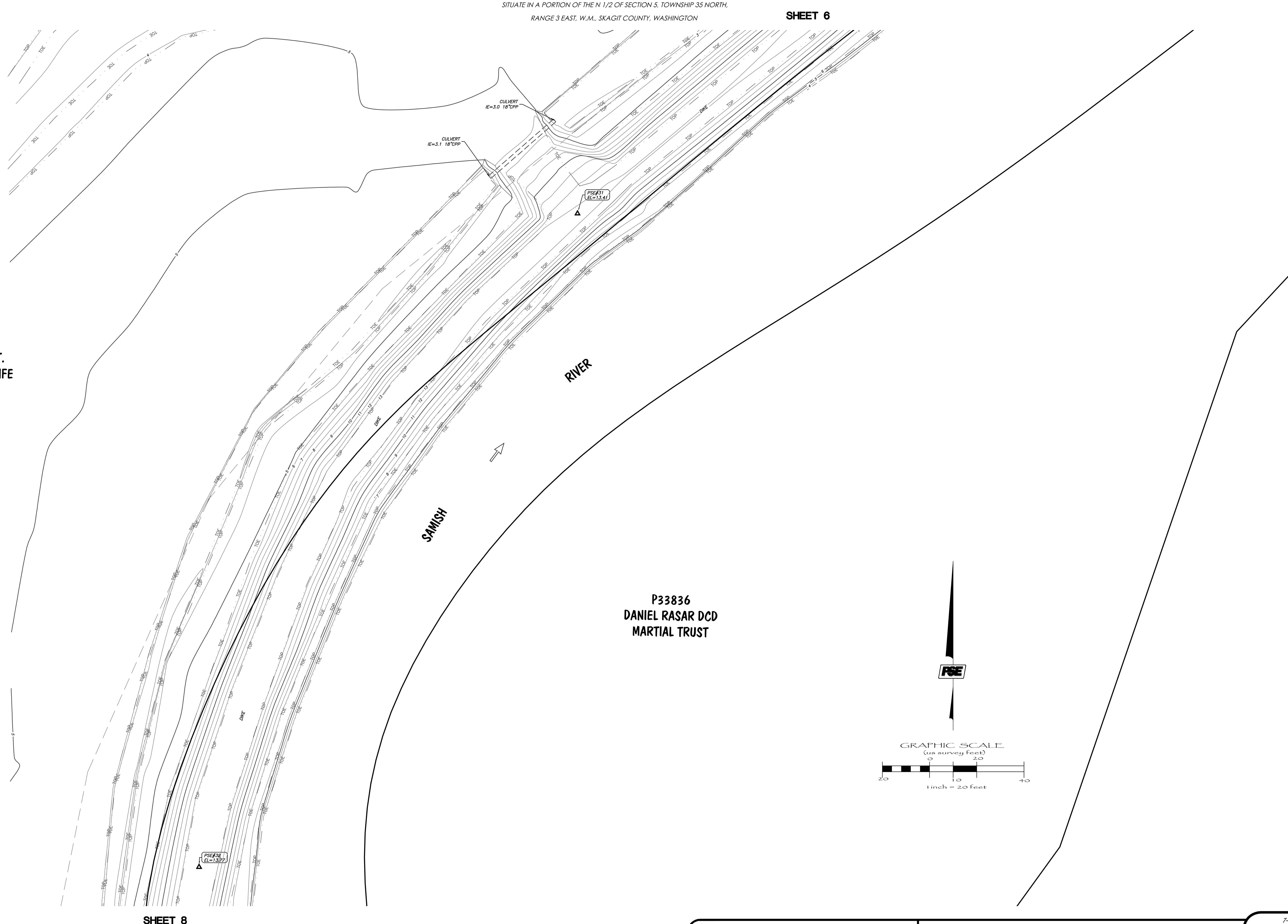

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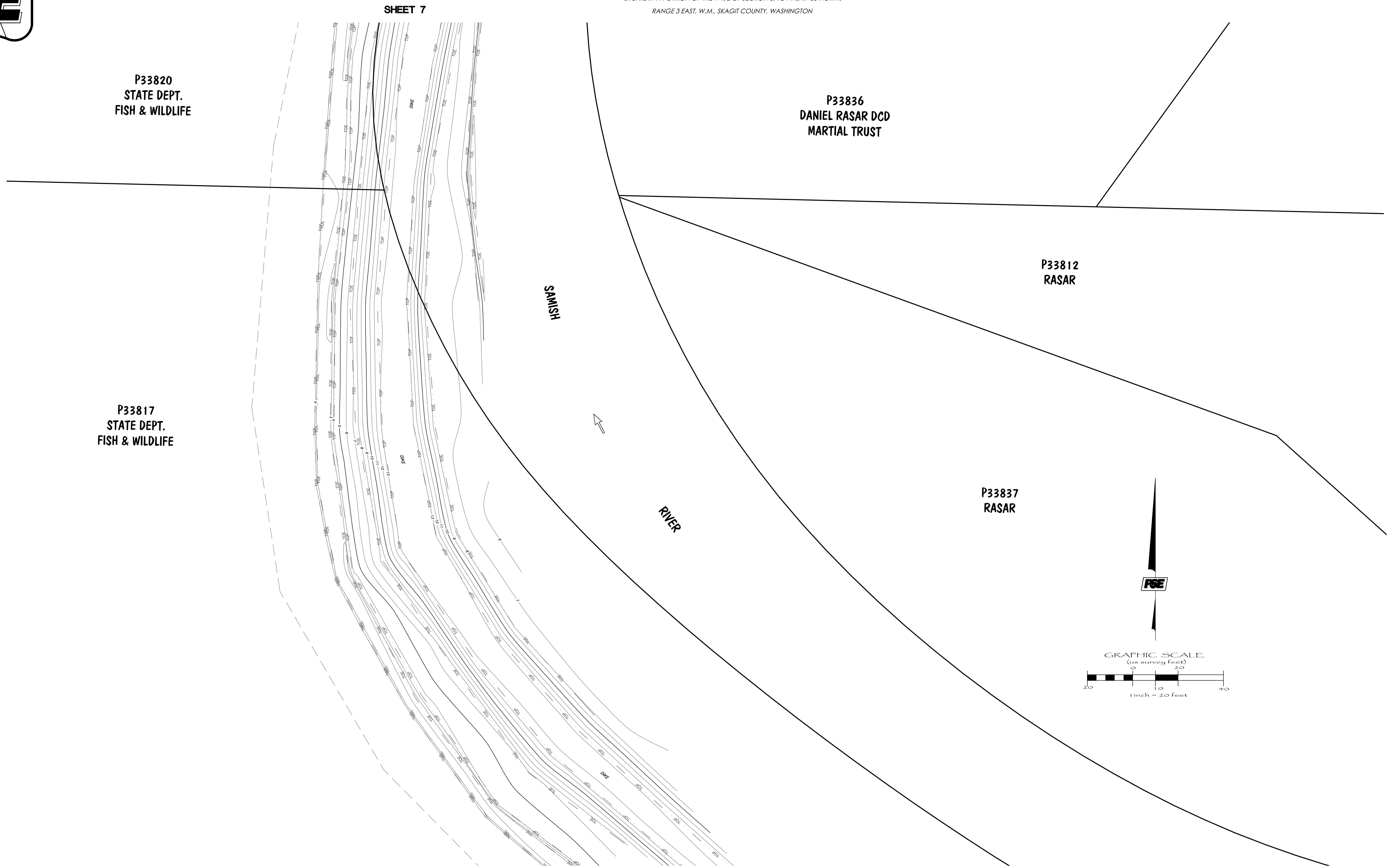

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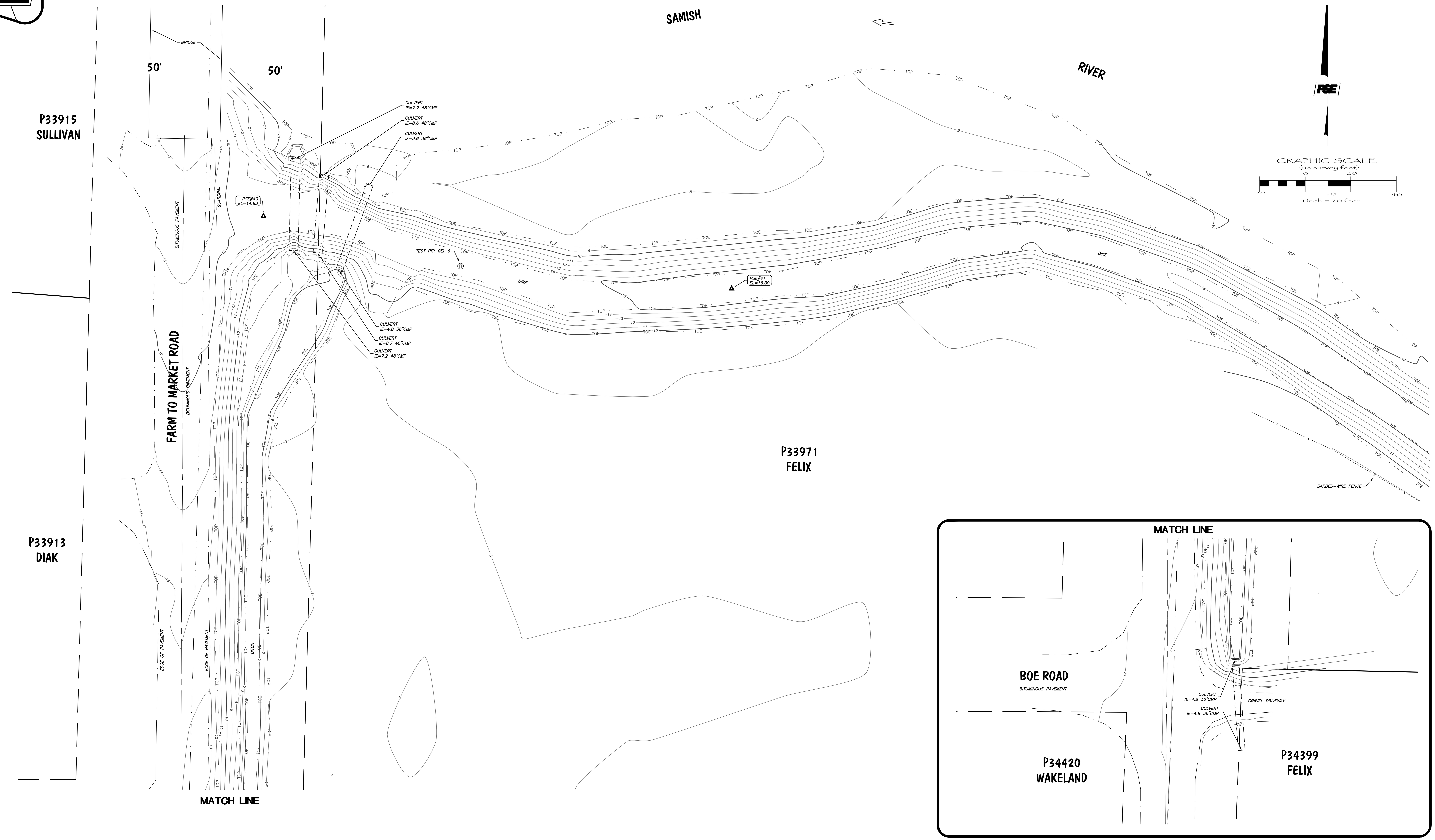

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SAMISH RIVER FLOOD RELIEF

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SHEET 9 OF 9

7-5-2018
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STATE OF WASHINGTON
REGISTERED PROFESSIONAL LAND SURVEYOR

ATTACHMENT C

Geotechnical Report

Geotechnical Engineering Services

Samish River Floodgates
Skagit County, Washington

for
Northwest Hydraulic Consultants, Inc.

December 30, 2022

GeoEngineers
Earth Science + Technology

Geotechnical Engineering Services

Samish River Floodgates
Skagit County, Washington

for
Northwest Hydraulic Consultants, Inc.

December 30, 2022

GeoEngineers

554 West Bakerview Road
Bellingham, Washington 98226
360.647.1510

Geotechnical Engineering Services

Samish River Floodgates
Skagit County, Washington

File No. 0220-097-00

December 30, 2022

Prepared for:

Northwest Hydraulic Consultants, Inc.
12787 Gateway Drive South
Seattle, Washington 98168

Attention: Derek Stuart, PE

Prepared by:

GeoEngineers, Inc.
554 West Bakerview Road
Bellingham, Washington 98226
360.647.1510

Mark W. Rose, PE
Geotechnical Engineer

Sean W. Cool, PE
Associate

MWR:SWC:tln:leh

Two copies submitted

Table of Contents

LIST OF FIGURES

APPENDICES

1.0 INTRODUCTION AND SCOPE

This revised report presents the results of GeoEngineers, Inc.'s (GeoEngineers') geotechnical engineering services for the proposed Samish River Floodgates project for Northwest Hydraulic Consultants, Inc. (NHC) in western Skagit County, Washington.

The proposed project consists of adding at least 17 new floodgate pipes at four locations adjacent to the Samish River and Samish Bay. The floodgates will be designed to allow basin floodwaters to drain to the Samish River or Samish Bay and prevent the back-flow from these waterbodies during high tides and channel water levels. As currently planned, the floodgate pipes will consist of 3- to 5-foot-diameter high density polyethylene (HDPE) with attached mechanical steel gate structures. The locations of the proposed floodgate sites are shown in the Vicinity Map (Figure 1) and discussed in detail below:

- Eight floodgates are planned adjacent to the Samish River immediately south of Bayview Edison Road ("Bayview Edison South" site). Pipe inverts will be near Elevation 5 feet. Four existing floodgates at a similar invert elevation are present adjacent to this site. Existing site conditions for this area are shown in Figure 2.
- Four floodgates are planned adjacent to Samish Bay near the Samish River delta north of Bayview Edison Road ("Bayview Edison North" site). Pipe inverts will be near Elevation 2 feet. Existing site conditions for this area are shown in Figure 3.
- A to-be-determined number of floodgates are planned adjacent to Alice Bay near 12025 Samish Island Road ("Samish Sports Club" site). Existing site conditions for this area are shown in Figure 4.
- Approximately five floodgates are planned adjacent to the Samish River immediately east of Farm to Market Road ("Farm to Market Road" site). Pipe inverts will be near Elevation 8 feet for four of the pipes and Elevation 4 feet for one pipe. Two existing floodgates with inverts between approximately Elevation 7 and 8½ feet are present adjacent to this site. Existing site conditions for this area are shown in Figure 5.

The critical geotechnical considerations for the proposed site development include settlement and bearing support for the floodgate pipes, pipe backfill, seepage around the structures, and temporary shoring and dewatering for the project construction. The purpose of our geotechnical engineering services is to explore subsurface conditions at the site as a basis for developing geotechnical recommendations for the proposed floodgates installation based on the understanding provided above. The scope included drilling five geotechnical borings, completing laboratory testing on samples obtained from the explorations, performing engineering analyses, and preparing this report. The scope of work is described in our proposal for the project dated April 25, 2018 and authorized by Derek Stuart of the NHC on April 26, 2018.

2.0 SITE CONDITIONS

2.1. Surface Conditions

The floodgate sites are located in the lowlands of the Samish River Valley to the south and west of Edison and north of Bayview. The overall topography at the sites is relatively level and topographic features are primarily related to drainage ditches and the levee embankment. The existing levee embankment typically has a crest width of 12 to 15 feet, with side slopes of approximately 1.5H:1V (horizontal to vertical) on the riverward side and 2H:1V on the landward side. The levee crest ranges from Elevation 12 feet at the Bayview Edison North site to Elevation 15 feet at the Farm to Market site.

The sites are vegetated with grass and brush, including the levee embankment itself. Existing floodgate/tidegate structures are present at the Bayview Edison South, Samish Sports Club, and Farm to Market Road sites.

2.2. Geology

We reviewed a Washington State Department of Natural Resources (DNR) map for the project area, "Geologic Map of the Bellingham 1:100,000 Quadrangle, Washington" by Lapen (2000). Soil deposits in the site area are mapped as Holocene era alluvial deposits consisting of clay, silt, and sand with minor amounts gravel. Organic material is also common in the local alluvium.

2.3. Subsurface Explorations

Subsurface soil and groundwater conditions were evaluated by advancing five geotechnical borings (B-1 through B-5) at the site using a track-mounted drill rig subcontracted to GeoEngineers on May 15 and 16, 2018. The borings were completed to depths of 21½ to 26½ feet below the existing ground surface (bgs). Details of the field exploration program, laboratory testing, and the boring logs are presented in Appendix A. The boring locations were located as follows:

- Boring B-1 was completed at the Bayview Edison South site. The approximate location of B-1 is shown in Figure 2.
- Borings B-2 and B-3 were completed at the Bayview Edison North site. The approximate locations of B-2 and B-3 are shown in Figure 3.
- Boring B-4 was completed at the Samish Sports Club site. The approximate location of B-4 is shown in Figure 4.
- Boring B-5 was completed at the Farm to Market Road site. The approximate location of B-5 is shown in Figure 5.

2.4. Subsurface Conditions

2.4.1. Soil Conditions

Subsurface soil conditions generally consisted of fill from the existing levee embankment overlying alluvial deposits.

Levee embankment fill was encountered at all boring locations. The fill typically consisted of soft to stiff silt and clay with sand, rootlets and other organic matter. Fill typically extended to depths ranging between 7½ to 10 feet bgs at all drilling locations. Moisture content of samples collected from the fill embankment typically ranged from approximately 30 to 70 percent. Embankment fill was likely derived from fine-grained portions of surrounding alluvial deposits.

Alluvial deposits were encountered below the fill soils to the full depth explored at all boring locations. The alluvium was a variable, consisting of layers of materials ranging from very soft to soft silt and clay to loose to medium dense fine to medium sand with variable amounts silt. Variable amounts of fibers, wood fragments and organic matter were also encountered in the alluvial deposits. Portions of the alluvium may also include near-shore beach or intertidal deposits but are not differentiated in this report.

2.4.2. Groundwater Conditions

Groundwater monitoring piezometers were not installed at the site. During drilling, saturated soils indicative of groundwater was typically encountered very near the levee embankment fill and native alluvium interface between 9 and 11 feet bgs, or approximately Elevation 2 to 5 feet. Groundwater conditions should be expected to vary as a function of season (higher during winter and spring months), precipitation, water levels in the Samish River, tides, and other factors.

3.0 CONCLUSIONS AND RECOMMENDATIONS

3.1. General

We conclude that the proposed floodgates may be completed as proposed using conventional earthwork equipment. A summary of the primary site preparation, design and construction considerations for the proposed project is provided below. The summary is presented for introductory purposes and should only be used in conjunction with the complete recommendations presented in this report.

- The proposed floodgate pipes will be installed in an existing levee embankment that is marginally stable under static conditions (factor of safety less than 1.5). The recommendations in this report will not mitigate for embankment stability under static or seismic conditions.
- The site soils appear to have moderate to high potential for liquefaction and several inches of settlement will likely occur as a result of a large design level earthquake.
- The proposed floodgates will be supported on soft to medium stiff silt or clay or loose silty sand. Subgrade soils should be prepared with geotextile fabric and foundation material as necessary to create a firm subgrade for construction. A keyway is required for seepage cutoff if foundation material is used. Drainage fill and possible seepage collar could be used to reduce the potential for negative effects of seepage along the pipe.
- We recommend pipe backfill and embankment material be an import material consisting of a minimum of 30 percent silt and clay, a maximum of 60 percent sand, a maximum of 60 percent silt, with nominal gravel and cobble content. Compaction specifications are provided herein.
- We recommend temporary slopes no steeper than 1.5H:1V, assuming a fully dewatered slope condition. Sheet pile shoring/coffer dam will likely be required to complete pipe excavation at lower elevations.
- We recommend that permanent slopes match the existing slopes on the riverward side of the levee and that the landward slopes be flattened to 3H:1V to provide a nominal improvement to embankment stability.
- Dewatering will likely be required to complete the project. Dewatering requirements will be a function of the base of structure elevation and water level at the time of construction.
- Embankment soils encountered at the site are fine-grained and wet weather trafficability will be very poor on these soils. We recommend that earthwork occur during dry summer months to reduce earthwork and dewatering efforts.

3.2. Seismic Considerations

We evaluated the site for seismic hazards including liquefaction, lateral spreading and fault rupture. Our evaluation indicates the saturated alluvial deposits underlying the floodgate sites are susceptible to liquefaction as discussed in the following report section. The existing levees may be at risk of liquefaction settlement and lateral spreading during a seismic event; however, a detailed assessment of the stability of the levees is beyond our scope of work. Based on Washington DNR and U.S. Geological Survey (USGS) maps of active faults in the Puget Sound region, there are mapped faults approximately 2 to 3 miles from the floodgate site. However, because there are no mapped faults in the immediate vicinity of the project area, it is our opinion that there is a low risk of fault displacement resulting in ground rupture at the surface.

Liquefaction is a phenomenon where soils experience a rapid loss of internal strength as a consequence of strong ground shaking. Ground settlement, lateral spreading and/or sand boils may result from liquefaction. Embankments supported on liquefied soils could suffer foundation settlement or lateral movement that could be severely damaging. Conditions favorable to liquefaction occur in loose to medium dense, clean to moderately silty sand that is below the groundwater level.

The alluvial deposits include layers of loose to medium dense sand with variable silt content. As previously stated, groundwater was encountered at a shallow depth within the native alluvial soil profile. The combination of loose sandy soils and high groundwater elevations creates a moderate to high liquefaction potential at this site. A full evaluation of the liquefaction potential of the floodgate sites is beyond our scope of work, but several inches of settlement will likely occur as a result of a large design-level earthquake. Sand boils and localized loss of ground support can also occur. The consequences of liquefaction settlement may range from a partial loss of functionality to significant distress and/or damage to the embankment following an earthquake.

The existing levee embankment does not appear to have been designed for seismic mitigation. Liquefaction mitigation is not typical for this type of project as the proposed embankment and new floodgates are intended for very infrequent, maintenance related occupation and are located in areas not accessible to the public, and the risk of a seismic event coinciding with a flooding event is very low.

3.3. Floodgate Embankment Stability Considerations

The existing levee embankment has approximately 1.5H:1V riverward slopes and 2H:1V landward slopes with a 12-foot wide berm crest. As currently proposed, landward slopes of the levee embankment will be regraded at the location of the floodgates to slopes of approximately 3H:1V where feasible. Riverward slopes will roughly match existing levee slopes. Changing the riverward slopes is not recommended without a full evaluation of the change in river dynamics and potential effects to the levee.

We completed a slope stability analysis to evaluate the embankment stability of the existing embankment as compared to the proposed postconstruction condition. The analysis was completed with Slope/W 2016 version 8.16.1 based on typical geometry, soil profile and assumed soil parameters. The existing levee embankment has a global stability factor of safety of less than 1.5 under static cases, on the order of 1.2 to 1.25. Our analysis concludes that by regrading the landward slope to 3H:1V, a nominal improvement in global slope stability is achieved compared to existing conditions; however, the factor of safety will remain below 1.5, likely on the order of 1.25 to 1.3. As noted previously, the site soils are subject to liquefaction following a seismic event. Based on our modeling, the existing levee embankment is not seismically stable (i.e., factor of safety below 1.0) during a design-level seismic event. The proposed floodgate improvements will not significantly increase seismic stability without additional mitigation.

3.4. Floodgate Pipe Design Considerations

Installation of the proposed floodgate pipes will require excavation to pipe subgrade, subgrade preparation, and backfill. Pipe design recommendations are provided in the following report sections. Recommendations for excavation slopes and shoring, dewatering, and earthwork are provided in subsequent sections of this report.

3.4.1. Pipe Subgrade Preparation

As currently proposed, the base of the floodgate pipes will be founded approximately 7 to 12 feet below the top of the existing embankment. Subgrade conditions are anticipated to be variable between the four sites depending on site specific conditions and pipe depths. Based on subsurface information collected from our borings, the proposed floodgate pipes will be supported on soft to medium stiff silt or clay, or loose sand or silty sand. Subgrade soils should be dewatered prior to excavation to final subgrade elevation, as described in Section 3.6 of this report.

The soft silt and clay subgrade soils are moisture sensitive and will not support construction equipment or even foot traffic to place the pipe without a layer of foundation material. The sandy soils may provide suitable pipe support if fully dewatered. We recommend that the pipe foundation support consist of the following:

- Woven fabric for stabilization with a 200-pound tensile strength in accordance with ASTM D 4632 (Mirafi HP270 or equivalent) placed over the native fine-grained subgrade (an appropriate Washington State Department of Transportation [WSDOT] Standard Specification is per Table 3 Section 9-33.2(1).
- Where soft subgrade conditions are present, a foundation layer consisting of 12- to 18-inches of a rock product such as: crushed surfacing base course per WSDOT Standard Specification 9-03.9(3) or permeable ballast per WSDOT Standard Specification 9-03.9(2).
- A minimum of 12 inches of pipe bedding and embankment backfill as described in the following report section.

If the foundation layer is used, it will provide a potential seepage pathway below the pipe. After placement of the foundation material and pipe bedding, we recommend an 8-foot wide cut-off trench be excavated across the entire width of the pipe excavation. The cut-off trench should extend through the pipe bedding and foundation material and a minimum of 2 feet into the underlying soils, and be backfilled with additional compacted embankment material or control density fill (CDF).

Care should be exercised when applying excessive vibration for compaction to make sure that pumping does not occur. We recommend the condition of the floodgate foundation subgrade excavation be evaluated by a GeoEngineers representative to confirm that conditions are consistent with our assumptions.

3.4.2. Pipe Bedding and Embankment Backfill

We recommend that pipe bedding and embankment backfill soils surrounding the pipe consist of a mixed silt, clay and sand material that can be compacted to specified requirements and will be placed in a manner to create a relatively homogeneous, impermeable zone around the floodgate pipes and for the levee embankment. We recommend that the embankment be constructed of soils with roughly the following characteristics per the United States Department of Agriculture's (USDA) Textural Triangle (i.e., the portion of the sample passing the U.S. No. 10 sieve):

- A minimum of 30 percent silt and clay and a maximum of 60 percent silt
- A maximum of 60 percent sand
- Nominal gravel and cobble content

In general, imported soils from sites with glaciomarine drift and/or glacial till geologic units will typically meet these requirements. The existing levee embankment material could be reused as bedding and backfill material, but laboratory testing indicates the existing materials have moisture contents significantly above optimum for compaction. We anticipate the existing material will have too high of a moisture content to meet compaction requirements unless the soil is thoroughly moisture conditioned. We anticipate that the desired project schedule, which would include specific work windows during low river and tidal cycles, will not allow for adequate moisture conditioning time.

All structural backfill around the pipes and for the embankment closure should be compacted to about 90 to 92 percent of the maximum dry density (MDD), as determined using test method ASTM International (ASTM) D 1557, modified Proctor. Structural backfill should be placed and compacted within about -1 to +5 percent of the optimum moisture, with +1 to +3 percent being preferred. Soil outside of this range of moisture should be moisture conditioned as necessary prior to compaction. The embankment fill placed at this compaction is more likely to have sufficient flexibility to not be affected by cracking, due to minor settlements. The purpose of this moisture content control is to limit shrinkage of the embankment which can lead to cracking and deformation and impact stability of the levee.

New backfill soil should be keyed into the existing embankment using horizontal benches cut into the sidewalls of the excavation. The appropriate backfill lift thickness will depend on the material and the compaction equipment being used. We anticipate that small compaction equipment, such as jumping jack compactors, will be used immediately around pipes although small drum rollers could also be used. We recommend relatively thin loose lift thicknesses of 6 inches when small equipment is used. Loose lift thicknesses of 10 inches may be feasible when using a smooth drum roller, or 1.5 times the length of the projections on the roller if using a sheepsfoot roller. We recommend that the suitability of fill gradation, lift thickness, and compaction be regularly tested during construction.

3.4.3. Pipe Seepage Considerations

Seepage along pipe conduits can result in piping of material through the embankment. We recommend adding mitigation with drainage fill and/or seepage collars to reduce risk of seepage and piping.

The US Army Corps of Engineers (USACE) Design and Construction of Levees (2000) recommends that the outer portion of the landward side of the pipe be bedded in a more free-draining material that allows the dissipation of porewater pressure prior to exiting the embankment. In this instance, we recommend bedding the outer 5 to 10 feet of the pipe with crushed surfacing base course (WSDOT Standard Specification 9-03.9(3)) extending a minimum of 18 inches around the pipe. This material has less than 7.5 percent passing the US No. 200 sieve (less than 5 percent preferred) and may not be entirely free draining but will have a higher permeability than the embankment fill. The drainage layer will allow for seepage to exit the embankment in a controlled manner without piping of the fine-grained embankment material. We recommend that this material be covered at the outlet surface in a minimum 6-inch thick layer of 4-inch minus clear crushed rock and riprap armoring to protect from surface erosion. Because the high water levels occur on both sides of the embankment, this drainage fill seepage protection could be considered for installation of both sides of the levee.

Seepage collars may provide additional mitigation for seepage. If seepage collars are included in the design, we recommend one collar be installed per floodgate structure that extends perpendicular to the pipe and keys into the existing levee embankment. Collars can consist of pipe flanges, CDF, lean concrete, or compacted soil with at least 30 percent fines (silt or clay). Collars should be at least 2 feet wide and extend at least 6 inches below the excavation base and should key into the existing embankment at least 12 inches to cut off potential water migration through the backfill materials. Some documented cases of poorly compacted fill adjacent to seepage collars have led to embankment failures and attention to backfill and compaction is a critical component of proper seepage collar construction. We recommend that seepage collars only be used in conjunction with the drainage fill described above.

3.4.4. Pipe Settlement

Mechanisms for pipe settlement are from poor bearing support immediately below the pipe and consolidation of underlying compressible soils under new embankment loads. We expect that the actual distributed loads across the pipe foundation will result in a nominal net change in pressure below the pipes due to the embankment material that will be removed. Some slight load increase may result for regrading the landward slope. We estimate that on the order of 1 inch of postconstruction settlement could occur. The settlement will occur as settlement of the soft silt over time. We expect that the majority of the settlement will be complete within 3 to 6 months of placing the full height fill over the floodgates.

3.4.5. Buoyancy

We understand that the floodgates may result in partially empty pipes during high floodwater conditions. The pipes should be designed with sufficient cover and/or ballast material over the pipe to resist buoyant effects. If sufficient cover material is not available, tiedown anchors could be used; GeoEngineers can provide additional information regarding anchoring if requested.

3.4.6. Scour Protection

Scour protection should be in accordance with any recommendations provided by the project hydraulic engineer, if appropriate.

3.5. Excavations

Excavations will generally encounter embankment fill and native alluvial soils consisting of silty sand, sandy silt, and clay. Excavation of these materials can be completed using conventional earthwork equipment. Alluvial soils occasionally contain logs and other debris; the contractor should be prepared to handle larger obstructions if they are encountered.

3.5.1. Temporary Slopes

All excavations and other construction activities must be completed in accordance with applicable county, state and federal safety standards. The on-site soils can be excavated using conventional earthmoving equipment. The subgrade will be susceptible to disturbance and softening which could be reduced by use of smaller or low ground pressure equipment.

Regardless of the soil type encountered in the excavation either shoring, trench boxes or sloped sidewalls will be required for excavations deeper than 4 feet under Washington State Administrative Code (WAC) 296-155, Part N. Some localized excavations may be made as open cuts in conjunction with sloped sidewalls for shielding workers. For planning purposes only, the native and fill soil found on site is classified as “Type C” soil. The regulations allow temporary slopes for this condition up to 1.5H:1V.

The above regulations assume that surface loads such as construction equipment and storage loads will be kept a sufficient distance away from the top of the cut so the stability of the excavation is not affected. Flatter slopes and/or shoring will be necessary for those portions of the excavations which are subjected to significant seepage in order to maintain the stability of the cut. Temporary slopes in wet/saturated sand will be susceptible to sloughing, raveling and “running” conditions. It should be expected that unsupported cut slopes will experience some sloughing and raveling if exposed to surface water. Berms or other provisions should be installed along the top of the excavation to intercept surface runoff to reduce the potential for sloughing and erosion of cut slopes during wet weather.

3.5.2. Temporary Shoring

Where the floodgates are founded below anticipated river or tidal fluctuations at the time of construction, or where temporary slopes impact adjacent infrastructure, temporary shoring with sheet piles/sheet pile cofferdam is recommended. A sheet pile cofferdam can be used to help protect the excavation from inundation from tidal fluctuations and to serve as a partial groundwater cutoff to minimize the quantity of water that will need to be pumped and discharged.

Because of the diversity of available shoring systems, dewatering systems and construction techniques, the design of temporary shoring is most appropriately left up to the contractor proposing to complete the installation. However, we recommend that the temporary shoring, if required, be designed by an engineer licensed in Washington, and the PE stamped shoring plans and calculations be submitted to the Engineer for review prior to construction.

The sandy silt alluvial soils at the base of the proposed floodgates are at risk of basal heave if not properly accounted for in design of the shoring system. The combined shoring and dewatering system should consider basal heave with regard to the required depth of sheet piling and dewatering method and execution. If soil and water pressures inside and outside of the shored excavation are imbalanced, it may result in instability of the base of the excavation and which would be manifest as fissures or silt/sand boils with flowing water.

3.5.3. Permanent Slopes

We recommend permanent slopes no steeper than the existing permanent slope of approximately 1.5H:1V on the riverward side and 2H:1V on the landward side of the embankment. As discussed in Section 3.3, flattening the landward side to 3H:1V, where feasible, will provide a nominal improvement in overall embankment stability. Permanent slopes will require establishing vegetation and/or armoring to protect from erosion.

3.6. Construction Dewatering

At the time of this report, the base elevation of the proposed floodgate pipes ranged between Elevation 2 feet and Elevation 8 feet. Depending on the time of year of construction, we anticipate the floodgates will be installed near, or slightly below, groundwater elevation. Based on discussions with NHC, floodgate construction would ideally be completed during dry summer months and during low tide and river cycles to minimize dewatering requirements.

In our opinion, the contractor should be responsible for designing and installing the appropriate dewatering system needed to complete the work. We recommend that the project contract documents require the contractor to submit a dewatering plan with their bid estimate and include a line item for dewatering costs.

We expect that open pumping (sumps and pumps) within the excavation will be the preferred method to dewater the excavation if the groundwater only needs to be lowered nominally. Open pumping within the excavation after installation of a sheet pile coffer dam may also be sufficient if the sheet piles extend through fine-grained soils layers that will provide partial groundwater cut-off.

Other methods of shoring and dewatering may also be feasible; however, other methods will either require extensive dewatering or are likely to be more expensive and have more risks than conventional sheet pile cofferdam and open pumping. A vacuum well point system could be somewhat effective where more aggressive dewatering is necessary. Vacuum wellpoints are effective for dewatering most types of soils, whether pumping small amounts of water from silt or large quantities of water from coarse sand and gravel. Large or deep wells and will not likely provide efficient dewatering based on the typical native alluvial soil composition consisting of interbedded silt, clay and sand.

The amount of water removed from the excavation by open pumping should be minimized because of high turbidity levels. Temporary storage of dewatering effluent from the sumps in a settlement tank or basin may be required to meet discharge permit requirements and reduce sediment content prior to discharging the water to surface water courses.

Our shoring and dewatering discussion is provided to assist in the assessment of construction dewatering methods but are not intended to be for design because of the interaction between the shoring system, dewatering methods, and contractor means and methods. Groundwater can create a safety threat and can seriously compromise arrangements for shoring excavations. Also, given the potential for natural variation in geologic formations, differing site conditions may be encountered that could lead to substantially different groundwater inflows and dewatering challenges than are presented in this evaluation. We did not perform pumping tests or other detailed hydrogeologic evaluations and this information is presented for use by the contractor but is not intended to dictate designs.

3.7. Earthwork

3.7.1. Erosion Control

Temporary erosion control measures should be used during construction depending on the water in the river/bay, location, soil type, and other factors. Temporary erosion protection (e.g., straw, plastic, or rolled erosion control products) may be necessary to reduce sediment transport until vegetation is established or permanent surfacing applied for the area of excavation into the levee embankment. Appropriate best management practices should be incorporated into the temporary erosion and sediment control plan developed by the civil engineer. We are available to provide input if desirable.

3.7.2. Structural Fill

Recommendations for pipe backfill and drainage zone materials are presented in Section 3.4 of this report. In general, backfill should be placed in horizontal lifts not exceeding 6 inches in loose thickness or that necessary to obtain the specified compaction with the equipment used. Each lift must be thoroughly and uniformly compacted. All structural fill material should be free of organic matter, debris, and other deleterious material. The maximum particle size diameter should be the lesser of either 5 inches or one half of the loose lift thickness, or as recommended by the pipe manufacturer. Backfill material within the levee embankment should be compacted to 90 to 92 percent of the MDD in accordance with ASTM D 1557 at a moisture content of -1 to +5 percent of optimum, as discussed previously.

Sufficient earthwork monitoring and a sufficient number of in-place density tests should be performed to evaluate fill placement and compaction operations and to confirm that the required compaction is being achieved.

3.7.3. Reuse of On-site Soils

On-site soils typically consist of soft to stiff silt and clay with variable amounts of sand and some loose to medium dense silty sand. As discussed in Section 3.4, the moisture content of the onsite soils is typically significantly above optimum and achieving compaction specifications will be difficult without significant moisture conditioning (drying). On-site soils that meet the gradation specification can be considered for reuse if they can be moisture conditioned to near optimum moisture as described in Section 3.7.2.

3.7.4. Wet Weather Earthwork Considerations

As noted, the site soils are moisture sensitive and subject to disturbance when wet. We recommend project construction be scheduled during the dry season to take advantage of lower water levels in the Samish River and lower groundwater levels. If wet weather earthwork is required, we provide the following considerations:

- Construction activities should be scheduled so that the length of time that soils are left exposed to moisture is reduced to the extent practical and limit the size of areas that are stripped of vegetation.
- The ground surface in and around the work area should be sloped so that surface water is directed to a sump or discharge location. The ground surface should be graded such that areas of ponded water do not develop.
- Slopes with exposed soils should be covered with plastic sheeting or similar means.
- Providing upgradient perimeter ditches or low earthen berms and using temporary sumps to collect runoff and prevent water from ponding and damaging exposed subgrades.
- The site soils should not be left uncompacted and exposed to moisture. Sealing the surficial soils by rolling with a smooth-drum roller prior to periods of precipitation will reduce the extent to which these soils become wet or unstable.
- Limiting construction traffic over unprotected soil and by limiting the size and type of construction equipment used.

- Providing gravel “working mats” over areas of prepared subgrade. Gravel mats should be removed prior to pipe backfill placement.

3.8. Recommended Additional Geotechnical Services

GeoEngineers should be retained to review the project plans and specifications when complete to confirm that our design recommendations have been implemented as intended. We recommend part-time construction observation during excavation, floodgate installation, and backfill to document construction activities and advise the project team of areas of concern and recommended actions to promote the successful installation of the proposed structures.

4.0 LIMITATIONS

We have prepared this report for use by Northwest Hydraulic Consultants, Skagit County Public Works, and other members of the design team for use in design of the proposed Samish River Floodgates project in Skagit County, Washington.

Within the limitation of scope, schedule and budget, our services have been executed in accordance with generally accepted geotechnical practices in the area at the time the report was prepared. No warranty or other conditions, express or implied, should be understood.

Any electronic form, facsimile or hard copy of the original document (email, text, table, and/or figure), if provided, and any attachments are only a copy of the original document. The original document is stored by GeoEngineers, Inc. and will serve as the official document of record.

Please refer to the Appendix B, “Report Limitations and Guidelines for Use,” for additional information pertaining to use of this report.

5.0 REFERENCES

F. Pessl, Jr., Dethier, D.P., Booth, D.B., and Minard, J.P. 1989. “Surficial Geologic Map of the Port Townsend 30- by 60- Minute Quadrangle, Puget Sound Region, Washington.” United States Geological Survey.

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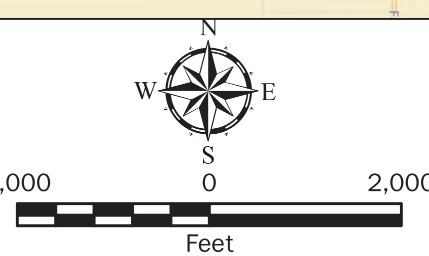
FIGURES



Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Mapbox Open Street Map, 2016

Projection: NAD 1983 UTM Zone 10N

Vicinity Map

Samish River Floodgates
Skagit County, Washington

GeoEngineers

Figure 1

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Legend

B-1 Approximate Boring Location

5 Contour (5-foot interval)

Contour (1-foot interval)

N W E S

50 0 50

Feet

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: LiDAR downloaded from Puget Sound LiDAR Consortium, Aerial from GoogleEarthPro

Projection: NAD 1983 StatePlane Washington North FIPS 4601 Feet

Site and Exploration Plan
Bayview Edison South

Samish River Floodgates
Skagit County, Washington

GeoEngineers

Figure 2

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Legend

B-2 Approximate Boring Location

5 Contour (5-foot interval)

Contour (1-foot interval)

N
W E
S

50 0 50
Feet

Notes:
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Projection: NAD 1983 StatePlane Washington North FIPS 4601 Feet

Site and Exploration Plan
Bayview Edison North

Samish River Floodgates
Skagit County, Washington

GEOENGINEERS

Figure 3

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Legend

B-4 Approximate Boring Location

N
W
E
S

50 0 50

Feet

Notes:

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Data Source: LiDAR downloaded from Puget Sound LiDAR Consortium, Aerial from GoogleEarthPro

Projection: NAD 1983 StatePlane Washington North FIPS 4601 Feet

Site and Exploration Plan
Samish Sports Club

Samish River Floodgates
Skagit County, Washington

GeoEngineers

Figure 4

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Legend

B-5 Approximate Boring Location

5 Contour (5-foot interval)

Contour (1-foot interval)

N
W E
S

70 0 70

Feet

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: LiDAR downloaded from Puget Sound LiDAR Consortium, Aerial from GoogleEarthPro

Projection: NAD 1983 StatePlane Washington North FIPS 4601 Feet

Site and Exploration Plan
Farm to Market Road

Samish River Floodgates
Skagit County, Washington

GeoEngineers

Figure 5

P:\0\0220097\GIS\MXD\0220097000_GeoTech_F05_FarmtoMarketRoad.mxd Date Exported: 08/01/18 by cchelf

APPENDICES

GeoEngineers

APPENDIX A
Field Exploration and Laboratory Testing

APPENDIX A
FIELD EXPLORATION AND LABORATORY TESTING

Field Explorations

Subsurface soil and groundwater conditions were evaluated by drilling five geotechnical borings at four proposed floodgate sites. The borings were completed to depths of 21½ to 26½ feet below the existing ground surface (bgs) on May 15 and 16, 2018 using a track-mounted drill rig subcontracted to GeoEngineers. The approximate locations of the explorations are shown in the Site and Exploration Plan Figures 2 through 5. The locations of the borings were determined by recreational grade GPS; therefore, the locations shown in the site plans should be considered approximate.

Disturbed soils samples were obtained using Standard Penetration Test (SPT) methodology with the standard split spoon sampler in the borings with a rope and cathead driven 140-pound hammer with 30-inch drop. The samples were placed in plastic bags to maintain the moisture content and transported back to our laboratory for analysis and testing.

The explorations were continuously monitored by a geotechnical engineer from our firm who examined and classified the soils/rock encountered, obtained representative soil/rock samples, observed groundwater conditions and prepared a detailed log of each exploration. Soils were visually classified in general accordance with ASTM D 2488-90, which is described in Figure A-1. An explanation of our boring log symbols is also shown on Figure A-1.

The logs of the borings are presented in Figures A-2 through A-6. The exploration logs are based on our interpretation of the field and laboratory data and indicate the various types of soils encountered. They also indicate the depths at which these soils or their characteristics change, although the change might actually be gradual. If the change occurred between samples in the boring, it was interpreted.

Observations of groundwater conditions were made during exploration. The groundwater conditions observed are presented on the logs. Groundwater conditions observed during an exploration represent a short-term condition and may or may not be representative of the long-term groundwater conditions at the site.

Laboratory Testing

Soil samples obtained from the explorations were transported to our laboratory and examined to confirm or modify field classifications, as well as to evaluate index properties of the soil samples. Representative samples were selected for laboratory testing consisting of the determination of the moisture content, percent fines, sieve analysis and Atterberg limits. The tests were performed in general accordance with test methods of ASTM International (ASTM) or other applicable procedures.

Moisture Content

Moisture content tests of selected samples were completed in general accordance with ASTM D 2216. The results of these tests are presented on the exploration logs in Appendix A at the depths at which the samples were obtained.

Percent Passing U.S. No 200 Sieve

Selected samples were "washed" through the U.S. No. 200 mesh sieve to determine the relative percentages of coarse- and fine-grained particles in the soil. The percent passing values represent the percentage by weight of the sample finer than the U.S. No. 200 sieve. These tests were conducted to verify field descriptions and to determine the fines content for analysis purposes. The tests were conducted in general accordance with ASTM D 1140, and the results are shown on the exploration logs in Appendix A at the representative sample depths.

Sieve Analyses

Sieve analyses were performed on selected samples in general accordance with ASTM D 422 to determine the sample grain size distribution. The wet sieve analysis method was used to determine the percentage of soil greater than the U.S. No. 200 mesh sieve. The results of the sieve analyses were plotted, classified in general accordance with the Unified Soil Classification System (USCS), and are presented in Figure A-7.

Atterberg Limits

Atterberg limit tests were completed for two soil samples. The tests were used to classify the soil as well as to aid in evaluating index properties and consolidation characteristics of the fine-grained soil deposits. The liquid limit and the plastic limit were obtained in general accordance with ASTM D 4318. The results of the Atterberg limits are summarized in Figure A-8.

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
MORE THAN 50% RETAINED ON NO. 200 SIEVE	SAND AND SANDY SOILS	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS
				SP	POORLY-GRADED SANDS, GRAVELLY SAND
	MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS, ROCK FLOUR, CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MORE THAN 50% PASSING NO. 200 SIEVE	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS AND SILTS OF MEDIUM TO HIGH PLASTICITY
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: Multiple symbols are used to indicate borderline or dual soil classifications

Sampler Symbol Descriptions

- 2.4-inch I.D. split barrel
- Standard Penetration Test (SPT)
- Shelby tube
- Piston
- Direct-Push
- Bulk or grab
- Continuous Coring

Blowcount is recorded for driven samplers as the number of blows required to advance sampler 12 inches (or distance noted). See exploration log for hammer weight and drop.

"P" indicates sampler pushed using the weight of the drill rig.

"WOH" indicates sampler pushed using the weight of the hammer.

ADDITIONAL MATERIAL SYMBOLS

SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
	AC	Asphalt Concrete
	CC	Cement Concrete
	CR	Crushed Rock/ Quarry Spalls
	SOD	Sod/Forest Duff
	TS	Topsoil

Groundwater Contact

Measured groundwater level in exploration, well, or piezometer

Measured free product in well or piezometer

Graphic Log Contact

Distinct contact between soil strata

Approximate contact between soil strata

Material Description Contact

Contact between geologic units

Contact between soil of the same geologic unit

Laboratory / Field Tests

%F	Percent fines
%G	Percent gravel
AL	Atterberg limits
CA	Chemical analysis
CP	Laboratory compaction test
CS	Consolidation test
DD	Dry density
DS	Direct shear
HA	Hydrometer analysis
MC	Moisture content
MD	Moisture content and dry density
Mohs	Mohs hardness scale
OC	Organic content
PM	Permeability or hydraulic conductivity
PI	Plasticity index
PP	Pocket penetrometer
SA	Sieve analysis
TX	Triaxial compression
UC	Unconfined compression
VS	Vane shear

Sheen Classification

NS	No Visible Sheen
SS	Slight Sheen
MS	Moderate Sheen
HS	Heavy Sheen

NOTE: The reader must refer to the discussion in the report text and the logs of explorations for a proper understanding of subsurface conditions. Descriptions on the logs apply only at the specific exploration locations and at the time the explorations were made; they are not warranted to be representative of subsurface conditions at other locations or times.

Key to Exploration Logs

GeoEngineers

Figure A-1

Rev 06/2017

Drilled	Start 5/16/2018	End 5/16/2018	Total Depth (ft) 26.5	Logged By BWS / Checked By MWR	Driller Boretec1, Inc.	Drilling Method Hollow-stem Auger

Surface Elevation (ft) 12 / Vertical Datum NAVD88	Hammer Data: Rope & Cathead, 140 (lbs) / 30 (in) Drop	Drilling Equipment: EC 95 Track
Easting (X) 1247564 / Northing (Y) 570861	System Datum: WA State Plane North, NAD83 (feet)	See "Remarks" section for groundwater observed

Notes:

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0						ML	Gray-brown silt with sand and rootlets (soft, moist) (fill)			
10											
		X	3	3		1 / MC			33		
	5	X	15	3		2	MH	Brown silt with occasional sand and organic matter (soft, moist)			
5											
		X	15	5		3 / MC		Becomes medium stiff; Grades to gray	71		
							CL	Gray-brown clay with occasional sand and organics (very soft to soft, wet) (alluvium)			Groundwater observed at approximately 9 feet at time of drilling
	10	X	18	2		4 / %F			34	76	
0											
							MH	Gray-brown silt with occasional sand and organic matter (very soft to soft, wet)			
	15	X	18	2		5 / MC			51		
-5											
	20	X	18	3		6 / MC			72		
-10											
							SP	Gray fine to medium sand (medium dense, wet)			
	25	X	18	21		7					

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on USGS Topo. Vertical approximated based on USGS Topo.

Log of Boring B-1

GEOENGINEERS

Project: Samish River Floodgates
Project Location: Bow, Washington
Project Number: 0220-097-00

Drilled	Start 5/16/2018	End 5/16/2018	Total Depth (ft)	21.5	Logged By BWS / Checked By MWR	Driller	Boretec1, Inc.	Drilling Method	Hollow-stem Auger

Surface Elevation (ft) / Vertical Datum	11 / NAVD88	Hammer Data	Rope & Cathead / 140 (lbs) / 30 (in) Drop	Drilling Equipment	EC 95 Track
Easting (X) / Northing (Y)	1246512 / 571504	System Datum	WA State Plane North / NAD83 (feet)	See "Remarks" section for groundwater observed	

Notes:

Elevation (feet)	Depth (feet)	FIELD DATA: Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
10	0							MH	Brown silt with occasional sand and organic matter (rootlets) (soft, moist) (fill)			
			12	4		1 / MC				48		
5	5		18	2		2 / MC				71		
			18	3		3 / AL			With occasional gravel	69		AL (LL = 71, PI = 28)
0	10		15	8		4 / %F		SM	Gray-brown silty fine to medium sand (loose, wet) (alluvial)	80	45	Groundwater observed at approximately 10 feet at time of drilling
								SP	Gray fine to medium sand (very loose, wet)			
-5	15		18	2		5						
								CL	Gray-brown clay with occasional sand (soft, wet)			
-10	20		15	4		6						

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on USGS Topo. Vertical approximated based on USGS Topo.

Date:8/1/18 Path:P:\0\0220097\GINT\022009700.GPJ DBLibrary/Library:GEOENGINEERS_DF_STD_US_JUNE_2017.GLB/GEI8_GEOTECH_STANDARD_%F_NO_GW

Log of Boring B-2

GEOENGINEERS

Project: Samish River Floodgates
Project Location: Bow, Washington
Project Number: 0220-097-00

Figure A-3
Sheet 1 of 1

Drilled	Start 5/16/2018	End 5/16/2018	Total Depth (ft)	26.5	Logged By BWS / Checked By MWR	Driller Boretec1, Inc.	Drilling Method Hollow-stem Auger

Surface Elevation (ft) / Vertical Datum	11 / NAVD88	Hammer Data	Rope & Cathead 140 (lbs) / 30 (in) Drop
Easting (X) / Northing (Y)	1246655 / 571391	System Datum	WA State Plane North NAD83 (feet)
Drilling Equipment	EC 95 Track		See "Remarks" section for groundwater observed

Notes:

Elevation (feet)	Depth (feet)	FIELD DATA: Interval / Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
10	0						MH	Brown silt with occasional sand and organic matter (fibers) (medium stiff, moist) (fill)			
		9	5		1 / MC				48		
5	5	18	3		2 / MC				90		
		18	2		3						
0	10	15	11		4 / SA		SM	Gray silty fine to medium sand with trace fibers (medium dense, wet) (alluvium)	30	23	Groundwater observed at approximately 9½ feet at time of drilling
							SP	Gray fine to coarse sand (loose, wet)			
-5	15	18	3		5A						
					5B / MC		CL	Gray clay with occasional sand and organic matter (wood fibers) (soft, wet)	39		
-10	20	18	3		6		SP	Gray fine to coarse sand (very loose, wet)			
							ML	Gray sandy silt (soft, wet)			
							SP	Gray fine to coarse sand with occasional gravel (medium dense, wet)			
-15	25	18	12		7						

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on USGS Topo. Vertical approximated based on USGS Topo.

Log of Boring B-3

GEOENGINEERS

Project: Samish River Floodgates
Project Location: Bow, Washington
Project Number: 0220-097-00

Figure A-4
Sheet 1 of 1

Drilled	Start 5/16/2018	End 5/16/2018	Total Depth (ft) 26.5	Logged By BWS / Checked By MWR	Driller Boretec1, Inc.	Drilling Method Hollow-stem Auger

Surface Elevation (ft) 7 / Vertical Datum NAVD88	Hammer Data: Rope & Cathead 140 (lbs) / 30 (in) Drop	Drilling Equipment: EC 95 Track
Easting (X) 1240249 / Northing (Y) 573170	System Datum: WA State Plane North NAD83 (feet)	See "Remarks" section for groundwater observed

Notes:

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0							MH	Gray-brown silt with occasional sand and organic matter (rootlets, wood fibers) (stiff, moist) (fill)			
5		X	18	10		1 / MC				38		
	5	X	18	4		2 / MC			Becomes soft to medium stiff	47		
0		X	18	3		3 / MC		MH	Gray-brown silt with organic matter (fibers) (soft, moist) (alluvium)	66		
	10	X	18	2		4 / MC				50		
-5								SP	Gray fine to medium sand with trace silt (medium dense, wet)			Groundwater observed at approximately 13½ feet at time of drilling
	15	X	15	12		5						
-10												
	20	X	18	13		6						
-15												
	25	X	18	12		7						

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on USGS Topo. Vertical approximated based on USGS Topo.

Log of Boring B-4

GEOENGINEERS

Project: Samish River Floodgates
Project Location: Bow, Washington
Project Number: 0220-097-00

Drilled	Start 5/15/2018	End 5/15/2018	Total Depth (ft) 26.5	Logged By MWR / Checked By MWR	Driller Boretec1, Inc.	Drilling Method Hollow-stem Auger

Surface Elevation (ft) 12 / Vertical Datum NAVD88	Hammer Data: Rope & Cathead 140 (lbs) / 30 (in) Drop	Drilling Equipment: EC 95 Track
Easting (X) 1250227 / Northing (Y) 562668	System Datum: WA State Plane North NAD83 (feet)	See "Remarks" section for groundwater observed

Notes:

Elevation (feet)	Depth (feet)	Recovered (in)	Blows/foot	Sample Name / Testing	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0			1	ML	Brown silt with rootlets (medium stiff, moist) (fill)			
10		12	6	2	ML	Gray-brown with iron staining sandy silt with trace rootlets (medium stiff, moist)			
	5	15	4	3 / MC			28		
5		18	9	4A / MC	MH	Gray-brown with iron staining sandy silt with organics (organic matter, wood fragments) (medium stiff, moist)	48		
					SM	Brown silty fine sand (loose, moist) (alluvium)			
	10	12	8	5 / SA		Grades to gray-brown, becomes wet	31	21	Groundwater observed at approximately 10 feet at time of drilling
0					SP-SM	Gray fine to medium sand with silt (loose, wet)			
	15	18	6	6					
-5					SP	Gray fine to medium sand with trace organic matter (wood fragments) (loose, wet)			
	20	18	6	7					
-10									
	25	18	6	8					

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on USGS Topo. Vertical approximated based on USGS Topo.

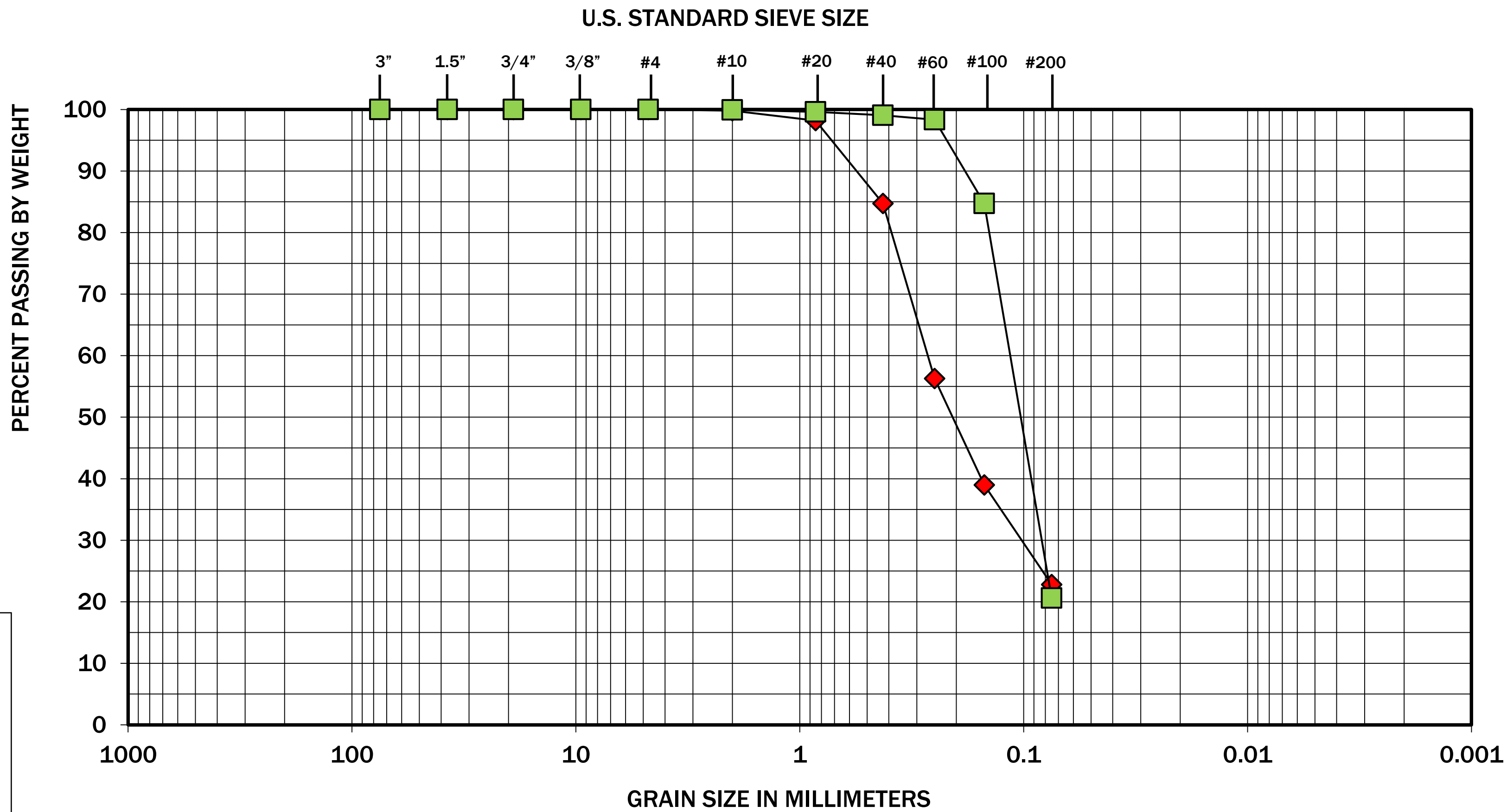
Date:8/1/18 Path:P:\0\0220097\GINT\022009700.GPJ DBLibrary/Library:GEOENGINEERS_DF_STD_US_JUNE_2017.GLB/GEI8_GEOTECH_STANDARD_%F_NO_GW

Log of Boring B-5

GEOENGINEERS

Project: Samish River Floodgates
Project Location: Bow, Washington
Project Number: 0220-097-00

Figure A-6
Sheet 1 of 1



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Symbol	Boring Number	Depth (feet)	Moisture (%)	Soil Description
◆ (red diamond)	B-3	10	30	Silty sand (SM)
■ (green square)	B-5	10	31	Silty sand (SM)

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The grain size analysis results were obtained in general accordance with ASTM D 6913.

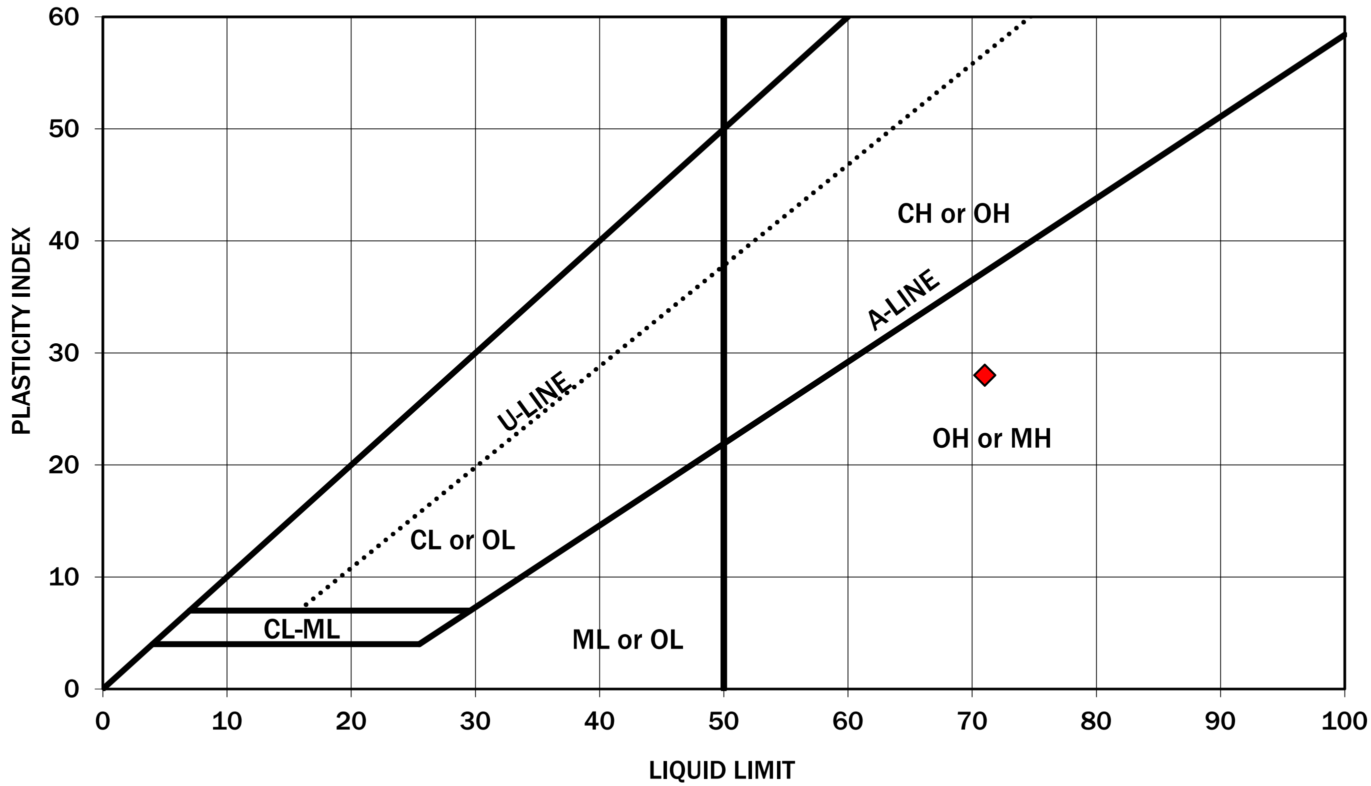
GeoEngineers

Samish River Floodgates
Bow, Washington

Sieve Analysis Results

Figure A-7

PLASTICITY CHART



Symbol	Boring Number	Depth (feet)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Soil Description
◆	B-2	7.5	69	71	28	Silt with occasional sand (MH)

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The liquid limit and plasticity index were obtained in general accordance with ASTM D 4318.

Atterberg Limits Test Results

Samish River Floodgates
Bow, Washington

GEOENGINEERS

Figure A-8

0220-097-00 Date Exported: 08/01/18

Appendix B
Report Limitations and Guidelines for Use

APPENDIX B
REPORT LIMITATIONS AND GUIDELINES FOR USE

This appendix provides information to help you manage your risks with respect to the use of this report.

Read These Provisions Closely

It is important to recognize that the geoscience practices (geotechnical engineering, geology and environmental science) rely on professional judgment and opinion to a greater extent than other engineering and natural science disciplines, where more precise and/or readily observable data may exist. To help clients better understand how this difference pertains to our services, GeoEngineers includes the following explanatory "limitations" provisions in its reports. Please confer with GeoEngineers if you need to know more how these "Report Limitations and Guidelines for Use" apply to your project or site.

Geotechnical Services Are Performed for Specific Purposes, Persons and Projects

This report has been prepared for Northwest Hydraulic Consultants and Skagit County Public Works for the project specifically identified in the report. The information contained herein is not applicable to other sites or projects.

GeoEngineers structures its services to meet the specific needs of its clients. No party other than the party to whom this report is addressed may rely on the product of our services unless we agree to such reliance in advance and in writing. Within the limitations of the agreed scope of services for the Project, and its schedule and budget, our services have been executed in accordance with our Agreement with Northwest Hydraulic Consultants dated April 25, 2018 and authorized April 26, 2018 and generally accepted geotechnical practices in this area at the time this report was prepared. We do not authorize, and will not be responsible for, the use of this report for any purposes or projects other than those identified in the report.

A Geotechnical Engineering or Geologic Report is Based on a Unique Set of Project-Specific Factors

This report has been prepared for the proposed Samish Floodgates project in Skagit County, Washington. GeoEngineers considered a number of unique, project-specific factors when establishing the scope of services for this project and report. Unless GeoEngineers specifically indicates otherwise, it is important not to rely on this report if it was:

- Not prepared for you,
- Not prepared for your project,
- Not prepared for the specific site explored, or
- Completed before important project changes were made.

For example, changes that can affect the applicability of this report include those that affect:

- The function of the proposed structure;
- Elevation, configuration, location, orientation or weight of the proposed structure;
- Composition of the design team; or
- Project ownership.

If changes occur after the date of this report, GeoEngineers cannot be responsible for any consequences of such changes in relation to this report unless we have been given the opportunity to review our interpretations and recommendations. Based on that review, we can provide written modifications or confirmation, as appropriate.

Subsurface Conditions Can Change

This geotechnical or geologic report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by man-made events such as construction on or adjacent to the site, new information or technology that becomes available subsequent to the report date, or by natural events such as floods, earthquakes, slope instability or groundwater fluctuations. If more than a few months have passed since issuance of our report or work product, or if any of the described events may have occurred, please contact GeoEngineers before applying this report for its intended purpose so that we may evaluate whether changed conditions affect the continued reliability or applicability of our conclusions and recommendations.

Geotechnical and Geologic Findings Are Professional Opinions

Our interpretations of subsurface conditions are based on field observations from widely spaced sampling locations at the site. Site exploration identifies the specific subsurface conditions only at those points where subsurface tests are conducted or samples are taken. GeoEngineers reviewed field and laboratory data and then applied its professional judgment to render an informed opinion about subsurface conditions at other locations. Actual subsurface conditions may differ, sometimes significantly, from the opinions presented in this report. Our report, conclusions and interpretations are not a warranty of the actual subsurface conditions.

Geotechnical Engineering Report Recommendations Are Not Final

The recommendations included in this report are preliminary and should not be considered final. GeoEngineers' recommendations can be finalized only by observing actual subsurface conditions revealed during construction. GeoEngineers cannot assume responsibility or liability for the recommendations in this report if we do not perform construction observation.

We recommend that you allow sufficient monitoring, testing and consultation during construction by GeoEngineers to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes if the conditions revealed during the work differ from those anticipated, and to evaluate whether earthwork activities are completed in accordance with our recommendations. Retaining GeoEngineers for construction observation for this project is the most effective means of managing the risks associated with unanticipated conditions.

A Geotechnical Engineering or Geologic Report Could Be Subject to Misinterpretation

Misinterpretation of this report by members of the design team or by contractors can result in costly problems. GeoEngineers can help reduce the risks of misinterpretation by conferring with appropriate members of the design team after submitting the report, reviewing pertinent elements of the design team's plans and specifications, participating in pre-bid and preconstruction conferences, and providing construction observation.

Do Not Redraw the Exploration Logs

Geotechnical engineers and geologists prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. The logs included in a geotechnical engineering or geologic report should never be redrawn for inclusion in architectural or other design drawings. Photographic or electronic reproduction is acceptable, but separating logs from the report can create a risk of misinterpretation.

Give Contractors a Complete Report and Guidance

To help reduce the risk of problems associated with unanticipated subsurface conditions, GeoEngineers recommends giving contractors the complete geotechnical engineering or geologic report, including these "Report Limitations and Guidelines for Use." When providing the report, you should preface it with a clearly written letter of transmittal that:

- Advises contractors that the report was not prepared for purposes of bid development and that its accuracy is limited; and
- Encourages contractors to confer with GeoEngineers and/or to conduct additional study to obtain the specific types of information they need or prefer.

Contractors Are Responsible for Site Safety on Their Own Construction Projects

Our geotechnical recommendations are not intended to direct the contractor's procedures, methods, schedule or management of the work site. The contractor is solely responsible for job site safety and for managing construction operations to minimize risks to on-site personnel and adjacent properties.

Biological Pollutants

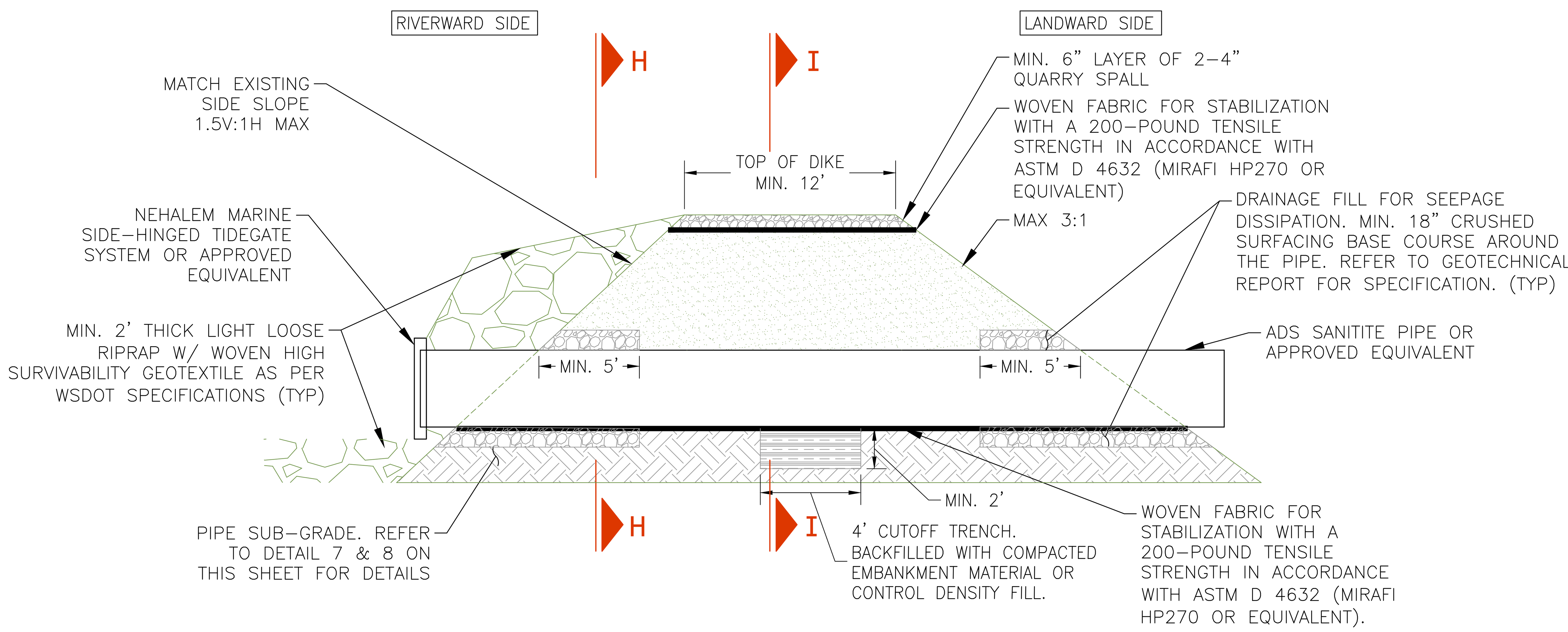
GeoEngineers' Scope of Work specifically excludes the investigation, detection, prevention or assessment of the presence of Biological Pollutants. Accordingly, this report does not include any interpretations, recommendations, findings or conclusions regarding the detecting, assessing, preventing or abating of Biological Pollutants, and no conclusions or inferences should be drawn regarding Biological Pollutants as they may relate to this project. The term "Biological Pollutants" includes, but is not limited to, molds, fungi, spores, bacteria and viruses, and/or any of their byproducts.

A Client that desires these specialized services is advised to obtain them from a consultant who offers services in this specialized field.

ATTACHMENT D

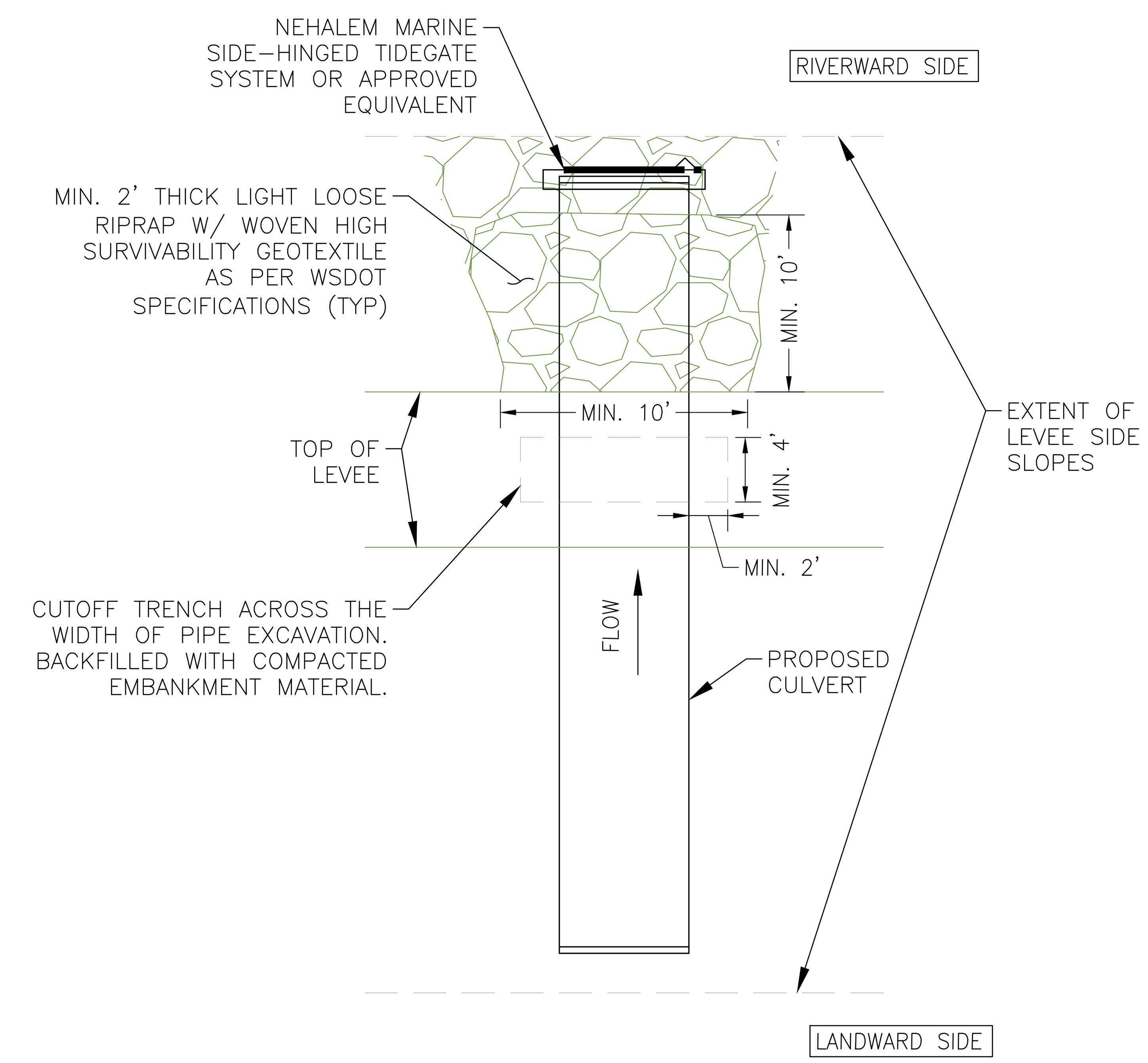
Project Drawings

(60% detail sheet, see ATTACHMENT F for JARPA drawings as attachment to BE report)



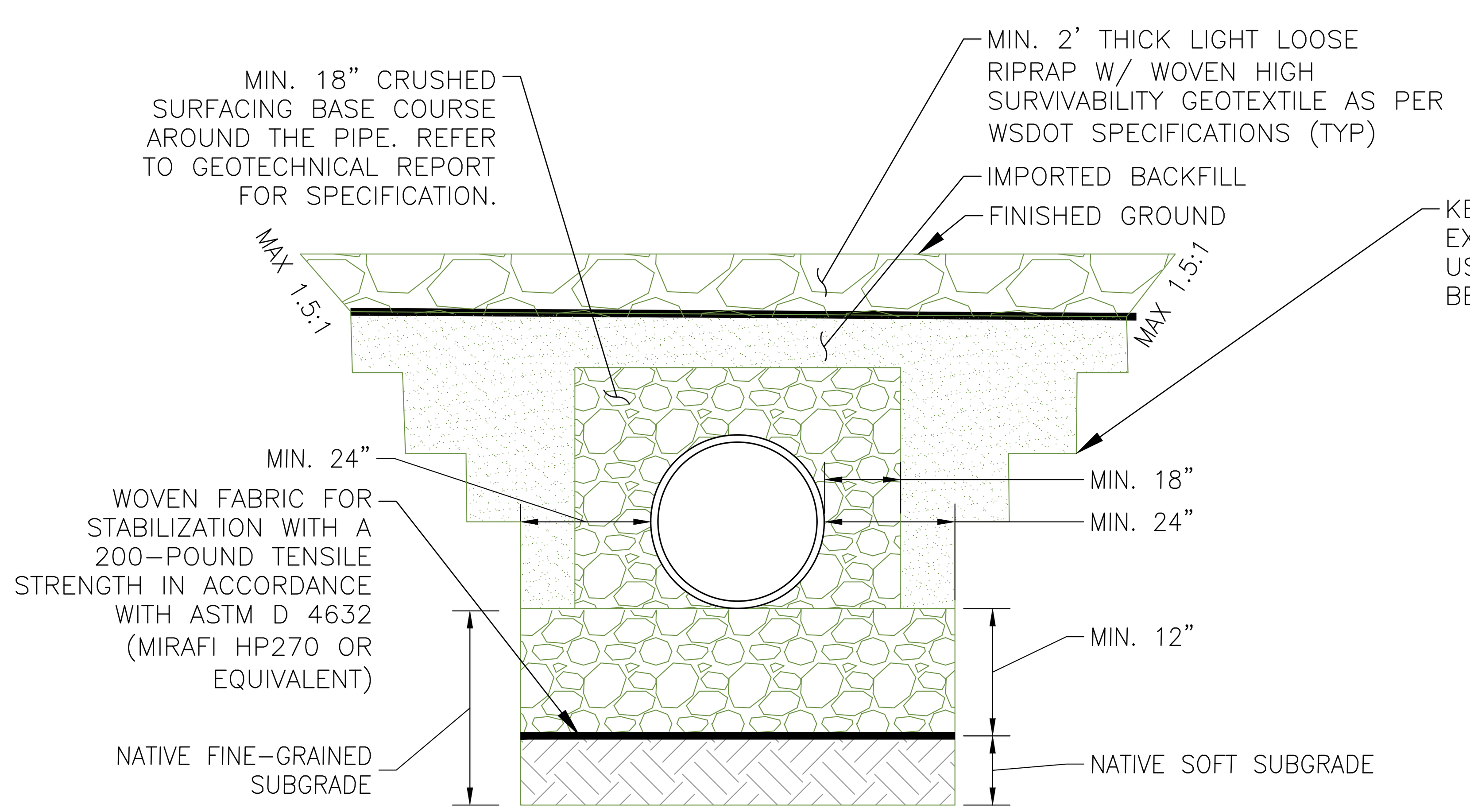
6 TYPICAL FLOOD/DRAINAGE CULVERT & DIKE SECTION

NOT TO SCALE



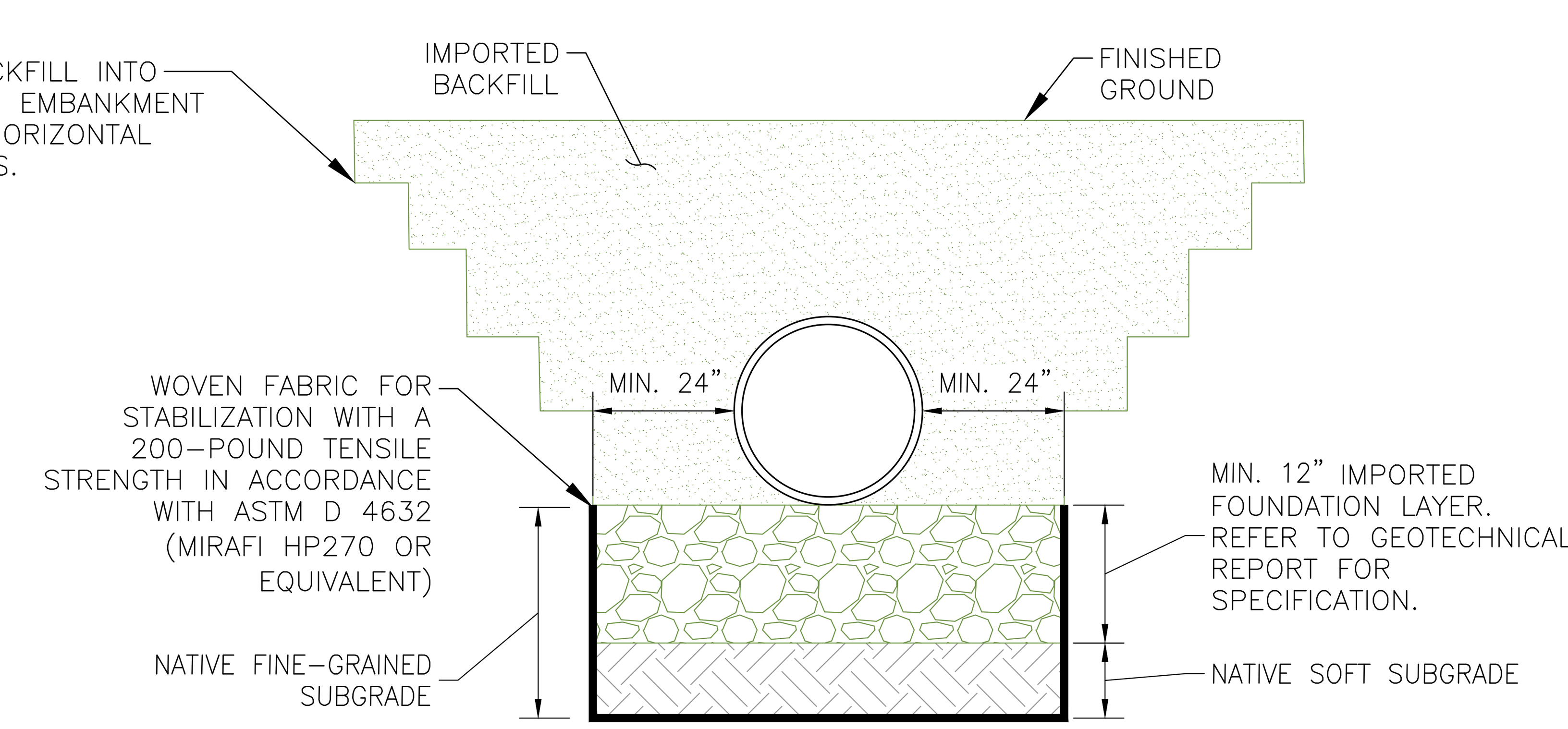
9 TYPICAL NEW FLOOD/DRAINAGE CULVERT PLAN VIEW

NOT TO SCALE



7 TYPICAL CULVERT TRENCH BACKFILL (SECTION H-H)

NOT TO SCALE



8 TYPICAL CULVERT TRENCH BACKFILL (SECTION I-I)

NOT TO SCALE

NOTES:

1. IMPORTED BACKFILL FOR PIPE BEDDING AND EMBANKMENT BACKFILL TO HAVE THE FOLLOWING CHARACTERISTICS:
   (1) MIN 30% SILT AND CLAY
   (2) MAX 60% SILT
   (3) MAX 60% SAND
   (4) NOMINAL GRAVEL AND COBBLE CONTENT
2. PIPE FOUNDATION SUPPORT MATERIAL TO BE CRUSHED SURFACING BASE COURSE PER WSDOT STANDARD SPECIFICATION 9–03.9(3).
3. DRAINAGE FILL FOR SEEPAGE DISSIPATION TO BE CRUSHED SURFACING BASE COURSE (WSDOT STANDARD SPECIFICATION 9–03.9(3).
4. REFER TO GEOENGINEER INC'S GEOTECHNICAL REPORT DATED AUGUST 1, 2018, revised January 2023 FOR DETAILED CONSTRUCTION AND MATERIAL SPECIFICATIONS AND REQUIREMENTS.

PRELIMINARY

DATUM
NAVD 88

CALL TWO (2) BUSINESS DAYS BEFORE YOU DIG
1–800–424–5555

nhc
northwest hydraulic consultants
215 west holly street, suite h–21
bellingham, washington 98225
phone: (206) 241–6000
www.nhcweb.com

SKAGIT COUNTY PUBLIC WORKS
1800 CONTINENTAL PLACE
MOUNT VERNON, WA 98273-5625
(360) 336-9400 FAX (360) 336 9478

NO.	REVISIONS	DATE
4	60% SUBMISSION	01/05/23
3	60% SUBMISSION	06/28/19
2	60% SUBMISSION	09/28/18
1	30% SUBMISSION	08/28/18

DESIGN ENGINEER

ENGINEER OF RECORD

PROJECT NO.: 2002084
FED. AID NO.: HPP-2029(040)
DESIGNED BY: ARW
DRAWN BY: ARW
CHECKED BY: VDC
APPROVED BY: VDC
PROJECT LOCATED NEAR: EDISON, WA
####

SKAGIT RIVER BRIDGE MODIFICATION AND INTERSTATE HIGHWAY PROTECTION PROJECT

DETAILS

1 INCH SCALE BAR
ADJUST SCALE ACCORDINGLY

SHEET 15 OF 15

ATTACHMENT E

Wetland Delineation Report

Wetland and Stream Delineation Report

Samish River Floodgates Project
Skagit County, Washington

for
Northwest Hydraulic Consultants, Inc.

December 30, 2022

GeoEngineers
Earth Science + Technology

Wetland and Stream Delineation Report

Samish River Floodgates Project
Skagit County, Washington

for
Northwest Hydraulic Consultants, Inc.

December 30, 2022

GeoEngineers

1101 South Fawcett Avenue, Suite 200
Tacoma, Washington 98402
253.383.4940

Wetland and Stream Delineation Report

Samish River Floodgates Project
Skagit County, Washington

File No. 0220-097-00

December 30, 2022

Prepared for:

Northwest Hydraulic Consultants, Inc.
12787 Gateway Drive S
Seattle, Washington 98168

Attention: Derek Stuart, PE

Prepared by:

GeoEngineers, Inc.
1101 S. Fawcett Avenue, Suite 200
Tacoma, Washington 98402
253.383.4940

for Adam L. Wright, WPIT
Biologist

Joseph Callaghan, MS, PWS
Associate Biologist

ALW:GWM:JOC:cam:leh

GeoEngineers

Table of Contents

LIST OF FIGURES

APPENDICES

1.0 INTRODUCTION

GeoEngineers, Inc. (GeoEngineers) was contracted by National Hydraulic Consultants, Inc. (NHC) to perform wetland and stream delineations to support the Samish River and Samish Bay Floodgate Structures Project (project) in Skagit County, Washington. Skagit County Public Works (SCPW) is planning to add new floodgate structures at four sites, two in the Samish Bay and two along the left bank of the Samish River. As currently planned, the floodgate structures will consist of 4-foot-diameter corrugated metal pipes (CMPs) with seepage collars. The floodgates will be designed to allow basin floodwaters to drain to the Samish River or Samish Bay and prevent the back-flow from these water bodies during high tides. This report has been written in accordance with Skagit County Code (SCC), Chapter 14.24 (Critical Areas Ordinance).

2.0 PROJECT LOCATION AND DESCRIPTION

Four sites were included as part of this investigation:

- Samish Sports Club, located at the end of a spur road off Samish Island Road (Section 31, Township 36N, Range 3E)
- Bayview Edison North, located near the Samish River Delta (Section 5, Township 35N, Range 3E)
- Bayview Edison South, located adjacent to the Samish River just above its confluence with the Bay (Section 5, Township 35N, Range 3E)
- Farm to Market Road, located about 1.5 miles upstream of Bayview Edison Road (Section 9, Township 35N, Range 3E)

Figure 1 (Vicinity Map) shows the location of each site. The area is in Water Resources Inventory Area (WRIA) 11 (Lower Skagit/Samish), Hydraulic Unit Code (HUC) 17110002 (Strait of Georgia).

Land use surrounding the sites features predominantly agricultural production and sparse single-family residences. An existing levee and floodgate system is located at each site proposed for upgrades. Site-specific vegetation and habitat conditions will be discussed individually below.

3.0 SITE ASSESSMENTS; WETLAND AND STREAM DELINEATION

3.1. Data Research

The following environmental maps of the project area were collected and reviewed as part of a paper inventory and included in Appendix A:

- United States Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) online mapper (USFWS 2018)
- The United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Web Soil Survey (USDA-NRCS 2018)
- The Washington State Department of Natural Resources (DNR) Forest Practices Application Review System (FPARS) (DNR 2018)

- Washington State Department of Fish and Wildlife (WDFW) Priority Habitat and Species (PHS) mapping application (WDFW 2018)

The dominant soil type is Skagit Silt Loam, mapped at the three northern locations. Farm to Market road is mapped Sucas Silt Loam. The environmental databases each show the Samish River and Bay as protected habitats, and FPARS and NWI maps ditches behind the levees as streams and riverine systems, respectively. The only site mapped with wetland features besides these ditches is Bayview-Edison North, which shows emergent wetland fields to the west and a ponded area to the southeast.

PHS maps Townsend's big ear bat (*Corynorhinus townsendii)* populations at the township level near Samish Sports Club. All Puget Sound salmon/trout species could be present within the Samish Bay and River, including Endangered Species Act (ESA)-listed Chinook (*Oncorhynchus tshawytscha)*, steelhead (*Oncorhynchus mykiss)*, and bull trout (*Salvelinus malma)*.

3.2. Field Investigation

Critical areas site visits were conducted on June 7, 2018. Our scope included wetland and ordinary high water mark (OHWM) delineation within the existing levee district easement and "over-the-fence" assessment for offsite features. Recent Light Detection and Ranging (LiDAR) data (3-foot accuracy; http://lidarportal.dnr.wa.gov) combined with observations of vegetation and visible hydrology was used to assist with delineating off-site features. A photographic record was collected during the field visits to document site conditions and included in Appendix B.

The identification of aquatic critical areas (wetlands and streams) was conducted in accordance with guidelines presented in SCC Chapter 14.42 (Critical Areas Ordinance). The wetland delineation followed methods detailed in the U.S. Army Corps of Engineers (USACE) Wetlands Delineation Manual (Environmental Laboratory 1987) and the Western Mountains, Valleys, and Coast Regional Supplement (USACE 2010). Delineated wetlands were rated using the Washington State Wetland Rating System for Western Washington (Hruby 2014). Appendices C and D include sample plot data forms and wetland rating forms, respectively.

The OHWM of streams, the Samish River and marine shorelines was determined by examining breaks in the topography, drift lines, shifts in vegetation and signs of water marks, according to USACE protocol as referenced from Regulatory Guidance Letter (No. 05-05), Ordinary High Water Mark Identification, December 7, 2005 and according to the Washington State Department of Ecology (Ecology) 2016 guidance (Anderson et al. 2016). The Washington Administrative Code (WAC) was also referenced for the definition of OHWM (WAC, 173-22-030 § 11).

GeoEngineers mapped the following features at each site:

- Samish Sports Club: delineated OHWM along/adjacent to the existing floodgates and one wetland (Wetland A) upstream and slightly east of the crossing (Figure 2).
- Bayview Edison-North: delineated OHWM along the Samish Bay channel and OHWM of a ditch along the backside of the levee; documented wetland conditions along the backside of the levee (Wetland B), along the east portion of the channel (Figure 3).
- Bayview Edison-South: delineated OHWM along the Samish River; "over the fence" wetland/OHWM features along the backside of the levee (Figure 4).

- Farm to Market Road: delineated OHWM and wetland (Wetland C) along the Samish River side of the levee. Delineated OHWM at a private residence culvert crossing, about 250 feet south of the levee. “Over the fence” OHWM delineation between the southern culvert crossing and the backside of the levee (Figure 5).

Samish Sports Club

Samish Sports Club is accessed through a locked gate off Samish Island Road. The site is located on a point extending into Samish Bay, just southeast of Samish Island. Several buildings and a floating dock structure exist near the floodgates. Four floodgates were observed, roughly evenly spaced and at a consistent elevation. OHWM was mapped on both sides of the levee, extending at least 50 feet along the shoreline to either side. The marine shoreline is designated Rural Conservancy, with a 150-foot buffer according to SCC 14.24.530 (1)c.

Waterward of the levee is a tidal estuarine wetland dominated by soft rush (*Juncus effusus*). Landward, the main ditch channel, roughly 50 feet wide, flows north towards the floodgates. A single culvert, about 75 feet upstream of the floodgates, connects this channel to a smaller ditch running along the backside of the levee. It was not clear which direction this smaller ditch flows. A flat bench between the smaller ditch and the levee supports hydrophytic vegetation and shows hydric soils. It appears overbank flooding from the ditch, as well as direct precipitation, supply much of the hydrology. This area was delineated (Wetland A) and rated (Category III). The proposed floodgate work will not impact the wetland, nor would it increase or alter the level of land use in the vicinity. Wetland A scored 4 points for habitat, and according to SCC 14.24.23 (1)b, qualifies for a 40-foot buffer. Table 1 below summarizes Wetland A delineation and rating.

Bayview Edison-North

Floodgates at this site are accessed through a private driveway north of Bayview Edison Road. A dock and associated wooden piling wall exist waterward of the levee. A ditch running along the backside of the levee is crossed by a slightly-improved dirt/grass roadway. The waterward side of the levee is armored with riprap and no floodgates were observed. OHWM was delineated along the waterward edge of the levee for over 100 feet on either side of the roadway. The marine shoreline is designated Rural Conservancy, with a 150-foot buffer according to SCC 14.24.530 (1)c. OHWM along banks of the backside ditch were delineated for approximately 50 feet on either side of the access road. Adjacent mowed fields further landward of the levee did not show obvious signs of wetland hydrology or vegetation.

East of the access road, wetland conditions were identified between the backside ditch and the toe of the levee slope. Wetland B was delineated in the area with assistance from topographic LiDAR and rated Category III Riverine wetland according to Ecology’s 2014 method. The proposed floodgate work will not increase or alter the level of land use in the vicinity. Wetland impacts will be minor and mostly temporary during construction. Wetland B scored 5 points for habitat, and according to SCC 14.24.23 (1)b, qualifies for a 75-foot buffer. Table 2 below summarizes results of this effort.

Bayview Edison-South

Four floodgates were observed at this site, located south of the Bayview Edison Road bridge over the Samish River. The levee is armored with mixed riprap and quarry spall sized material, mostly centered near the floodgate structures. A scour line and debris wracking were noted at the toe of the levee slope, which was delineated with a global positioning system (GPS) as the river OHWM. Below this line, mudflat gradually slopes into the wetted perimeter of the river, vegetated by reed canarygrass (*Phalaris arundinacea*), seaside arrowgrass (*Triglochin maritima*), and sedge (*Carex spp.*). This vegetated bench below OHWM extended about 75 feet from the levee right below the bridge, narrowing to south where it extends a mere foot or two at the southern extent of OHWM delineation. The Samish River is a Shoreline of the State (Type-S water), which has a standard buffer width of 200 feet (SCC 14.24.530 (1)c).

A ditch runs along the backside of the levee and below the southern edge of Bayview Edison Road. Vegetation along the backside levee slope consists of upland shrubs such as red elderberry (*Sambucus racemosa*) and weedy vegetation such as Himalayan blackberry (*Rubus armeniacus*) and hemlock (*Conium maculatum*). Hydrophytic vegetation was observed along the edges of the ditch below the levee, with indications of seasonal flooding such as cracked surface depressions and debris wracking. Due to the dense, shrubby vegetation and apparent topographic breaks between levee and ditch channel, LiDAR was used to delineate the backside ditch OHWM, which encompasses areas featuring wetland vegetation.

Farm to Market Road

Wetland and OHWM features were delineated on the Samish River side of the levee. The Samish River is a Shoreline of the State (Type-S water), which has a standard buffer width of 200 feet (SCC 14.24.530 (1)c). A tall bench extends about 10 to 50 feet from the toe of the levee slope to the scour line of the river. This area (Wetland C) is dominated by reed canarygrass, with occasional patches of small-fruited bulrush (*Scirpus microcarpus*), cattail (*Typha latifolia*), and yellow flag iris (*Iris pseudacorus*), particularly in microdepressions. Two of the three floodgates observed had outfalls to this vegetated bench, with some scour noted but disconnected from the main river channel. The third, lower elevation floodgate, did appear to directly connect with the backside ditch OHWM and the Samish River OHWM. This area was delineated (Wetland C) and rated (Category III). The proposed floodgate work will not increase or alter the level of land use in the vicinity, and impacts will be minor and mostly temporary. Wetland C scored 4 points for habitat, and according to SCC 14.24.23 (1)b, qualifies for a 40-foot buffer. Wetland C details are included in Table 3.

OHWM was mapped around a driveway crossing the backside ditch, about 500 feet south. As the ditch approaches the levee it widens from approximately 10 feet to about 30 feet. This ditch feature north of the driveway crossing was approximated onto the map using LiDAR.

TABLE 1. WETLAND A

Wetland A - Information	
Location	Samish Sports Club; bench between levee backslope toe and ditch
WRIA	11 – Lower Skagit/Samish
Local Jurisdiction	Skagit County
Washington State Rating	III (18 points)[1]
Buffer Width	40 feet[2]
Size	~330 square feet
Cowardin Class	Palustrine emergent/scrub-shrub
HGM Class	Riverine

Wetland A is a small shallow depression located between the levee and the ditch running along the backslope.

Description Summary	
Vegetation	**<u>Herbaceous</u>**: Soft rush (*Juncus effusus*), velvet grass (*Holcus lanatus*), red fescue (*Festuca rubra*) **<u>Shrub</u>**: Himalayan blackberry (*Rubus armeniacus*)
Soils	Soils meet the criteria for hydric soils indicator S5 (Sandy redox)
Hydrology	**<u>Indicators</u>**: Geomorphic position, FAC-neutral test **<u>Source</u>**: Groundwater interface with ditch, seasonal overbank flooding
Notes	The ditch adjacent to Wetland A connects to the floodgate crossing channel just southwest via a small culvert.

Western Washington Wetland Rating Functions Summary (Appendix D - 18 points total)	
Water Quality	**<u>7 points:</u>** Vegetation characteristics of the wetland provide potential water quality functions; pollution issues in the surrounding landscape provide opportunity.
Hydrologic	**<u>7 points:</u>** Wetland could trap some floodwater that would otherwise be carried to adjacent fields or development.
Habitat	**<u>4 points:</u>** Limited size, hydroperiods or habitat features. Developed agriculture landscape setting limits terrestrial habitat; boat traffic limits aquatic marine.
Buffer Condition	The wetland is surrounded by relatively flat, predominantly herbaceous-vegetated fields. Some estuarine wetland exists on the waterward side of the levee.

Notes:

1. Wetland rating in accordance with Washington State Wetlands Rating System for Western Washington (Hruby 2014).

2. According to SCC 14.24.230 (b), habitat score <5 and low land use impact. The final buffer width is subject to approval by the jurisdictional authority.

TABLE 2. WETLAND B

Wetland B - Information	
Location	Bayview Edison North; low bench between backside ditch and levee
WRIA	11 – Lower Skagit/Samish
Local Jurisdiction	Skagit County
Washington State Rating	III (18 points)[1]
Buffer Width	75 feet[2]
Size	~ 3,000 square feet
Cowardin Class	Palustrine emergent
HGM Class	Riverine

Wetland B is a flat herbaceous bench between the ditch channel and the levee slope.

Description Summary	
Vegetation	**Herbaceous**: Soft rush (*Juncus effusus*), red fescue (*Festuca rubra*)
Soils	Soils meet the criteria for hydric soils indicator F3 (Depleted Matrix)
Hydrology	**Indicators**: Water at 8 inches and saturated 6 inches below ground surface **Source**: Groundwater interface with adjacent ditch, seasonal overbank flooding
Notes	Wetland B is located where the backslope ditch pulls away from the toe of the levee slope.
Western Washington Wetland Rating Functions Summary (Appendix D - 18 points total)	
Water Quality	**7 points:** Vegetation characteristics of the wetland provide potential water quality functions; pollution issues in the surrounding landscape provide opportunity.
Hydrologic	**6 points:** Wetland could trap some floodwater that would otherwise be carried to adjacent fields or development.
Habitat	**5 points:** Limited size, hydroperiods or habitat features.
Buffer Condition	The wetland is located adjacent to a residential backyard, with boating access and use in the adjacent bay.

Notes:

1. Wetland rating in accordance with Washington State Wetlands Rating System for Western Washington (Hruby 2014).

2. According to SCC 14.24.230 (b), habitat score 5-7 ft and low land use impact. The final buffer width is subject to approval by the jurisdictional authority.

TABLE 2. WETLAND C

Wetland C - Information		
Location	Farm to market road, on bench between levee and Samish River channel	
WRIA	11 – Lower Skagit/Samish	
Local Jurisdiction	Skagit County	
Washington State Rating	III (18 points)[1]	
Buffer Width	40 feet[2]	
Size	~14,000 square feet	
Cowardin Class	Palustrine emergent	
HGM Class	Slope	Wetland C is situated on a flat bench between the levee and the Samish River.

Description Summary	
Vegetation	**<u>Herbaceous</u>**: Reed canarygrass (*Phalaris arundinacea*), small-fruited bulrush (*Scirpus microcarpus*), cattail (*Typha latifolia*)
Soils	Soils meet the criteria for hydric soils indicator F6 (Redox Dark Surface)
Hydrology	**<u>Indicators</u>**: Geomorphic position, FAC-Neutral Test **<u>Source</u>**: Groundwater interface with river, overbank flooding
Notes	Water surface of river about 4 feet below ground surface of wetland (June 2018).

Western Washington Wetland Rating Functions Summary (Appendix D - 18 points total)	
Water Quality	**<u>7 points:</u>** Steep slope limiting function but local and landscape level issues with water quality.
Hydrologic	**<u>7 points:</u>** Steep slope and vegetative conditions limiting flood control potential.
Habitat	**<u>4 points:</u>** Limited size, hydroperiods or habitat interspersion.
Buffer Condition	The wetland is surrounded by agriculture land, fields, and sparse residential development.

Notes:

1. Wetland rating in accordance with Washington State Wetlands Rating System for Western Washington (Hruby 2014).

2. According to SCC 14.24.230 (b), habitat score <5 ft and low land use impact. The final buffer width is subject to approval by the jurisdictional authority.

4.0 SUMMARY

GeoEngineers performed wetland and stream delineation services supporting NHC and SCPW with the Samish River Floodgates Project. Across four sites we delineated three wetlands and marked OHWM along the levee. All wetlands were rated Category III using Ecology's 2014 rating system, Wetlands A and C with four habitat points and Wetland B with five. Skagit County Code allows buffers of 40 feet and 75 feet, respectively, for these wetlands. This assumes a low intensity of proposed adjacent land use. The marine shoreline areas (Samish Sports Club and Bayview-Edison North) are designated Rural Conservancy and require 150 foot buffers. The Samish River is a Shoreline of the State (Type-S water) with a standard riparian buffer width of 200 feet. Impact assessment, and potential mitigation requirements, were not included as part of this study.

5.0 LIMITATIONS

GeoEngineers has prepared this Wetland and Stream Delineation Report in general accordance with the scope and limitations of our proposal. Within the limitations of scope, schedule and budget, our services have been executed in accordance with the generally accepted practices for wetland, and stream delineation in this area at the time this report was prepared. No warranty or other conditions, express or implied, should be understood.

This report has been prepared for the exclusive use of NHC and SCPW, authorized agents and regulatory agencies following the described methods and information available at the time of the work. No other party may rely on the product of our services unless we agree in advance to such reliance in writing. The information contained herein should not be applied for any purpose or project except the one originally contemplated.

The applicant is advised to contact all appropriate regulatory agencies (local, state and federal) prior to design or construction of any development to obtain necessary permits and approvals.

6.0 REFERENCES

Anderson, Paul, S. Meyer, P. Olson and E. Stockdale. 2016. Determining the Ordinary High Water Mark for Shoreline Management Act Compliance in Washington State. Washington State Department of Ecology Publication No. 16-06-029. Available at: https://fortress.wa.gov/ecy/publications/documents/1606029.pdf.

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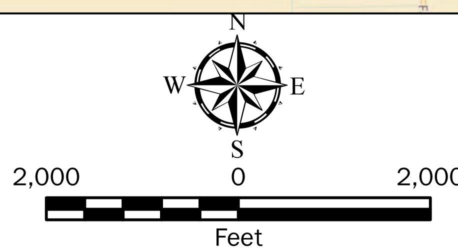
FIGURES



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Mapbox Open Street Map, 2016

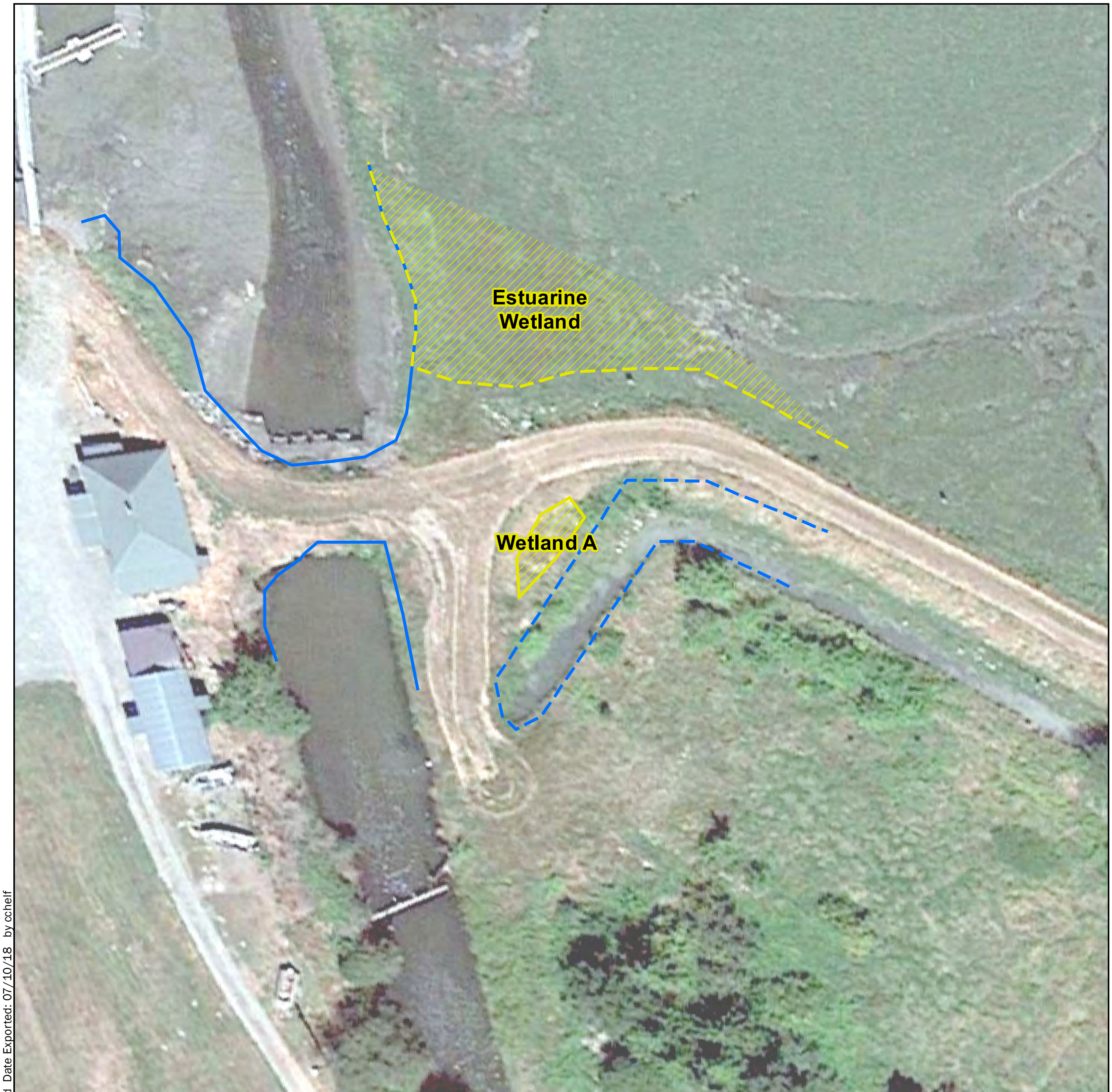
Projection: NAD 1983 UTM Zone 10N

Vicinity Map

Samish River Floodgates
Skagit County, Washington

GEOENGINEERS

Figure 1



Legend

- Delineated Wetland Boundary Based on GPS
- Approximate Wetland Boundary Based on LiDAR
- Wetland
- Delineated OHWM Based on GPS
- Approximate OHWM Based on LiDAR

N
W E
S

50 0 50

Feet

Site Plan
Samish Sports Club

Samish River Floodgates
Skagit County, Washington

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Figure 2

Notes:
1. The locations of all features shown are approximate.
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Data Source: LiDAR downloaded from Puget Sound LiDAR Consortium, Aerial from GoogleEarthPro

Projection: NAD 1983 StatePlane Washington North FIPS 4601 Feet

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Legend

- Delineated Wetland Boundary Based on GPS
- Approximate Wetland Boundary Based on LiDAR
- Wetland
- Delineated OHWM Based on GPS
- Approximate OHWM Based on LiDAR

N
W E
S

50 0 50

Feet

Site Plan
Bayview Edison North

Samish River Floodgates
Skagit County, Washington

GeoEngineers

Figure 3

Notes:
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Data Source: LiDAR downloaded from Puget Sound LiDAR Consortium, Aerial from GoogleEarthPro

Projection: NAD 1983 StatePlane Washington North FIPS 4601 Feet

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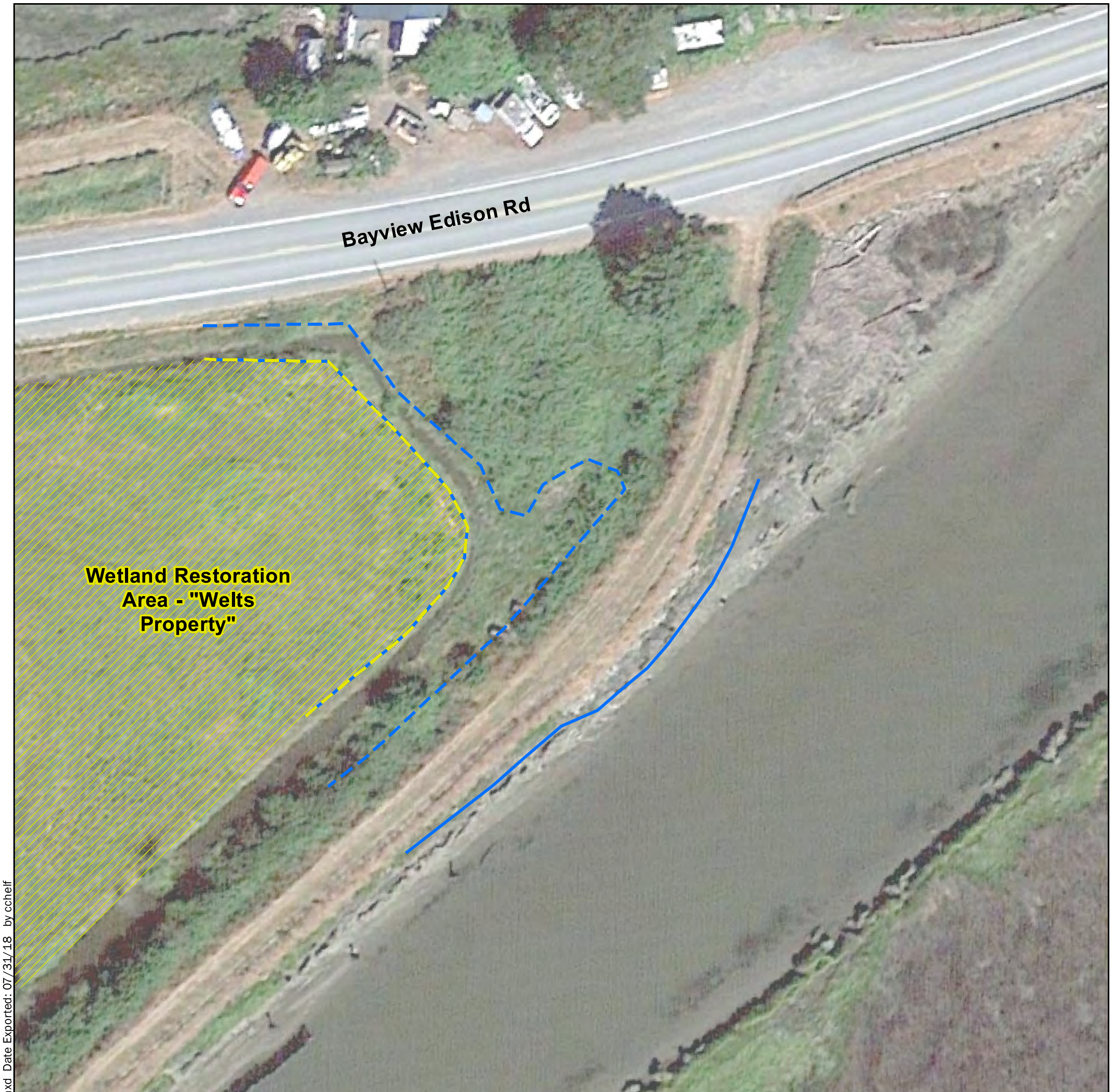

Legend

- Delineated Wetland Boundary Based on GPS
- Approximate Wetland Boundary Based on LiDAR
- Wetland
- Delineated OHWM Based on GPS
- Approximate OHWM Based on LiDAR

N E S W

50 0 50

Feet

Notes:
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Data Source: LiDAR downloaded from Puget Sound LiDAR Consortium, Aerial from GoogleEarthPro

Projection: NAD 1983 StatePlane Washington North FIPS 4601 Feet

Site Plan
Bayview Edison South

Samish River Floodgates
Skagit County, Washington

GEOENGINEERS

Figure 4

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Legend

- Delineated Wetland Boundary Based on GPS
- Approximate Wetland Boundary Based on LiDAR
- Wetland
- Delineated OHWM Based on GPS
- Approximate OHWM Based on LiDAR

N
W E
S

70 0 70

Feet

Site Plan
Farm to Market Road

Samish River Floodgates
Skagit County, Washington

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Figure 5

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: LiDAR downloaded from Puget Sound LiDAR Consortium, Aerial from GoogleEarthPro

Projection: NAD 1983 StatePlane Washington North FIPS 4601 Feet

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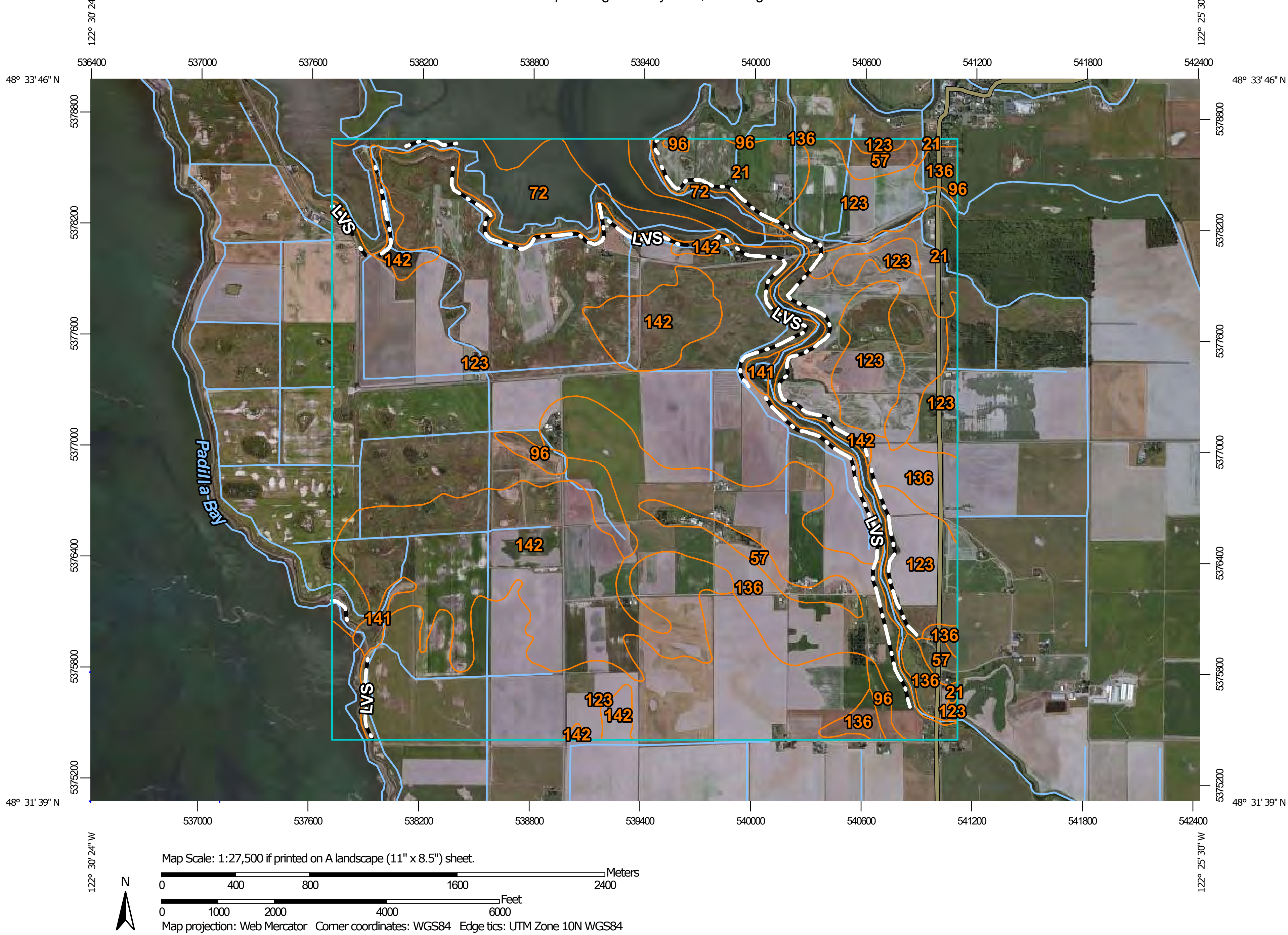
APPENDICES

APPENDIX A
Data Review Maps

Soil Map—Skagit County Area, Washington



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Skagit County Area, Washington
Survey Area Data: Version 17, Mar 29, 2018

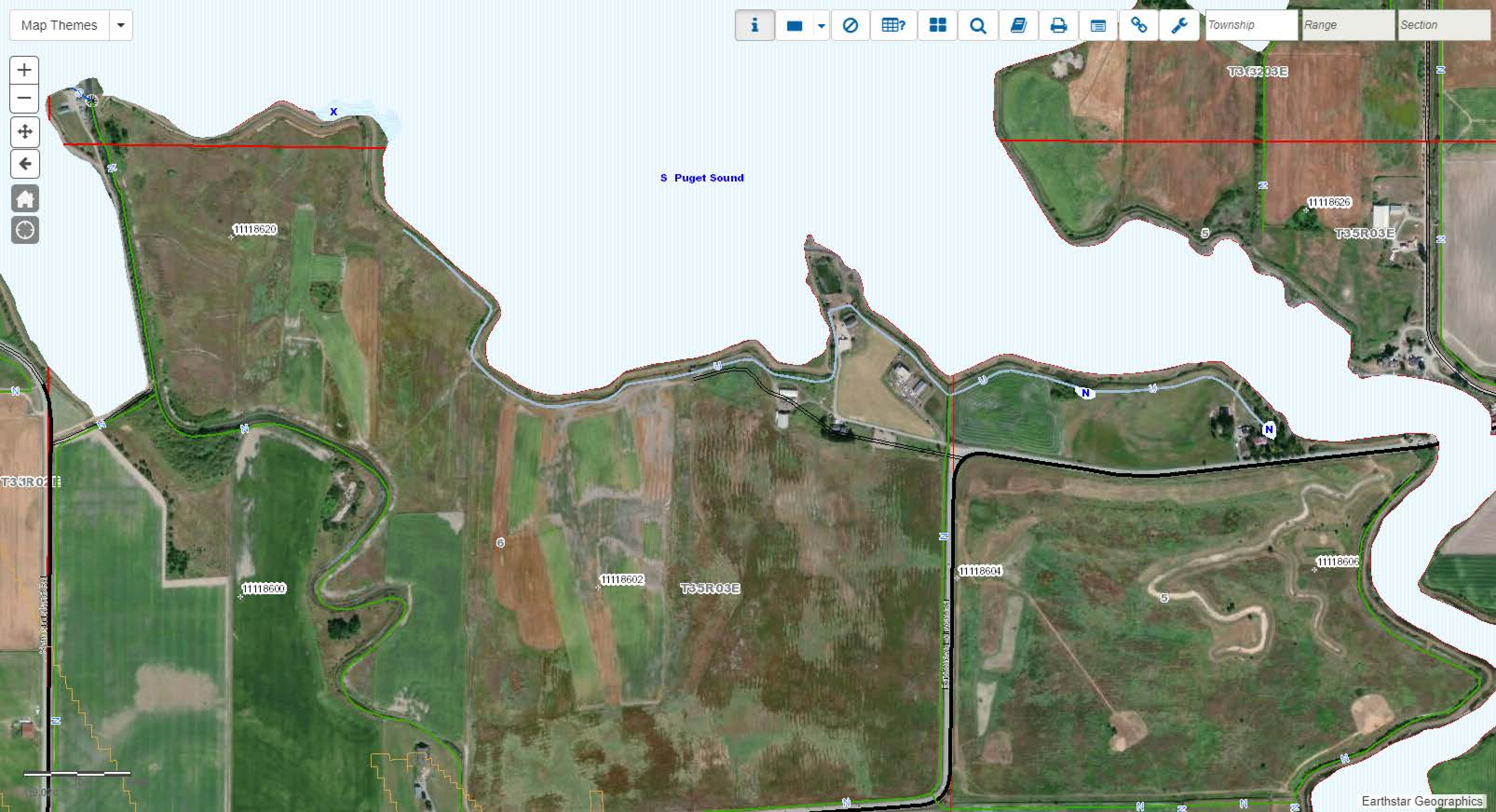
Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 9, 2010—Aug 28, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
21	Briscot fine sandy loam	106.8	3.9%
57	Field silt loam, protected	54.3	2.0%
72	Hydraquents, tidal	150.6	5.5%
96	Mt. Vernon very fine sandy loam	21.4	0.8%
123	Skagit silt loam	1,416.1	51.8%
136	Sumas silt loam	342.7	12.5%
141	Tacoma silt loam	15.4	0.6%
142	Tacoma silt loam, drained	521.5	19.1%
Totals for Area of Interest		**2,734.9**	**100.0%**


Map Themes
Township
Range
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S Puget Sound
11118620
11118626
T35R03E
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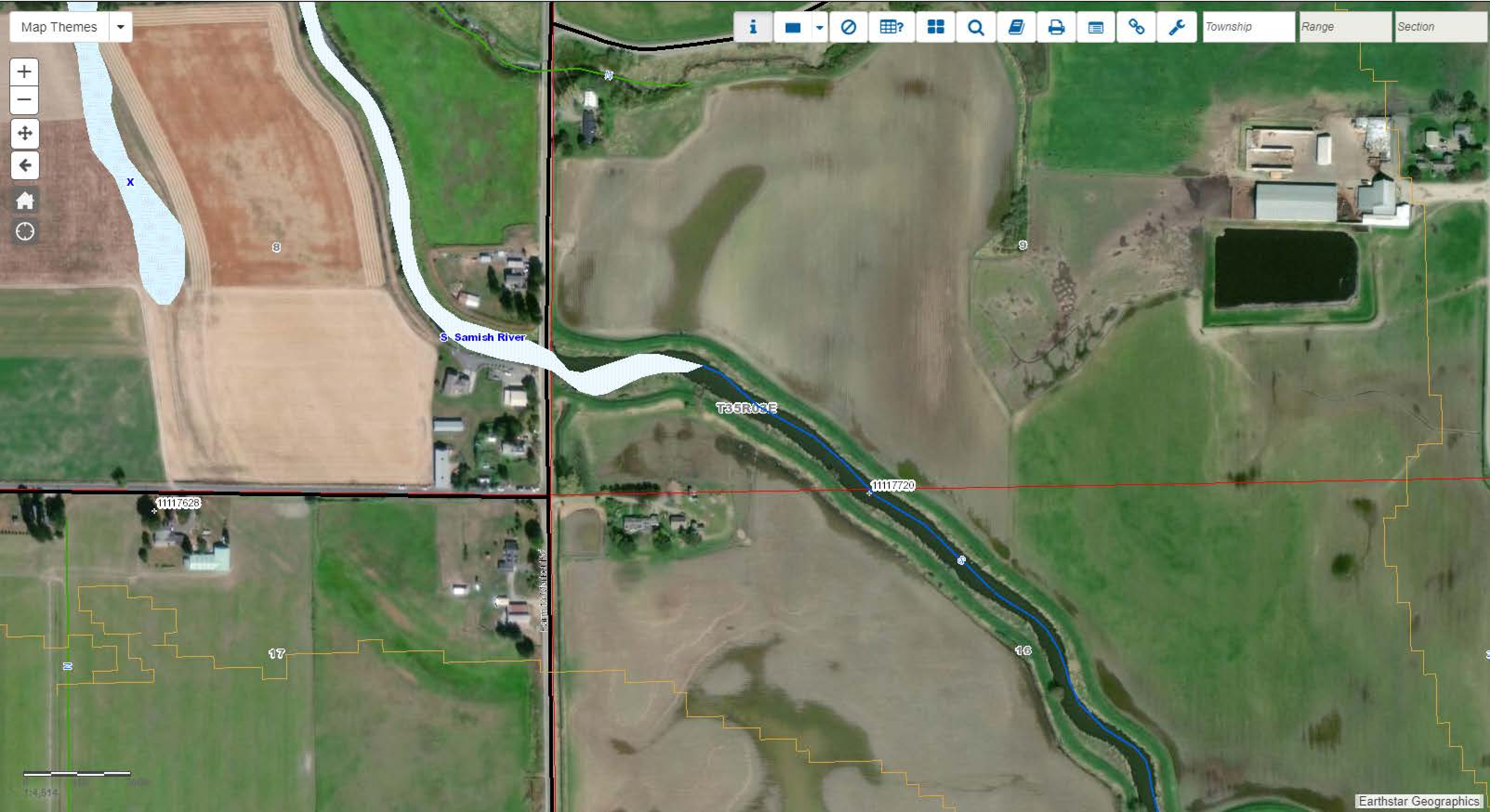
Earthstar Geographics



Map Themes
Township
Range
Section
S. Samish River
T35R03E
11117720
11117628
8
9
16
17
Earthstar Geographics


Measure
LEGEND
E2AB/USN
E2USN
PUBHx
PEM1Cd
PEM1Cd
E1UBL
E2EM1/USN
E2EM1N
1:4,514
48.554 | -122.459 (center)
USDA FSA, DigitalGlobe, GeoEye | U.S. Fish and Wildlife Service, National Standards and Support Team, wetlands_team@fws.gov | Count...
POWERED BY esri


Measure
LEGEND
R1UBV
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PUBHx
1:4,514
48.532 | -122.448
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POWERED BY esri

Measure
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E2USN
E2EM1N
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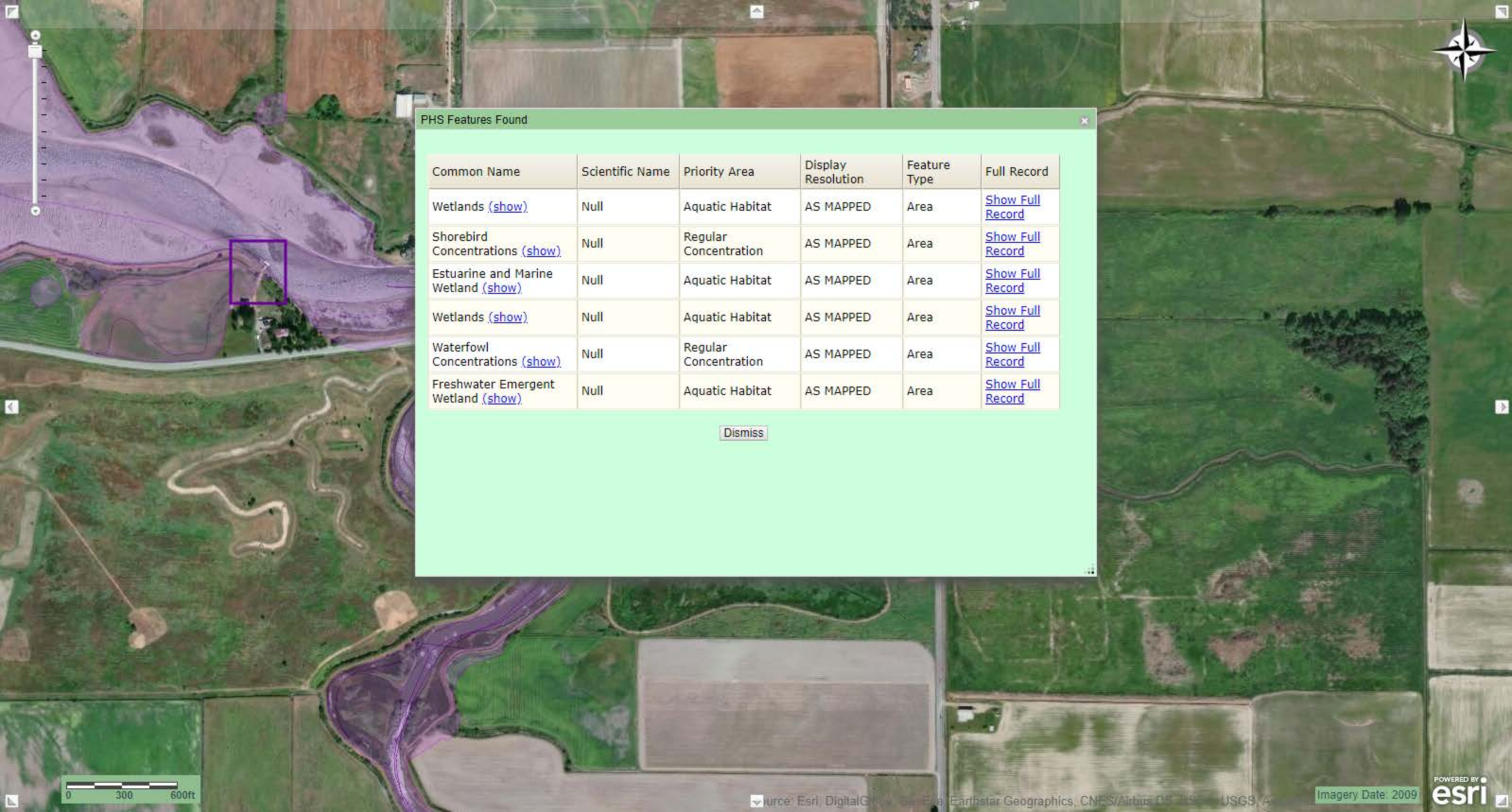
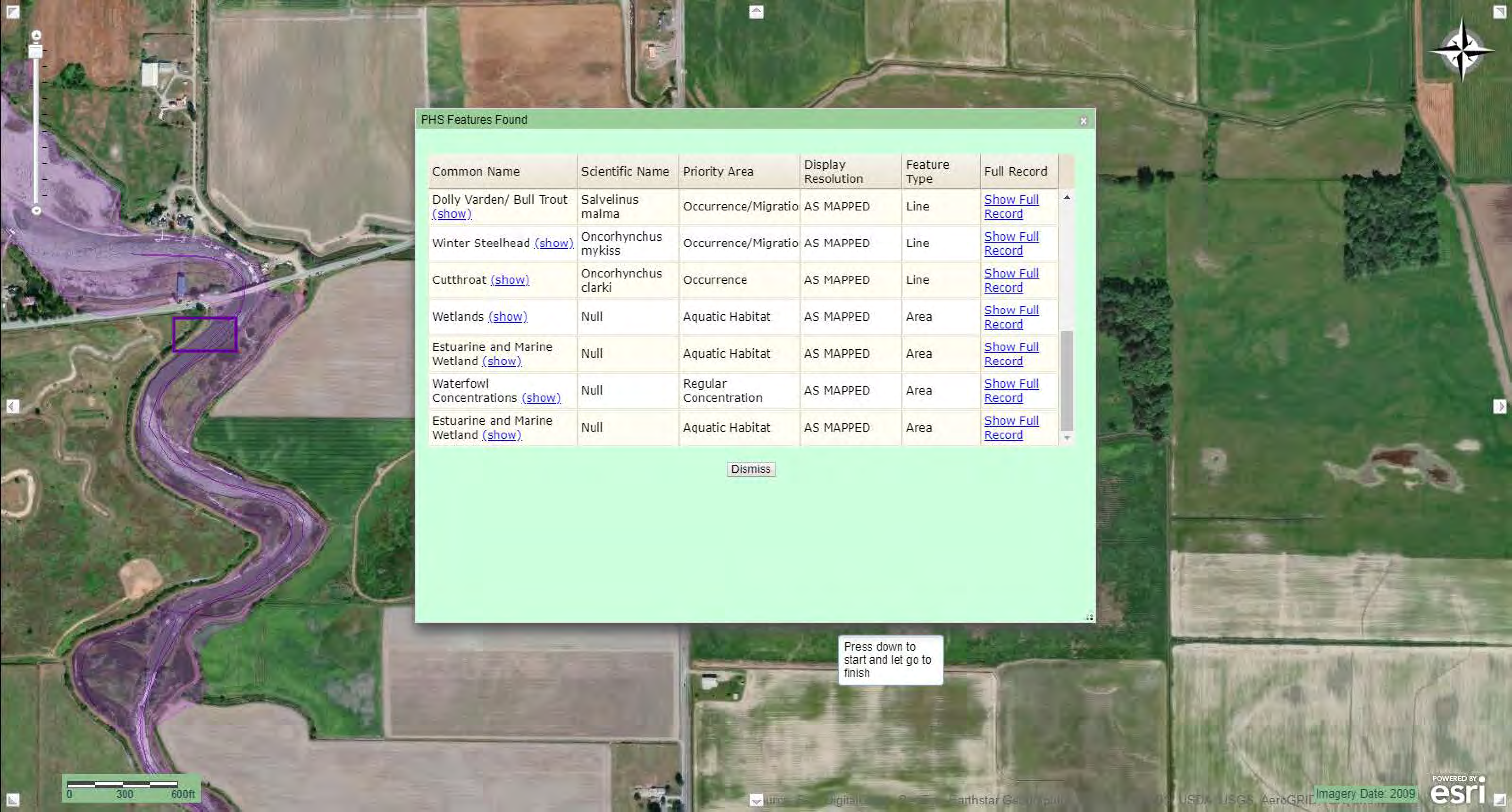


PHS Features Found

Common Name	Scientific Name	Priority Area	Display Resolution	Feature Type	Full Record
Wetlands (show)	Null	Aquatic Habitat	AS MAPPED	Area	Show Full Record
Shorebird Concentrations (show)	Null	Regular Concentration	AS MAPPED	Area	Show Full Record
Estuarine and Marine Wetland (show)	Null	Aquatic Habitat	AS MAPPED	Area	Show Full Record
Wetlands (show)	Null	Aquatic Habitat	AS MAPPED	Area	Show Full Record
Waterfowl Concentrations (show)	Null	Regular Concentration	AS MAPPED	Area	Show Full Record
Freshwater Emergent Wetland (show)	Null	Aquatic Habitat	AS MAPPED	Area	Show Full Record

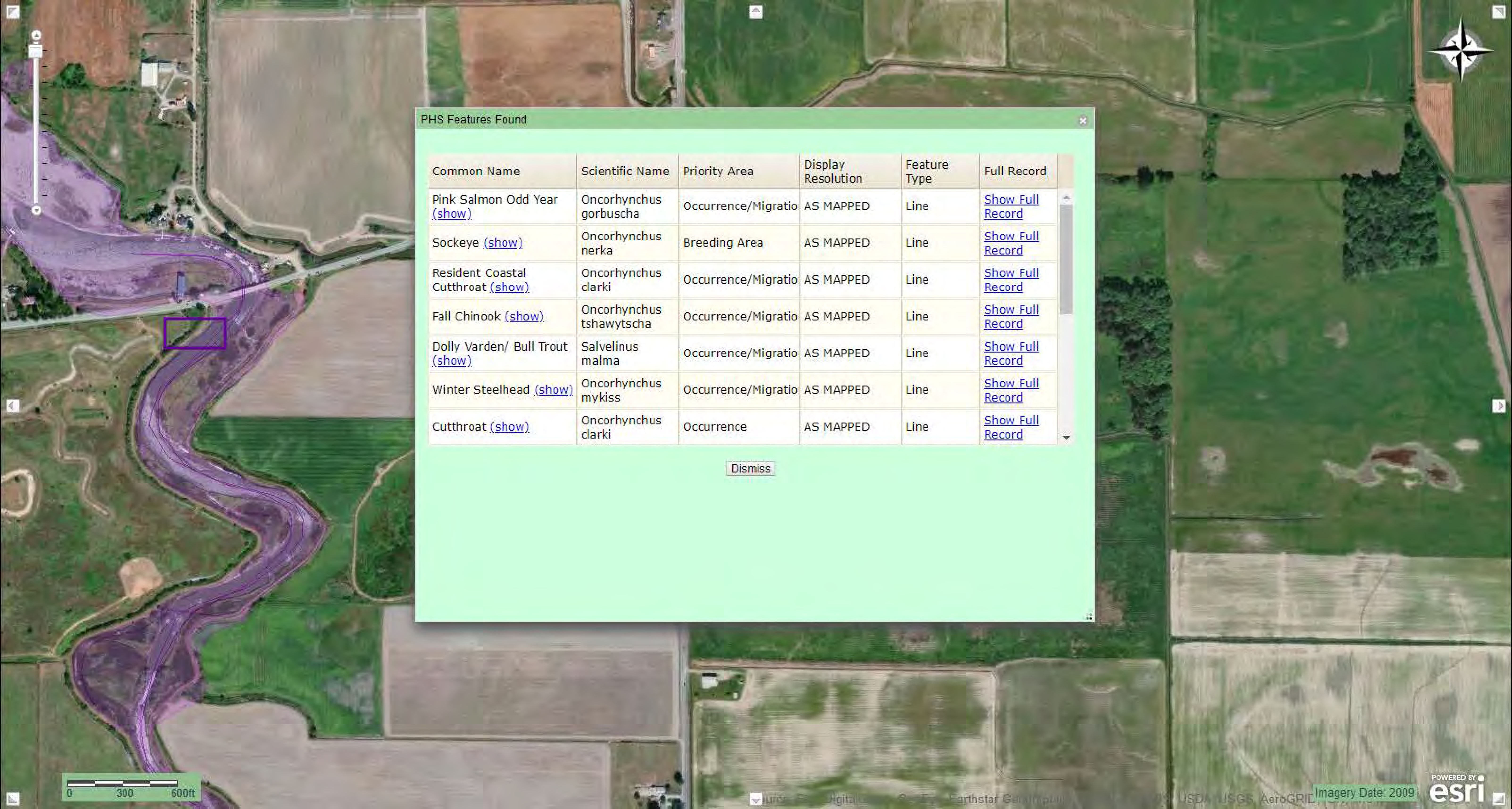
Dismiss



PHS Features Found

Common Name	Scientific Name	Priority Area	Display Resolution	Feature Type	Full Record
Dolly Varden/ Bull Trout (show)	Salvelinus malma	Occurrence/Migratio	AS MAPPED	Line	Show Full Record
Winter Steelhead (show)	Oncorhynchus mykiss	Occurrence/Migratio	AS MAPPED	Line	Show Full Record
Cutthroat (show)	Oncorhynchus clarki	Occurrence	AS MAPPED	Line	Show Full Record
Wetlands (show)	Null	Aquatic Habitat	AS MAPPED	Area	Show Full Record
Estuarine and Marine Wetland (show)	Null	Aquatic Habitat	AS MAPPED	Area	Show Full Record
Waterfowl Concentrations (show)	Null	Regular Concentration	AS MAPPED	Area	Show Full Record
Estuarine and Marine Wetland (show)	Null	Aquatic Habitat	AS MAPPED	Area	Show Full Record

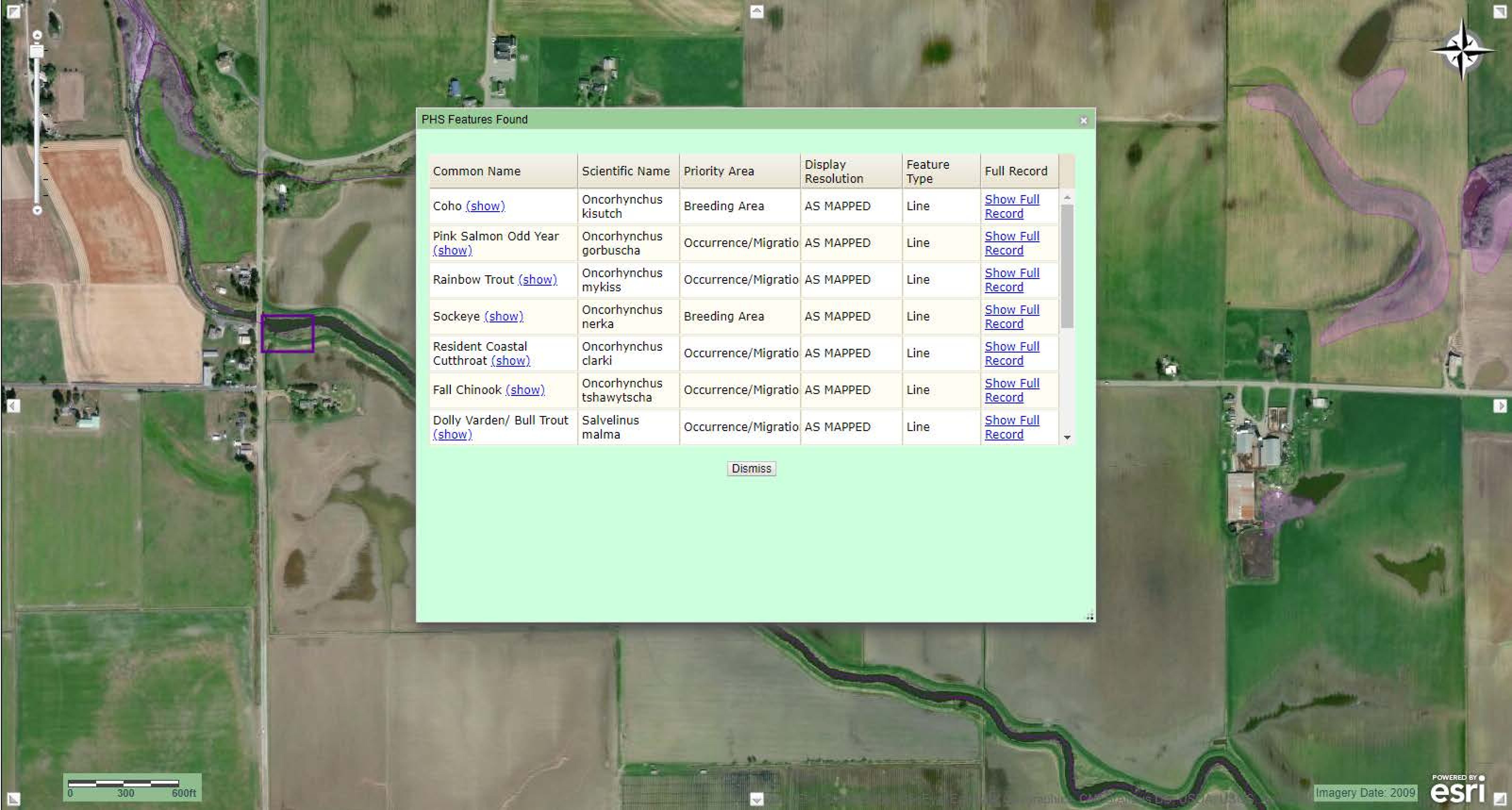
Dismiss



PHS Features Found

Common Name	Scientific Name	Priority Area	Display Resolution	Feature Type	Full Record
Pink Salmon Odd Year (show)	Oncorhynchus gorbuscha	Occurrence/Migratio	AS MAPPED	Line	Show Full Record
Sockeye (show)	Oncorhynchus nerka	Breeding Area	AS MAPPED	Line	Show Full Record
Resident Coastal Cutthroat (show)	Oncorhynchus clarki	Occurrence/Migratio	AS MAPPED	Line	Show Full Record
Fall Chinook (show)	Oncorhynchus tshawytscha	Occurrence/Migratio	AS MAPPED	Line	Show Full Record
Dolly Varden/ Bull Trout (show)	Salvelinus malma	Occurrence/Migratio	AS MAPPED	Line	Show Full Record
Winter Steelhead (show)	Oncorhynchus mykiss	Occurrence/Migratio	AS MAPPED	Line	Show Full Record
Cutthroat (show)	Oncorhynchus clarki	Occurrence	AS MAPPED	Line	Show Full Record

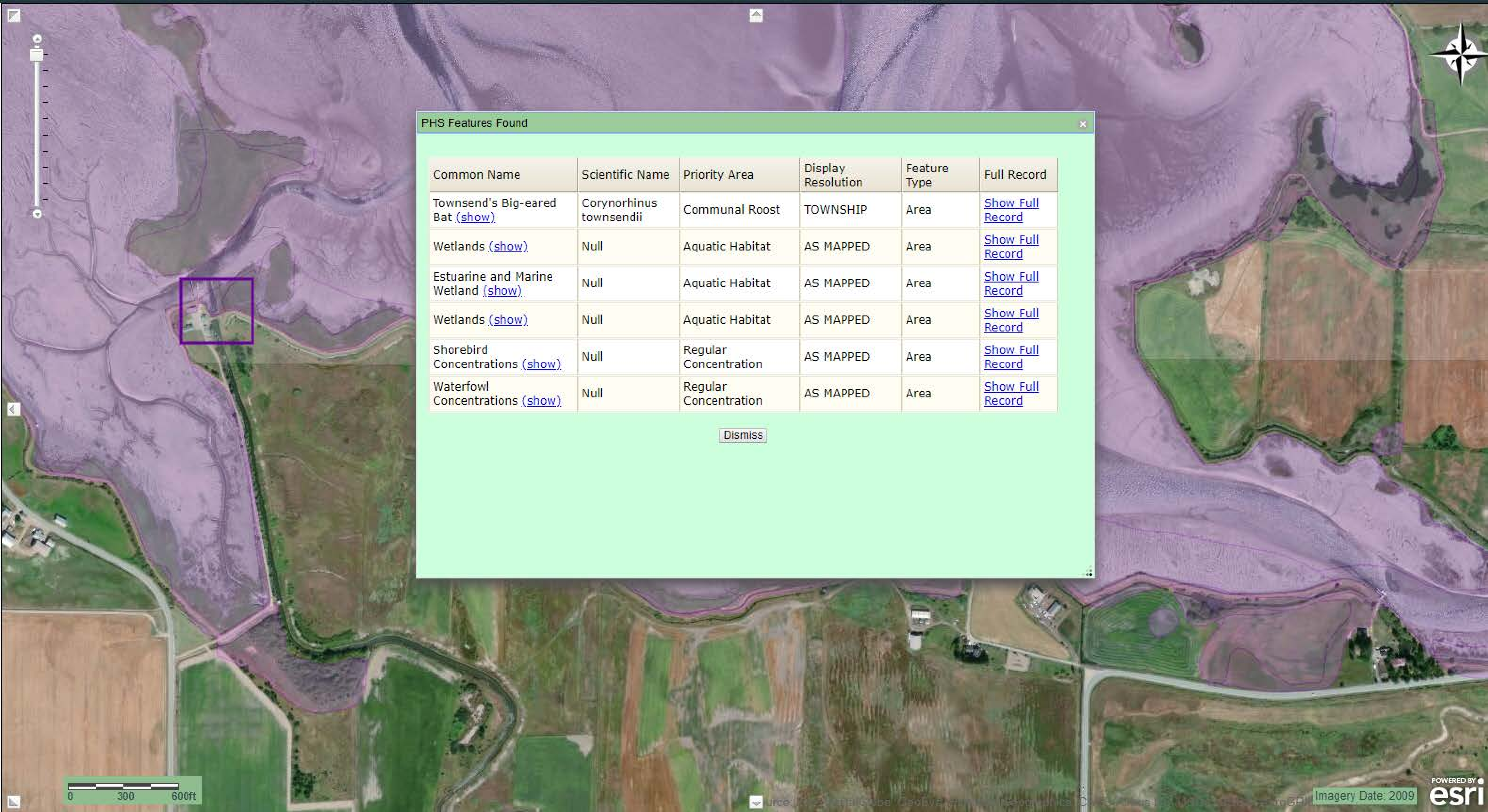
Dismiss



PHS Features Found

Common Name	Scientific Name	Priority Area	Display Resolution	Feature Type	Full Record
Coho (show)	Oncorhynchus kisutch	Breeding Area	AS MAPPED	Line	Show Full Record
Pink Salmon Odd Year (show)	Oncorhynchus gorbuscha	Occurrence/Migratio	AS MAPPED	Line	Show Full Record
Rainbow Trout (show)	Oncorhynchus mykiss	Occurrence/Migratio	AS MAPPED	Line	Show Full Record
Sockeye (show)	Oncorhynchus nerka	Breeding Area	AS MAPPED	Line	Show Full Record
Resident Coastal Cutthroat (show)	Oncorhynchus clarki	Occurrence/Migratio	AS MAPPED	Line	Show Full Record
Fall Chinook (show)	Oncorhynchus tshawytscha	Occurrence/Migratio	AS MAPPED	Line	Show Full Record
Dolly Varden/ Bull Trout (show)	Salvelinus malma	Occurrence/Migratio	AS MAPPED	Line	Show Full Record

Dismiss



PHS Features Found

Common Name	Scientific Name	Priority Area	Display Resolution	Feature Type	Full Record
Townsend's Big-eared Bat (show)	Corynorhinus townsendii	Communal Roost	TOWNSHIP	Area	Show Full Record
Wetlands (show)	Null	Aquatic Habitat	AS MAPPED	Area	Show Full Record
Estuarine and Marine Wetland (show)	Null	Aquatic Habitat	AS MAPPED	Area	Show Full Record
Wetlands (show)	Null	Aquatic Habitat	AS MAPPED	Area	Show Full Record
Shorebird Concentrations (show)	Null	Regular Concentration	AS MAPPED	Area	Show Full Record
Waterfowl Concentrations (show)	Null	Regular Concentration	AS MAPPED	Area	Show Full Record

Dismiss

APPENDIX B
Site Photographs

Photograph 1. Tidal floodgates at the Samish Sports Club site, viewed looking southeast.

Photograph 2. Channel upstream of the floodgates, looking north.

Site Photographs

Skagit River Bridge Modification and Interstate Highway Protection Project
Skagit County, Washington

GeoEngineers

Figure B-1

Photograph 3. Wetland A is a small depression located below the levee and above a ditch just east of the floodgate crossing.

Photograph 4. At the Bayview Edison North site, floodgates are proposed to the left and right of this access road.

Site Photographs

Skagit River Bridge Modification and Interstate Highway Protection Project
Skagit County, Washington

GeoEngineers

Figure B-2

Photograph 5. The Bayview Edison North levee is armored with rip rap and supports a timber pile pier structure.

Photograph 6. Wetland B has developed between the backside of the Bayview Edison North levee and a ditch.

Site Photographs

Skagit River Bridge Modification and Interstate Highway Protection Project
Skagit County, Washington

GeoEngineers

Figure B-3

Photograph 7. The Bayview Edison South levee floodgates outfall below OHWM to a vegetated/mudflat bench.

Photograph 8. Landward of the Bayview Edison South levee is a wide ditch running below the road and levee, surrounding what appears to be a relic agricultural field converted to a habitat restoration site.

Site Photographs

Skagit River Bridge Modification and Interstate Highway Protection Project
Skagit County, Washington

GeoEngineers

Figure B-3

Photograph 9. Two of three floodgates at the Farm to Table Road site discharge to a wide flat bench, Wetland C, while one outfalls directly to the river.

Photograph 10. Culvert under a driveway crossing and ditch viewed north towards the Farm to Table Road floodgates site.

Site Photographs

Skagit River Bridge Modification and Interstate Highway Protection Project
Skagit County, Washington

GeoEngineers | Figure B-5

APPENDIX C
Sample Plot Data Forms

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Samish River Floodgates City/County: Skagit Sampling Date: June 7th, 2018

Applicant/Owner: Skagit County Public Works State: Wa Sampling Point: SP1

Investigator(s): A. Wright Section, Township, Range: Sec 31, Town 36N, Range 3E

Landform (hillslope, terrace, etc.): terrace Local relief (concave, convex, none): concave Slope (%): 0-2%

Subregion (LRR): A Lat: 48.559397 Long: -122.485795 Datum: WGS84

Soil Map Unit Name: Skagit Silt Loam NWI Classification: Unmapped

Are climatic / hydrologic conditions on the site typical for this time of year? ○ Yes ○ No (If no, explain in Remarks.)

Are Vegetation ☐, Soil ☐, or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? ◉ Yes ○ No

Are Vegetation ☐, Soil ☐, or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	◉ Yes	○ No
Hydric Soil Present?	◉ Yes	○ No
Wetland Hydrology Present?	◉ Yes	○ No

Is the Sampled Area within a Wetland? ◉ Yes ○ No

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size:)	Absolute % Cover	Dom. Sp.?	Relative % Cover	Indicator Status
1.				
2.				
3.				
4.				
	= Total Cover			
Sapling/Shrub Stratum (Plot size: 10')				
1. *Rubus armeniacus*	20	Y	100.0	FAC
2.				
3.				
4.				
5.				
	20 = Total Cover			
Herb Stratum (Plot size: 5')				
1. *Juncus effusus*	5	N	5.3	FACW
2. *Festuca rubra*	10	N	10.5	FAC
3. *Holcus lanatus*	80	Y	84.2	FAC
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
	95 = Total Cover			
Woody Vine Stratum (Plot size:)				
1.				
2.				
	= Total Cover			

% Bare Ground in Herb Stratum ____

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100.0% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	0	x 1 =	0
FACW species	5	x 2 =	10
FAC species	110	x 3 =	330
FACU species	0	x 4 =	0
UPL species	0	x 5 =	0
Column Totals:	115 (A)		340 (B)

Prevalence Index = B/A = 2.957

Hydrophytic Vegetation Indicators:

- ☐ 1 - Rapid Test for Hydrophytic Vegetation
- ☑ 2 - Dominance Test is >50%
- ☑ 3 - Prevalence Index is ≤3.0[1]
- ☐ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ 5 - Wetland Non-Vascular Plants[1]
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? ◉ Yes ○ No

Remarks:

SOIL

Sampling Point: SP1

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)		Matrix %	Redox Features Color (moist)		Redox %	Type¹	Loc²	Texture	Remarks
0-16	10YR	4/1	75	10YR	5/6	10	C	PL&M	landy loam	loose sand lense at 10-12"
	10YR	5/2	15							

¹Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. ²Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicble to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1)
- ☐ Sandy Gleyed Matrix (S4)
- ☑ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Loamy Mucky Mineral (F1) (except MLRA 1)
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)

Indicators for Problematic Hydric Soils³:

- ☐ 2 cm Muck (A10)
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

³Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ____________

Depth (inches): ____________

Hydric Soil Present? ◉ Yes ○ No

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Surface Soil Cracks (B6)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Water-Stained Leaves (B9) (except MLRA 1, 2, 4A, and 4B)
- ☐ Salt Crust (B11)
- ☐ Aquatic Invertebrates (B13)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Stunted or Stressed Plants (D1) (LRR A)
- ☐ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ☐ Water-Stained Leaves (B9) (MLRA 1, 2, 4A, and 4B)
- ☐ Drainage Patterns (B10)
- ☐ Dry-Season Water Table (C2)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☑ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☑ FAC-Neutral Test (D5)
- ☐ Raised Ant Mounds (D6) (LRR A)
- ☐ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	○ Yes	◉ No	Depth (inches):
Water Table Present?	○ Yes	◉ No	Depth (inches):
Saturation Present? (includes capillary fringe)	○ Yes	◉ No	Depth (inches):

Wetland Hydrology Present? ◉ Yes ○ No

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Samish River Floodgates | City/County: Skagit | Sampling Date: June 7th, 2018

Applicant/Owner: Skagit County Public Works | State: Wa | Sampling Point: SP2

Investigator(s): A. Wright | Section, Township, Range: Sec 31, Town 36N, Range 3E

Landform (hillslope, terrace, etc.): terrace | Local relief (concave, convex, none): concave | Slope (%): 0-2%

Subregion (LRR): A | Lat: 48.554987 | Long: -122.459549 | Datum: WGS84

Soil Map Unit Name: Tacoma silt loam; drained | NWI Classification: Unmapped

Are climatic / hydrologic conditions on the site typical for this time of year? ○ Yes ○ No (If no, explain in Remarks.)

Are Vegetation ☐ , Soil ☐ , or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? ◉ Yes ○ No

Are Vegetation ☐ , Soil ☐ , or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	◉ Yes	○ No
Hydric Soil Present?	◉ Yes	○ No
Wetland Hydrology Present?	◉ Yes	○ No

Is the Sampled Area within a Wetland? ◉ Yes ○ No

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size:)	Absolute % Cover	Dom. Sp.?	Relative % Cover	Indicator Status
1.				
2.				
3.				
4.				
		= Total Cover		
Sapling/Shrub Stratum (Plot size:)				
1.				
2.				
3.				
4.				
5.				
		= Total Cover		
Herb Stratum (Plot size: 10')				
1. *Juncus effusus*	40	Y	40.0	FACW
2. *Festuca rubra*	60	Y	60.0	FAC
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
	100	= Total Cover		
Woody Vine Stratum (Plot size:)				
1.				
2.				
		= Total Cover		
% Bare Ground in Herb Stratum				

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100.0% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	0	x 1 =	0
FACW species	40	x 2 =	80
FAC species	60	x 3 =	180
FACU species	0	x 4 =	0
UPL species	0	x 5 =	0
Column Totals:	100 (A)		260 (B)

Prevalence Index = B/A = 2.600

Hydrophytic Vegetation Indicators:

- ☐ 1 - Rapid Test for Hydrophytic Vegetation
- ☑ 2 - Dominance Test is >50%
- ☑ 3 - Prevalence Index is ≤3.0[1]
- ☐ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ 5 - Wetland Non-Vascular Plants[1]
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? ◉ Yes ○ No

Remarks:

SOIL

Sampling Point: SP2

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)		Matrix %	Redox Features Color (moist)		Redox %	Type¹	Loc²	Texture	Remarks
0-16	10YR	4/1	90	10YR	5/6	10	C	PL&M	Silt loam	organic/rhizomatous top 3"

¹Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. ²Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicble to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1)
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Loamy Mucky Mineral (F1) (except MLRA 1)
- ☐ Loamy Gleyed Matrix (F2)
- ☑ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)

Indicators for Problematic Hydric Soils³:

- ☐ 2 cm Muck (A10)
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

³Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ______

Depth (inches): ______

Hydric Soil Present? ◉ Yes ○ No

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Surface Soil Cracks (B6)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Water-Stained Leaves (B9) (except MLRA 1, 2, 4A, and 4B)
- ☐ Salt Crust (B11)
- ☐ Aquatic Invertebrates (B13)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Stunted or Stressed Plants (D1) (LRR A)
- ☐ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ☐ Water-Stained Leaves (B9) (MLRA 1, 2, 4A, and 4B)
- ☐ Drainage Patterns (B10)
- ☐ Dry-Season Water Table (C2)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☑ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☑ FAC-Neutral Test (D5)
- ☐ Raised Ant Mounds (D6) (LRR A)
- ☐ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	○ Yes	◉ No	Depth (inches):
Water Table Present?	◉ Yes	○ No	Depth (inches): 8
Saturation Present? (includes capillary fringe)	◉ Yes	○ No	Depth (inches): 6

Wetland Hydrology Present? ◉ Yes ○ No

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Samish River Floodgates | City/County: Skagit | Sampling Date: June 7th, 2018

Applicant/Owner: Skagit County Public Works | State: Wa | Sampling Point: SP3

Investigator(s): A. Wright | Section, Township, Range: Sec 31, Town 36N, Range 3E

Landform (hillslope, terrace, etc.): terrace | Local relief (concave, convex, none): concave | Slope (%): 0-2%

Subregion (LRR): A | Lat: 48.531403 | Long: -122.443861 | Datum: WGS84

Soil Map Unit Name: Sucas Silt Loam | NWI Classification: Unmapped

Are climatic / hydrologic conditions on the site typical for this time of year? ○ Yes ○ No (If no, explain in Remarks.)

Are Vegetation ☐ , Soil ☐ , or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? ● Yes ○ No

Are Vegetation ☐ , Soil ☐ , or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	● Yes	○ No
Hydric Soil Present?	● Yes	○ No
Wetland Hydrology Present?	● Yes	○ No

Is the Sampled Area within a Wetland? ● Yes ○ No

Remarks:

VEGETATION – Use scientific names of plants.

	Absolute % Cover	Dom. Sp.?	Relative % Cover	Indicator Status
Tree Stratum (Plot size:)				
1.				
2.				
3.				
4.				
= Total Cover				
Sapling/Shrub Stratum (Plot size:)				
1.				
2.				
3.				
4.				
5.				
= Total Cover				
Herb Stratum (Plot size: 10')				
1. *Phalaris arundinacea*	90	**Y**	90.0	FACW
2. *Juncus effusus*	5	N	5.0	FACW
3. *Scirpus microcarpus*	5	N	5.0	OBL
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
= Total Cover	100			
Woody Vine Stratum (Plot size:)				
1.				
2.				
= Total Cover				

% Bare Ground in Herb Stratum

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 1 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100.0% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	5	x 1 =	5
FACW species	95	x 2 =	190
FAC species	0	x 3 =	0
FACU species	0	x 4 =	0
UPL species	0	x 5 =	0
Column Totals:	100 (A)		195 (B)

Prevalence Index = B/A = 1.950

Hydrophytic Vegetation Indicators:

- ☐ 1 - Rapid Test for Hydrophytic Vegetation
- ☑ 2 - Dominance Test is >50%
- ☑ 3 - Prevalence Index is ≤3.0[1]
- ☐ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ 5 - Wetland Non-Vascular Plants[1]
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? ● Yes ○ No

Remarks:
cattail and yellow flag iris in adjacent low areas

SOIL

Sampling Point: SP3

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)		Matrix %	Redox Features Color (moist)		Redox %	Type¹	Loc²	Texture	Remarks
0-16	10YR	3/1	90	10YR	4/6	10	C	PL&M	Silt loam	

¹Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. ²Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicble to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1)
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Loamy Mucky Mineral (F1) (except MLRA 1)
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☑ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)

Indicators for Problematic Hydric Soils³:

- ☐ 2 cm Muck (A10)
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

³Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ____________

Depth (inches): ____________

Hydric Soil Present? ● Yes ○ No

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Surface Soil Cracks (B6)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Water-Stained Leaves (B9) (except MLRA 1, 2, 4A, and 4B)
- ☐ Salt Crust (B11)
- ☐ Aquatic Invertebrates (B13)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Stunted or Stressed Plants (D1) (LRR A)
- ☐ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ☐ Water-Stained Leaves (B9) (MLRA 1, 2, 4A, and 4B)
- ☐ Drainage Patterns (B10)
- ☐ Dry-Season Water Table (C2)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☑ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☑ FAC-Neutral Test (D5)
- ☐ Raised Ant Mounds (D6) (LRR A)
- ☐ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present? ○ Yes ● No Depth (inches): ____

Water Table Present? ○ Yes ● No Depth (inches): ____

Saturation Present? (includes capillary fringe) ○ Yes ● No Depth (inches): ____

Wetland Hydrology Present? ● Yes ○ No

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

Topographic bench between levee and vertical channel bank. Two floodgates discharge to this upper surface, third floodgate directly to river channel.

APPENDIX D
Wetland Rating Form

RATING SUMMARY – Western Washington

Name of wetland (or ID #): Wetland A Date of site visit: 7-Jun

Rated by A. Wright Trained by Ecology? ☑ Yes ☐ No Date of training Apr-15

HGM Class used for rating Riverine & Fresh Water Tidal Wetland has multiple HGM classes? ☐ Yes ☑ No

NOTE: Form is not complete with out the figures requested (*figures can be combined*).
Source of base aerial photo/map Google Earth

OVERALL WETLAND CATEGORY III (based on functions ☑ or special characteristics ☐)

1. Category of wetland based on FUNCTIONS

____ **Category I** - Total score = 23 - 27
____ **Category II** - Total score = 20 - 22
__X__ **Category III** - Total score = 16 - 19
____ **Category IV** - Total score = 9 - 15

FUNCTION	Improving Water Quality	Hydrologic	Habitat	
	List appropriate rating (H, M, L)			
Site Potential	M	M	L	
Landscape Potential	M	M	L	
Value	H	H	M	**Total**
Score Based on Ratings	7	7	4	**18**

Score for each function based on three ratings
(*order of ratings is not important*)

9 = H, H, H
8 = H, H, M
7 = H, H, L
7 = H, M, M
6 = H, M, L
6 = M, M, M
5 = H, L, L
5 = M, M, L
4 = M, L, L
3 = L, L, L

2. Category based on SPECIAL CHARACTERISTICS of wetland

CHARACTERISTIC	Category
Estuarine	
Wetland of High Conservation Value	
Bog	
Mature Forest	
Old Growth Forest	
Coastal Lagoon	
Interdunal	
None of the above	X

Maps and Figures required to answer questions correctly for Western Washington

Depressional Wetlands

Map of:	To answer questions:	Figure #
Cowardin plant classes	D 1.3, H 1.1, H 1.4	
Hydroperiods	D 1.4, H 1.2	
Location of outlet (*can be added to map of hydroperiods*)	D 1.1, D 4.1	
Boundary of area within 150 ft of the wetland (*can be added to another figure*)	D 2.2, D 5.2	
Map of the contributing basin	D 4.3, D 5.3	
1 km Polygon: Area that extends 1 km from entire wetland edge - including polygons for accessible habitat and undisturbed habitat	H 2.1, H 2.2, H 2.3	
Screen capture of map of 303(d) listed waters in basin (from Ecology website)	D 3.1, D 3.2	
Screen capture of list of TMDLs for WRIA in which unit is found (from web)	D 3.3	

Riverine Wetlands

Map of:	To answer questions:	Figure #
Cowardin plant classes	H 1.1, H 1.4	1
Hydroperiods	H 1.2	1
Ponded depressions	R 1.1	1
Boundary of area within 150 ft of the wetland (*can be added to another figure*)	R 2.4	1
Plant cover of trees, shrubs, and herbaceous plants	R 1.2, R 4.2	1
Width of unit vs. width of stream (*can be added to another figure*)	R 4.1	1
Map of the contributing basin	R 2.2, R 2.3, R 5.2	2
1 km Polygon: Area that extends 1 km from entire wetland edge - including polygons for accessible habitat and undisturbed habitat	H 2.1, H 2.2, H 2.3	3
Screen capture of map of 303(d) listed waters in basin (from Ecology website)	R 3.1	4
Screen capture of list of TMDLs for WRIA in which unit is found (from web)	R 3.2, R 3.3	5

Lake Fringe Wetlands

Map of:	To answer questions:	Figure #
Cowardin plant classes	L 1.1, L 4.1, H 1.1, H 1.4	
Plant cover of trees, shrubs, and herbaceous plants	L 1.2	
Boundary of area within 150 ft of the wetland (*can be added to another figure*)	L 2.2	
1 km Polygon: Area that extends 1 km from entire wetland edge - including polygons for accessible habitat and undisturbed habitat	H 2.1, H 2.2, H 2.3	
Screen capture of map of 303(d) listed waters in basin (from Ecology website)	L 3.1, L 3.2	
Screen capture of list of TMDLs for WRIA in which unit is found (from web)	L 3.3	

Slope Wetlands

Map of:	To answer questions:	Figure #
Cowardin plant classes	H 1.1, H 1.4	
Hydroperiods	H 1.2	
Plant cover of **dense** trees, shrubs, and herbaceous plants	S 1.3	
Plant cover of **dense, rigid** trees, shrubs, and herbaceous plants (*can be added to another figure*)	S 4.1	
Boundary of area within 150 ft of the wetland (*can be added to another figure*)	S 2.1, S 5.1	
1 km Polygon: Area that extends 1 km from entire wetland edge - including polygons for accessible habitat and undisturbed habitat	H 2.1, H 2.2, H 2.3	
Screen capture of map of 303(d) listed waters in basin (from Ecology website)	S 3.1, S 3.2	
Screen capture of list of TMDLs for WRIA in which unit is found (from web)	S 3.3	

HGM Classification of Wetland in Western Washington

For questions 1 -7, the criteria described must apply to the entire unit being rated.
If hydrologic criteria listed in each question do not apply to the entire unit being rated, you probably have a unit with multiple HGM classes. In this case, identify which hydrologic criteria in questions 1 - 7 apply, and go to Question 8.

1. Are the water levels in the entire unit usually controlled by tides except during floods?

☑ NO - go to 2 ☐ **YES** - the wetland class is **Tidal Fringe** - go to 1.1

1.1 Is the salinity of the water during periods of annual low flow below 0.5 ppt (parts per thousand)?

☐ **NO - Saltwater Tidal Fringe (Estuarine)** ☐ **YES - Freshwater Tidal Fringe**

*If your wetland can be classified as a Freshwater Tidal Fringe use the forms for **Riverine** wetlands. If it is Saltwater Tidal Fringe it is an **Estuarine** wetland and is not scored. This method **cannot** be used to score functions for estuarine wetlands.*

2. The entire wetland unit is flat and precipitation is the only source (>90%) of water to it. Groundwater and surface water runoff are NOT sources of water to the unit.

☑ NO - go to 3 ☐ **YES** - The wetland class is **Flats**

*If your wetland can be classified as a Flats wetland, use the form for **Depressional** wetlands.*

3. Does the entire wetland unit **meet all** of the following criteria?
☐ The vegetated part of the wetland is on the shores of a body of permanent open water (without any plants on the surface at any time of the year) at least 20 ac (8 ha) in size;
☐ At least 30% of the open water area is deeper than 6.6 ft (2 m).

☑ NO - go to 4 ☐ **YES** - The wetland class is **Lake Fringe** (Lacustrine Fringe)

4. Does the entire wetland unit **meet all** of the following criteria?
☐ The wetland is on a slope (*slope can be very gradual*),
☐ The water flows through the wetland in one direction (unidirectional) and usually comes from seeps. It may flow subsurface, as sheetflow, or in a swale without distinct banks.
☐ The water leaves the wetland **without being impounded.**

☑ NO - go to 5 ☐ **YES** - The wetland class is **Slope**

NOTE: Surface water does not pond in these type of wetlands except occasionally in very small and shallow depressions or behind hummocks (depressions are usually <3 ft diameter and less than 1 ft deep).

5. Does the entire wetland unit **meet all** of the following criteria?
☑ The unit is in a valley, or stream channel, where it gets inundated by overbank flooding from that stream or river,
☑ The overbank flooding occurs at least once every 2 years.

☐ NO - go to 6 ☑ **YES** - The wetland class is **Riverine**

NOTE: The Riverine unit can contain depressions that are filled with water when the river is not flooding.

6. Is the entire wetland unit in a topographic depression in which water ponds, or is saturated to the surface, at some time during the year? *This means that any outlet, if present, is higher than the interior of the wetland.*

☐ NO - go to 7 ☐ **YES** - The wetland class is **Depressional**

7. Is the entire wetland unit located in a very flat area with no obvious depression and no overbank flooding? The unit does not pond surface water more than a few inches. The unit seems to be maintained by high groundwater in the area. The wetland may be ditched, but has no obvious natural outlet.

☐ NO - go to 8 ☐ **YES** - The wetland class is **Depressional**

8. Your wetland unit seems to be difficult to classify and probably contains several different HGM classes. For example, seeps at the base of a slope may grade into a riverine floodplain, or a small stream within a Depressional wetland has a zone of flooding along its sides. GO BACK AND IDENTIFY WHICH OF THE HYDROLOGIC REGIMES DESCRIBED IN QUESTIONS 1-7 APPLY TO DIFFERENT AREAS IN THE UNIT (make a rough sketch to help you decide). Use the following table to identify the appropriate class to use for the rating system if you have several HGM classes present within the wetland unit being scored.

NOTE: Use this table only if the class that is recommended in the second column represents 10% or more of the total area of the wetland unit being rated. If the area of the HGM class listed in column 2 is less than 10% of the unit; classify the wetland using the class that represents more than 90% of the total area.

HGM classes within the wetland unit being rated	HGM class to use in rating
Slope + Riverine	Riverine
Slope + Depressional	Depressional
Slope + Lake Fringe	Lake Fringe
Depressional + Riverine along stream within boundary of depression	Depressional
Depressional + Lake Fringe	Depressional
Riverine + Lake Fringe	Riverine
Salt Water Tidal Fringe and any other class of freshwater wetland	Treat as ESTUARINE

If you are still unable to determine which of the above criteria apply to your wetland, or if you have ***more than 2 HGM classes*** *within a wetland boundary, classify the wetland as Depressional for the rating.*

NOTES and FIELD OBSERVATIONS:

RIVERINE AND FRESHWATER TIDAL FRINGE WETLANDS

Water Quality Functions - Indicators that the site functions to improve water quality

R 1.0. Does the site have the potential to improve water quality?		
R 1.1. Area of surface depressions within the Riverine wetland that can trap sediments during a flooding event: Depressions cover > 3/4 area of wetland Depressions cover > ½ area of wetland Depressions present but cover < ½ area of wetland No depressions present	 points = 8 points = 4 points = 2 points = 0	2
R 1.2. Structure of plants in the wetland (areas with >90% cover at person height, **not** Cowardin classes) Trees or shrubs > 2/3 area of the wetland ☐ Trees or shrubs > 1/3 area of the wetland ☑ Herbaceous plants (> 6 in high) > 2/3 area of the wetland Herbaceous plants (> 6 in high) > 1/3 area of the wetland Trees, shrubs, and ungrazed herbaceous < 1/3 area of the wetland	 points = 8 points = 6 points = 6 points = 3 points = 0	6
Total for R 1	Add the points in the boxes above	**8**

Rating of Site Potential If score is: ☐ **12 - 16 = H** ☑ **6 - 11 = M** ☐ **0 - 5 = L** *Record the rating on the first page*

R 2.0. Does the landscape have the potential to support the water quality function of the site?		
R 2.1. Is the wetland within an incorporated city or within its UGA?	Yes = 2 No = 0	0
R 2.2. Does the contributing basin to the wetland include a UGA or incorporated area?	Yes = 1 No = 0	0
R 2.3. Does at least 10% of the contributing basin contain tilled fields, pastures, or forests that have been clearcut within the last 5 years?	Yes = 1 No = 0	1
R 2.4. Is > 10% of the area within 150 ft of the wetland in land uses that generate pollutants?	Yes = 1 No = 0	0
R 2.5. Are there other sources of pollutants coming into the wetland that are not listed in questions R 2.1 - R 2.4? Other Sources Creek/ditch draining ag fields	Yes = 1 No = 0	1
Total for R 2	Add the points in the boxes above	**2**

Rating of Landscape Potential If score is: ☐ **3 - 6 = H** ☑ **1 or 2 = M** ☐ **0 = L** *Record the rating on the first page*

R 3.0. Is the water quality improvement provided by the site valuable to society?		
R 3.1. Is the wetland along a stream or river that is on the 303(d) list or on a tributary that drains to one within 1 mi?	Yes = 1 No = 0	1
R 3.2. Is the wetland along a stream or river that has TMDL limits for nutrients, toxics, or pathogens?	Yes = 1 No = 0	1
R 3.3. Has the site been identified in a watershed or local plan as important for maintaining water quality? (*answer YES if there is a TMDL for the drainage in which the unit is found*)	Yes = 2 No = 0	2
Total for R 3	Add the points in the boxes above	**4**

Rating of Value If score is: ☑ **2 - 4 = H** ☐ **1 = M** ☐ **0 = L** *Record the rating on the first page*

RIVERINE AND FRESHWATER TIDAL FRINGE WETLANDS	
Hydrologic Functions - Indicators that site functions to reduce flooding and stream erosion	
R 4.0. Does the site have the potential to reduce flooding and erosion?	
R 4.1. Characteristics of the overbank storage the wetland provides: *Estimate the average width of the wetland perpendicular to the direction of the flow and the width of the stream or river channel (distance between banks). Calculate the ratio: (average width of wetland)/(average width of stream between banks).* If the ratio is more than 20 — points = 9 If the ratio is 10 - 20 — points = 6 If the ratio is 5 - < 10 — points = 4 If the ratio is 1 - < 5 — points = 2 If the ratio is < 1 — points = 1	2
R 4.2. Characteristics of plants that slow down water velocities during floods: *Treat large woody debris as forest or shrub. Choose the points appropriate for the best description (polygons need to have >90% cover at person height. These are* <u>*NOT Cowardin*</u> *classes*). Forest or shrub for > $^{1}/_{3}$ area OR emergent plants > $^{2}/_{3}$ area — points = 7 Forest or shrub for > $^{1}/_{10}$ area OR emergent plants > $^{1}/_{3}$ area — points = 4 Plants do not meet above criteria — points = 0	7
Total for R 4 — Add the points in the boxes above	**9**

Rating of Site Potential If score is: ☐ **12 - 16 = H** ☑ **6 - 11 = M** ☐ **0 - 5 = L** *Record the rating on the first page*

R 5.0. Does the landscape have the potential to support the hydrologic functions of the site?		
R 5.1. Is the stream or river adjacent to the wetland downcut?	Yes = 0 No = 1	0
R 5.2. Does the up-gradient watershed include a UGA or incorporated area?	Yes = 1 No = 0	0
R 5.3 Is the up-gradient stream or river controlled by dams?	Yes = 0 No = 1	0
Total for R 5	Add the points in the boxes above	**0**

Rating of Landscape Potential If score is: ☐ **3 = H** ☐ **1 or 2 = M** ☑ **0 = L** *Record the rating on the first page*

R 6.0. Are the hydrologic functions provided by the site valuable to society?	
R 6.1. Distance to the nearest areas downstream that have flooding problems? *Choose the description that best fits the site.* The sub-basin immediately down-gradient of the wetland has flooding problems that result in damage to human or natural resources (e.g., houses or salmon redds) — points = 2 Surface flooding problems are in a sub-basin farther down-gradient — points = 1 No flooding problems anywhere downstream — points = 0	0
R 6.2. Has the site been identified as important for flood storage or flood conveyance in a regional flood control plan? Yes = 2 No = 0	2
Total for R 6 — Add the points in the boxes above	**2**

Rating of Value If score is: ☑ **2 - 4 = H** ☐ **1 = M** ☐ **0 = L** *Record the rating on the first page*

These questions apply to wetlands of all HGM classes.

HABITAT FUNCTIONS - Indicators that site functions to provide important habitat

H 1.0. Does the site have the potential to provide habitat?

H 1.1. Structure of plant community: *Indicators are Cowardin classes and strata within the Forested class.* Check the Cowardin plant classes in the wetland. *Up to 10 patches may be combined for each class to meet the threshold of ¼ ac or more than 10% of the unit if it is smaller than 2.5 ac. Add the number of structures checked.*

- ☐ Aquatic bed — 4 structures or more: points = 4
- ☑ Emergent — 3 structures: points = 2
- ☑ Scrub-shrub (areas where shrubs have > 30% cover) — 2 structures: points - 1
- ☐ Forested (areas where trees have > 30% cover) — 1 structure: points = 0

If the unit has a Forested class, check if:

- ☐ The Forested class has 3 out of 5 strata (canopy, sub-canopy, shrubs, herbaceous, moss/ground-cover) that each cover 20% within the Forested polygon

Score: 1

H 1.2. Hydroperiods

Check the types of water regimes (hydroperiods) present within the wetland. The water regime has to cover more than 10% of the wetland or ¼ ac to count (*see text for descriptions of hydroperiods*).

- ☐ Permanently flooded or inundated — 4 or more types present: points = 3
- ☑ Seasonally flooded or inundated — 3 types present: points = 2
- ☐ Occasionally flooded or inundated — 2 types present: points = 1
- ☐ Saturated only — 1 types present: points = 0
- ☑ Permanently flowing stream or river in, or adjacent to, the wetland
- ☐ Seasonally flowing stream in, or adjacent to, the wetland
- ☐ **Lake Fringe wetland** — **2 points**
- ☐ **Freshwater tidal wetland** — **2 points**

Score: 1

H 1.3. Richness of plant species

Count the number of plant species in the wetland that cover at least 10 ft^2.

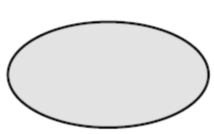
Different patches of the same species can be combined to meet the size threshold and you do not have to name the species. ***Do not include Eurasian milfoil, reed canarygrass, purple loosestrife, Canadian thistle***

If you counted:		
	> 19 species	points = 2
	5 - 19 species	points = 1
	< 5 species	points = 0

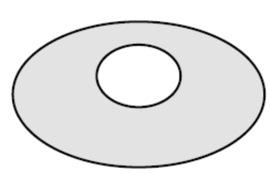
Score: 1

H 1.4. Interspersion of habitats

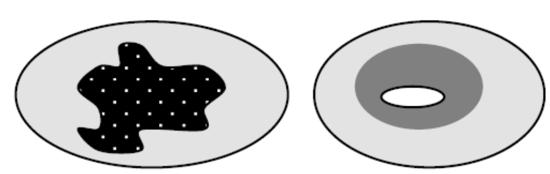
Decide from the diagrams below whether interspersion among Cowardin plants classes (described in H 1.1), or the classes and unvegetated areas (can include open water or mudflats) is high, moderate, low, or none. *If you have four or more plant classes or three classes and open water, the rating is always high.*



None = 0 points

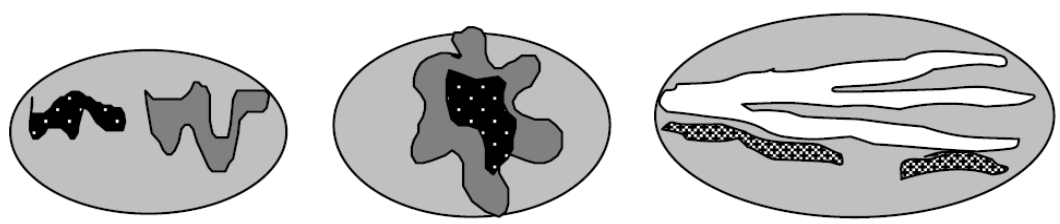


Low = 1 point



Moderate = 2 points

All three diagrams in this row are **HIGH** = 3 points



Score: 1

H 1.5. Special habitat features: Check the habitat features that are present in the wetland. *The number of checks is the number of points.* ☑ Large, downed, woody debris within the wetland (> 4 in diameter and 6 ft long) ☐ Standing snags (dbh > 4 in) within the wetland ☐ Undercut banks are present for at least 6.6 ft (2 m) **and/or** overhanging plants extends at least 3.3 ft (1 m) over a stream (or ditch) in, or contiguous with the wetland, for at least 33 ft (10 m) ☐ Stable steep banks of fine material that might be used by beaver or muskrat for denning (> 30 degree slope) OR signs of recent beaver activity are present (*cut shrubs or trees that have not yet weathered where wood is exposed*) ☐ At least ¼ ac of thin-stemmed persistent plants or woody branches are present in areas that are permanently or seasonally inundated (*structures for egg-laying by amphibians*) ☐ Invasive plants cover less than 25% of the wetland area in every stratum of plants (*see H 1.1 for list of strata*)	1
Total for H 1 — Add the points in the boxes above	**5**

Rating of Site Potential If Score is: ☐ **15 - 18 = H** ☐ **7 - 14 = M** ☑ **0 - 6 = L** *Record the rating on the first page*

H 2.0. Does the landscape have the potential to support the habitat function of the site?	
H 2.1 Accessible habitat (include *only habitat that directly abuts wetland unit*). *Calculate:* 0 % undisturbed habitat + (0 % moderate & low intensity land uses / 2) = 0% If total accessible habitat is: > $^1/_3$ (33.3%) of 1 km Polygon — points = 3 20 - 33% of 1 km Polygon — points = 2 10 - 19% of 1 km Polygon — points = 1 < 10 % of 1 km Polygon — points = 0	0
H 2.2. Undisturbed habitat in 1 km Polygon around the wetland. *Calculate:* 0 % undisturbed habitat + (0 % moderate & low intensity land uses / 2) = 0% Undisturbed habitat > 50% of Polygon — points = 3 Undisturbed habitat 10 - 50% and in 1-3 patches — points = 2 Undisturbed habitat 10 - 50% and > 3 patches — points = 1 Undisturbed habitat < 10% of 1 km Polygon — points = 0	0
H 2.3 Land use intensity in 1 km Polygon: If > 50% of 1 km Polygon is high intensity land use — points = (-2) ≤ 50% of 1km Polygon is high intensity — points = 0	0
Total for H 2 — Add the points in the boxes above	**0**

Rating of Landscape Potential If Score is: ☐ **4 - 6 = H** ☐ **1 - 3 = M** ☑ **< 1 = L** *Record the rating on the first page*

H 3.0. Is the habitat provided by the site valuable to society?	
H 3.1. Does the site provide habitat for species valued in laws, regulations, or policies? *Choose only the highest score that applies to the wetland being rated*. Site meets ANY of the following criteria: — points = 2 ☐ It has 3 or more priority habitats within 100 m (see next page) ☐ It provides habitat for Threatened or Endangered species (any plant or animal on the state or federal lists) ☐ It is mapped as a location for an individual WDFW priority species ☐ It is a Wetland of High Conservation Value as determined by the Department of Natural Resources ☐ It has been categorized as an important habitat site in a local or regional comprehensive plan, in a Shoreline Master Plan, or in a watershed plan Site has 1 or 2 priority habitats (listed on next page) with in 100m — points = 1 Site does not meet any of the criteria above — points = 0	1

Rating of Value If Score is: ☐ **2 = H** ☑ **1 = M** ☐ **0 = L** *Record the rating on the first page*

WDFW Priority Habitats

Priority habitats listed by WDFW (see complete descriptions of WDFW priority habitats, and the counties in which they can be found, in: Washington Department of Fish and Wildlife. 2008. Priority Habitat and Species List. Olympia, Washington. 177 pp.
http://wdfw.wa.gov/publications/00165/wdfw00165.pdf or access the list from here:
http://wdfw.wa.gov/conservation/phs/list/

Count how many of the following priority habitats are within 330 ft (100 m) of the wetland unit: ***NOTE**: This question is independent of the land use between the wetland unit and the priority habitat.*

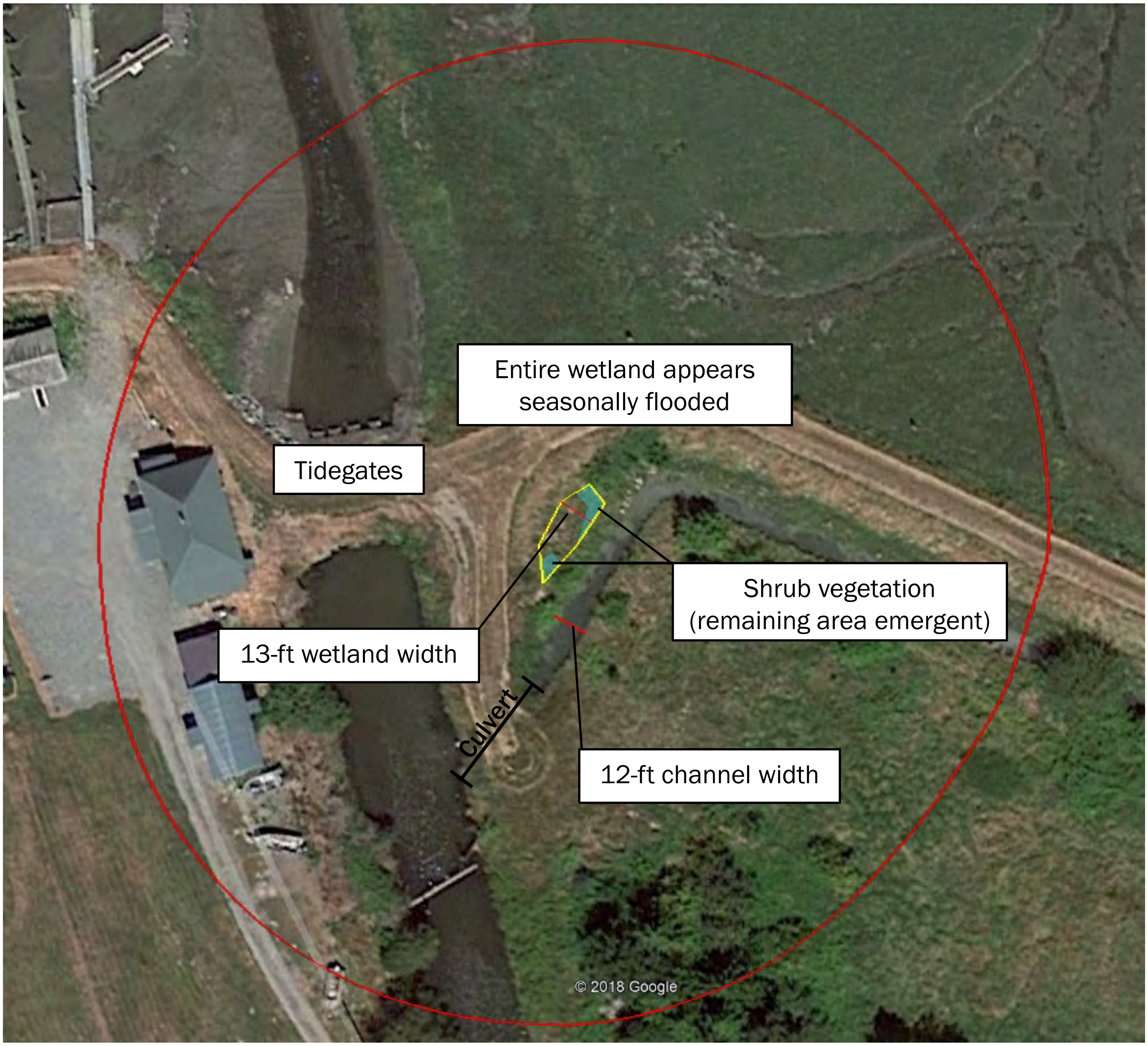
- ☐ **Aspen Stands**: Pure or mixed stands of aspen greater than 1 ac (0.4 ha).
- ☐ **Biodiversity Areas and Corridors**: Areas of habitat that are relatively important to various species of native fish and wildlife (*full descriptions in WDFW PHS report*).
- ☐ **Herbaceous Balds**: Variable size patches of grass and forbs on shallow soils over bedrock.
- ☐ **Old-growth/Mature forests**: Old-growth west of Cascade crest – Stands of at least 2 tree species, forming a multi-layered canopy with occasional small openings; with at least 8 trees/ac (20 trees/ha) > 32 in (81 cm) dbh or > 200 years of age. Mature forests – Stands with average diameters exceeding 21 in (53 cm) dbh; crown cover may be less than 100%; decay, decadence, numbers of snags, and quantity of large downed material is generally less than that found in old-growth; 80-200 years old west of the Cascade crest.
- ☐ **Oregon White Oak**: Woodland stands of pure oak or oak/conifer associations where canopy coverage of the oak component is important (*full descriptions in WDFW PHS report p. 158 – see web link above*).
- ☑ **Riparian**: The area adjacent to aquatic systems with flowing water that contains elements of both aquatic and terrestrial ecosystems which mutually influence each other.
- ☐ **Westside Prairies**: Herbaceous, non-forested plant communities that can either take the form of a dry prairie or a wet prairie (*full descriptions in WDFW PHS report p. 161 – see web link above*).
- ☑ **Instream**: The combination of physical, biological, and chemical processes and conditions that interact to provide functional life history requirements for instream fish and wildlife resources.
- ☐ **Nearshore**: Relatively undisturbed nearshore habitats. These include Coastal Nearshore, Open Coast Nearshore, and Puget Sound Nearshore. (*full descriptions of habitats and the definition of relatively undisturbed are in WDFW report – see web link on previous page*).
- ☐ **Caves**: A naturally occurring cavity, recess, void, or system of interconnected passages under the earth in soils, rock, ice, or other geological formations and is large enough to contain a human.
- ☐ **Cliffs**: Greater than 25 ft (7.6 m) high and occurring below 5000 ft elevation.
- ☐ **Talus**: Homogenous areas of rock rubble ranging in average size 0.5 - 6.5 ft (0.15 - 2.0 m), composed of basalt, andesite, and/or sedimentary rock, including riprap slides and mine tailings. May be associated with cliffs.
- ☐ **Snags and Logs**: Trees are considered snags if they are dead or dying and exhibit sufficient decay characteristics to enable cavity excavation/use by wildlife. Priority snags have a diameter at breast height of > 20 in (51 cm) in western Washington and are > 6.5 ft (2 m) in height. Priority logs are > 12 in (30 cm) in diameter at the largest end, and > 20 ft (6 m) long.

Note: All vegetated wetlands are by definition a priority habitat but are not included in this list because they are addressed elsewhere.

CATEGORIZATION BASED ON SPECIAL CHARACTERISTICS

Wetland Type *Check off any criteria that apply to the wetland. List the category when the appropriate criteria are met.*	Category
SC 1.0. Estuarine Wetlands Does the wetland meet the following criteria for Estuarine wetlands? ☐ The dominant water regime is tidal, ☐ Vegetated, and ☐ With a salinity greater than 0.5 ppt ☐ Yes - Go to **SC 1.1** ☐ No = **Not an estuarine wetland**	
SC 1.1. Is the wetland within a National Wildlife Refuge, National Park, National Estuary Reserve, Natural Area Preserve, State Park or Educational, Environmental, or Scientific Reserve designated under WAC 332-30-151? ☐ Yes = **Category I** ☐ No - Go to **SC 1.2**	
SC 1.2. Is the wetland unit at least 1 ac in size and meets at least two of the following three conditions? ☐ The wetland is relatively undisturbed (has no diking, ditching, filling, cultivation, grazing, and has less than 10% cover of non-native plant species. (If non-native species are *Spartina* , see page 25) ☐ At least ¾ of the landward edge of the wetland has a 100 ft buffer of shrub, forest, or un-grazed or un-mowed grassland. ☐ The wetland has at least two of the following features: tidal channels, depressions with open water, or contiguous freshwater wetlands. ☐ Yes = **Category I** ☐ No = **Category II**	
SC 2.0. Wetlands of High Conservation Value (WHCV) SC 2.1. Has the WA Department of Natural Resources updated their website to include the list of Wetlands of High Conservation Value? ☐ Yes - Go to **SC 2.2** ☐ No - Go to **SC 2.3** SC 2.2. Is the wetland listed on the WDNR database as a Wetland of High Conservation Value? ☐ Yes = **Category I** ☐ No = **Not WHCV** SC 2.3. Is the wetland in a Section/Township/Range that contains a Natural Heritage wetland? http://www1.dnr.wa.gov/nhp/refdesk/datasearch/wnhpwetlands.pdf ☐ Yes - **Contact WNHP/WDNR and to SC 2.4** ☐ No = **Not WHCV** SC 2.4. Has WDNR identified the wetland within the S/T/R as a Wetland of High Conservation Value and listed it on their website? ☐ Yes = **Category I** ☐ No = **Not WHCV**	
SC 3.0. Bogs Does the wetland (or any part of the unit) meet both the criteria for soils and vegetation in bogs? *Use the key below. **If you answer YES you will still need to rate the wetland based on its functions**.* SC 3.1. Does an area within the wetland unit have organic soil horizons, either peats or mucks, that compose 16 in or more of the first 32 in of the soil profile? ☐ Yes - Go to **SC 3.3** ☐ No - Go to **SC 3.2** SC 3.2. Does an area within the wetland unit have organic soils, either peats or mucks, that are less than 16 in deep over bedrock, or an impermeable hardpan such as clay or volcanic ash, or that are floating on top of a lake or pond? ☐ Yes - Go to **SC 3.3** ☐ No = **Is not a bog** SC 3.3. Does an area with peats or mucks have more than 70% cover of mosses at ground level, AND at least a 30% cover of plant species listed in Table 4? ☐ Yes = **Is a Category I bog** ☐ No - Go to **SC 3.4** **NOTE**: If you are uncertain about the extent of mosses in the understory, you may substitute that criterion by measuring the pH of the water that seeps into a hole dug at least 16 in deep. If the pH is less than 5.0 and the plant species in Table 4 are present, the wetland is a bog. SC 3.4. Is an area with peats or mucks forested (> 30% cover) with Sitka spruce, subalpine fir, western red cedar, western hemlock, lodgepole pine, quaking aspen, Engelmann spruce, or western white pine, AND any of the species (or combination of species) listed in Table 4 provide more than 30% of the cover under the canopy? ☐ Yes = **Is a Category I bog** ☐ No = **Is not a bog**	

SC 4.0. Forested Wetlands Does the wetland have at least 1 contiguous acre of forest that meets one of these criteria for the WA Department of Fish and Wildlife's forests as priority habitats? ***If you answer YES you will still need to rate the wetland based on its functions.*** ☐ **Old-growth forests** (west of Cascade crest): Stands of at least two tree species, forming a multi-layered canopy with occasional small openings; with at least 8 trees/ac (20 trees/ha) that are at least 200 years of age OR have a diameter at breast height (dbh) of 32 in (81 cm) or more. ☐ **Mature forests** (west of the Cascade Crest): Stands where the largest trees are 80-200 years old OR the species that make up the canopy have an average diameter (dbh) exceeding 21 in (53 cm). ☐ Yes = **Category I** ☐ No = **Not a forested wetland for this section**	
SC 5.0. Wetlands in Coastal Lagoons Does the wetland meet all of the following criteria of a wetland in a coastal lagoon? ☐ The wetland lies in a depression adjacent to marine waters that is wholly or partially separated from marine waters by sandbanks, gravel banks, shingle, or, less frequently, rocks ☐ The lagoon in which the wetland is located contains ponded water that is saline or brackish (> 0.5 ppt) during most of the year in at least a portion of the lagoon (*needs to be measured near the bottom*) ☐ Yes - Go to **SC 5.1** ☐ No = **Not a wetland in a coastal lagoon** SC 5.1. Does the wetland meet all of the following three conditions? ☐ The wetland is relatively undisturbed (has no diking, ditching, filling, cultivation, grazing), and has less than 20% cover of aggressive, opportunistic plant species (see list of species on p. 100). ☐ At least ¾ of the landward edge of the wetland has a 100 ft buffer of shrub, forest, or un-grazed or un-mowed grassland. ☐ The wetland is larger than $^{1}/_{10}$ ac (4350 ft^2) ☐ Yes = **Category I** ☐ No = **Category II**	
SC 6.0. Interdunal Wetlands Is the wetland west of the 1889 line (also called the Western Boundary of Upland Ownership or WBUO)? ***If you answer yes you will still need to rate the wetland based on its habitat functions.*** In practical terms that means the following geographic areas: ☐ Long Beach Peninsula: Lands west of SR 103 ☐ Grayland-Westport: Lands west of SR 105 ☐ Ocean Shores-Copalis: Lands west of SR 115 and SR 109 ☐ Yes - Go to **SC 6.1** ☐ No = **Not an interdunal wetland for rating** SC 6.1. Is the wetland 1 ac or larger and scores an 8 or 9 for the habitat functions on the form (rates H,H,H or H,H,M for the three aspects of function)? ☐ Yes = **Category I** ☐ No - Go to **SC 6.2** SC 6.2. Is the wetland 1 ac or larger, or is it in a mosaic of wetlands that is 1 ac or larger? ☐ Yes = **Category II** ☐ No - Go to **SC 6.3** SC 6.3. Is the unit between 0.1 and 1 ac, or is it in a mosaic of wetlands that is between 0.1 and 1 ac? ☐ Yes = **Category III** ☐ No = **Category IV**	
Category of wetland based on Special Characteristics If you answered No for all types, enter "Not Applicable" on Summary Form	



0022009700 Date Exported: 07/09/2018

Notes:
1. These illustrations were interpreted based on aerial photograph and are approximate.
2. This illustration is for information purposes. It is intended to assist in showing features discussed in an attached wetland rating form. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files.

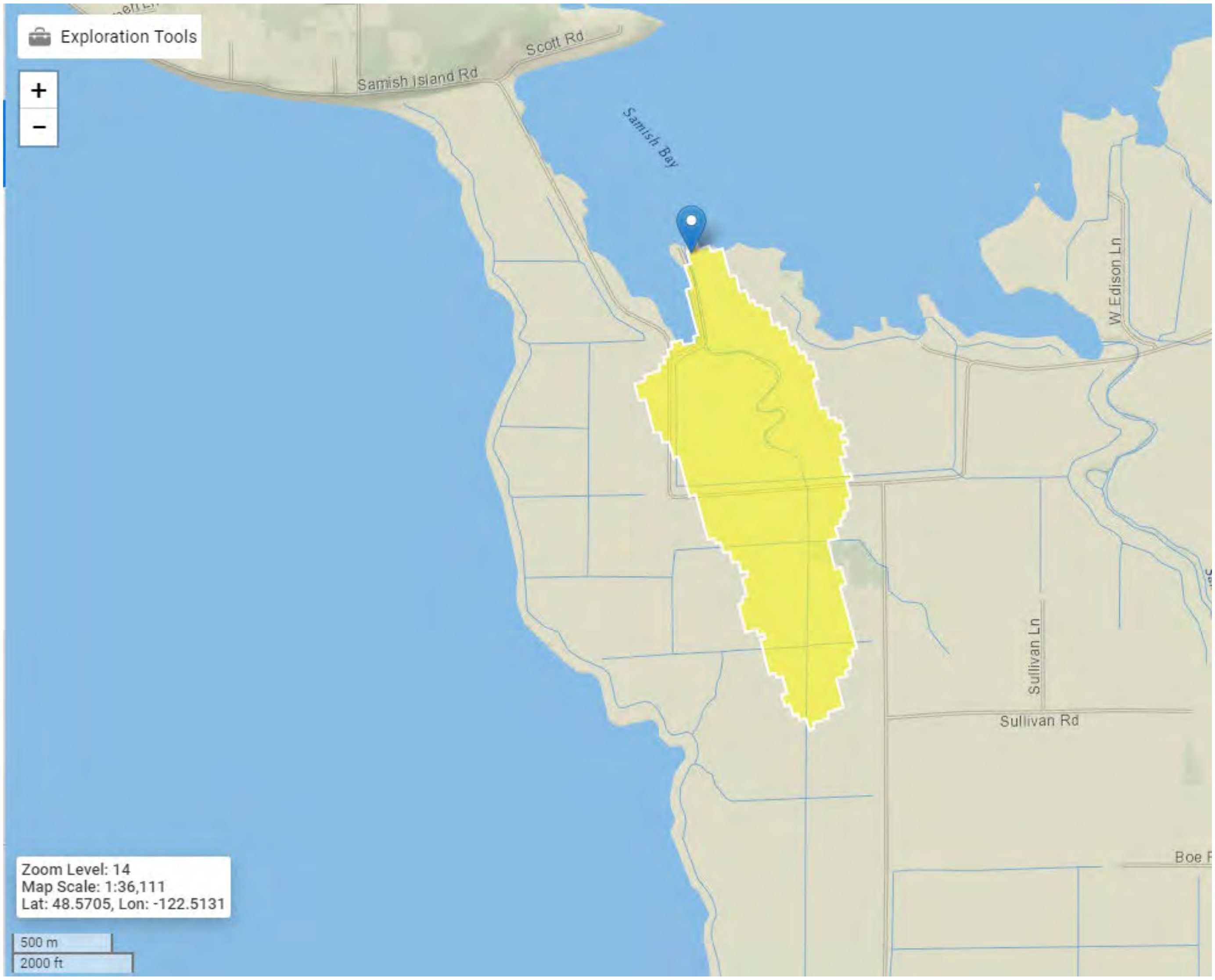
Data Source: Google Earth

150-ft Polygon, Vegetation, and Hydrology

Samish River Floodgates
Skagit County, Washington

GEOENGINEERS

Figure 1



Screenshot from: https://streamstats.usgs.gov/ss/

0022009700 Date Exported: 07/09/2018

Notes:
1. These illustrations were interpreted based on aerial photograph and are approximate.
2. This illustration is for information purposes. It is intended to assist in showing features discussed in an attached wetland rating form. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files.

Data Source: Streamstats Washington

Contributing Basin

Samish River Floodgates
Skagit County, Washington

GEOENGINEERS

Figure 2

Notes:
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Data Source: Google Earth

1km Polygon

Samish River Floodgates
Skagit County, Washington

GeoEngineers

Figure 3

0022009700 Date Exported: 07/09/2018

Screenshot from: https://fortress.wa.gov/ecy/waterqualityatlas/map.aspx

Notes:

1. These illustrations were interpreted based on aerial photograph and are approximate.
2. This illustration is for information purposes. It is intended to assist in showing features discussed in an attached wetland rating form. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files.

Data Source: Ecology Water Quality Atlas Map

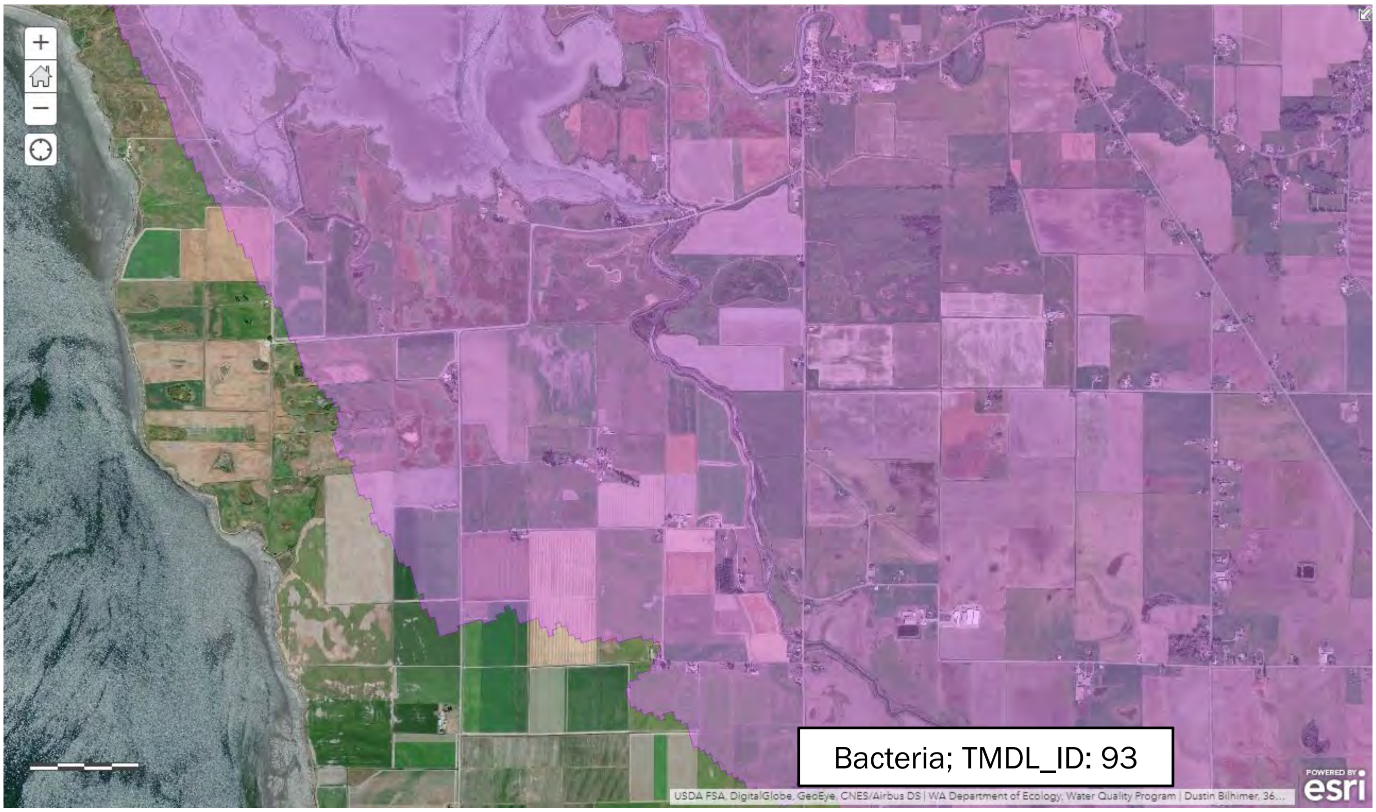
Screen Capture of 303(d) listed waters

Peter Western Bridge Replacement
Burien, Washington

GEOENGINEERS

Figure 4

0022009700 Date Exported: 07/09/2018



https://waecy.maps.arcgis.com/home/webmap/viewer.html?layers=016d27df46004d138cdda32259787400

Notes:
1. These illustrations were interpreted based on aerial photograph and are approximate.
2. This illustration is for information purposes. It is intended to assist in showing features discussed in an attached wetland rating form. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files.

Data Source: WAECY – TMDL Boundaries Map

Screen Capture of TMDL for WRIA

Peter Western Bridge Replacement
Burien, Washington

GEOENGINEERS

Figure 5

0022009700 Date Exported: 07/09/2018

RATING SUMMARY – Western Washington

Name of wetland (or ID #): Wetland B Date of site visit: 7-Jun

Rated by A. Wright Trained by Ecology? ☑ Yes ☐ No Date of training Apr-15

HGM Class used for rating Riverine & Fresh Water Tidal Wetland has multiple HGM classes? ☐ Yes ☑ No

NOTE: Form is not complete with out the figures requested (*figures can be combined*).
Source of base aerial photo/map Google Earth

OVERALL WETLAND CATEGORY III (based on functions ☑ or special characteristics ☐)

1. Category of wetland based on FUNCTIONS

___ **Category I** - Total score = 23 - 27
___ **Category II** - Total score = 20 - 22
X **Category III** - Total score = 16 - 19
___ **Category IV** - Total score = 9 - 15

FUNCTION	Improving Water Quality	Hydrologic	Habitat	
	List appropriate rating (H, M, L)			
Site Potential	M	M	L	
Landscape Potential	M	L	M	
Value	H	H	M	**Total**
Score Based on Ratings	7	6	5	**18**

Score for each function based on three ratings
(*order of ratings is not important*)

9 = H, H, H
8 = H, H, M
7 = H, H, L
7 = H, M, M
6 = H, M, L
6 = M, M, M
5 = H, L, L
5 = M, M, L
4 = M, L, L
3 = L, L, L

2. Category based on SPECIAL CHARACTERISTICS of wetland

CHARACTERISTIC	Category
Estuarine	
Wetland of High Conservation Value	
Bog	
Mature Forest	
Old Growth Forest	
Coastal Lagoon	
Interdunal	
None of the above	X

Maps and Figures required to answer questions correctly for Western Washington

Depressional Wetlands

Map of:	To answer questions:	Figure #
Cowardin plant classes	D 1.3, H 1.1, H 1.4	
Hydroperiods	D 1.4, H 1.2	
Location of outlet (*can be added to map of hydroperiods*)	D 1.1, D 4.1	
Boundary of area within 150 ft of the wetland (*can be added to another figure*)	D 2.2, D 5.2	
Map of the contributing basin	D 4.3, D 5.3	
1 km Polygon: Area that extends 1 km from entire wetland edge - including polygons for accessible habitat and undisturbed habitat	H 2.1, H 2.2, H 2.3	
Screen capture of map of 303(d) listed waters in basin (from Ecology website)	D 3.1, D 3.2	
Screen capture of list of TMDLs for WRIA in which unit is found (from web)	D 3.3	

Riverine Wetlands

Map of:	To answer questions:	Figure #
Cowardin plant classes	H 1.1, H 1.4	1
Hydroperiods	H 1.2	1
Ponded depressions	R 1.1	1
Boundary of area within 150 ft of the wetland (*can be added to another figure*)	R 2.4	1
Plant cover of trees, shrubs, and herbaceous plants	R 1.2, R 4.2	1
Width of unit vs. width of stream (*can be added to another figure*)	R 4.1	1
Map of the contributing basin	R 2.2, R 2.3, R 5.2	1
1 km Polygon: Area that extends 1 km from entire wetland edge - including polygons for accessible habitat and undisturbed habitat	H 2.1, H 2.2, H 2.3	2
Screen capture of map of 303(d) listed waters in basin (from Ecology website)	R 3.1	3
Screen capture of list of TMDLs for WRIA in which unit is found (from web)	R 3.2, R 3.3	4

Lake Fringe Wetlands

Map of:	To answer questions:	Figure #
Cowardin plant classes	L 1.1, L 4.1, H 1.1, H 1.4	
Plant cover of trees, shrubs, and herbaceous plants	L 1.2	
Boundary of area within 150 ft of the wetland (*can be added to another figure*)	L 2.2	
1 km Polygon: Area that extends 1 km from entire wetland edge - including polygons for accessible habitat and undisturbed habitat	H 2.1, H 2.2, H 2.3	
Screen capture of map of 303(d) listed waters in basin (from Ecology website)	L 3.1, L 3.2	
Screen capture of list of TMDLs for WRIA in which unit is found (from web)	L 3.3	

Slope Wetlands

Map of:	To answer questions:	Figure #
Cowardin plant classes	H 1.1, H 1.4	
Hydroperiods	H 1.2	
Plant cover of **dense** trees, shrubs, and herbaceous plants	S 1.3	
Plant cover of **dense, rigid** trees, shrubs, and herbaceous plants (*can be added to another figure*)	S 4.1	
Boundary of area within 150 ft of the wetland (*can be added to another figure*)	S 2.1, S 5.1	
1 km Polygon: Area that extends 1 km from entire wetland edge - including polygons for accessible habitat and undisturbed habitat	H 2.1, H 2.2, H 2.3	
Screen capture of map of 303(d) listed waters in basin (from Ecology website)	S 3.1, S 3.2	
Screen capture of list of TMDLs for WRIA in which unit is found (from web)	S 3.3	

HGM Classification of Wetland in Western Washington

For questions 1 -7, the criteria described must apply to the entire unit being rated.
If hydrologic criteria listed in each question do not apply to the entire unit being rated, you probably have a unit with multiple HGM classes. In this case, identify which hydrologic criteria in questions 1 - 7 apply, and go to Question 8.

1. Are the water levels in the entire unit usually controlled by tides except during floods?

☑ NO - go to 2 ☐ **YES** - the wetland class is **Tidal Fringe** - go to 1.1

1.1 Is the salinity of the water during periods of annual low flow below 0.5 ppt (parts per thousand)?

☐ **NO - Saltwater Tidal Fringe (Estuarine)** ☐ **YES - Freshwater Tidal Fringe**

If your wetland can be classified as a Freshwater Tidal Fringe use the forms for ***Riverine*** *wetlands. If it is Saltwater Tidal Fringe it is an* ***Estuarine*** *wetland and is not scored. This method* ***cannot*** *be used to score functions for estuarine wetlands.*

2. The entire wetland unit is flat and precipitation is the only source (>90%) of water to it. Groundwater and surface water runoff are NOT sources of water to the unit.

☑ NO - go to 3 ☐ **YES** - The wetland class is **Flats**

If your wetland can be classified as a Flats wetland, use the form for ***Depressional*** *wetlands.*

3. Does the entire wetland unit **meet all** of the following criteria?

☐ The vegetated part of the wetland is on the shores of a body of permanent open water (without any plants on the surface at any time of the year) at least 20 ac (8 ha) in size;
☐ At least 30% of the open water area is deeper than 6.6 ft (2 m).

☑ NO - go to 4 ☐ **YES** - The wetland class is **Lake Fringe** (Lacustrine Fringe)

4. Does the entire wetland unit **meet all** of the following criteria?

☐ The wetland is on a slope (*slope can be very gradual*),
☐ The water flows through the wetland in one direction (unidirectional) and usually comes from seeps. It may flow subsurface, as sheetflow, or in a swale without distinct banks.
☐ The water leaves the wetland **without being impounded.**

☑ NO - go to 5 ☐ **YES** - The wetland class is **Slope**

NOTE: Surface water does not pond in these type of wetlands except occasionally in very small and shallow depressions or behind hummocks (depressions are usually <3 ft diameter and less than 1 ft deep).

5. Does the entire wetland unit **meet all** of the following criteria?

☑ The unit is in a valley, or stream channel, where it gets inundated by overbank flooding from that stream or river,
☑ The overbank flooding occurs at least once every 2 years.

☐ NO - go to 6 ☑ **YES** - The wetland class is **Riverine**

NOTE: The Riverine unit can contain depressions that are filled with water when the river is not flooding.

6. Is the entire wetland unit in a topographic depression in which water ponds, or is saturated to the surface, at some time during the year? *This means that any outlet, if present, is higher than the interior of the wetland.*

☐ NO - go to 7 ☐ **YES** - The wetland class is **Depressional**

7. Is the entire wetland unit located in a very flat area with no obvious depression and no overbank flooding? The unit does not pond surface water more than a few inches. The unit seems to be maintained by high groundwater in the area. The wetland may be ditched, but has no obvious natural outlet.

☐ NO - go to 8 ☐ **YES** - The wetland class is **Depressional**

8. Your wetland unit seems to be difficult to classify and probably contains several different HGM classes. For example, seeps at the base of a slope may grade into a riverine floodplain, or a small stream within a Depressional wetland has a zone of flooding along its sides. GO BACK AND IDENTIFY WHICH OF THE HYDROLOGIC REGIMES DESCRIBED IN QUESTIONS 1-7 APPLY TO DIFFERENT AREAS IN THE UNIT (make a rough sketch to help you decide). Use the following table to identify the appropriate class to use for the rating system if you have several HGM classes present within the wetland unit being scored.

NOTE: Use this table only if the class that is recommended in the second column represents 10% or more of the total area of the wetland unit being rated. If the area of the HGM class listed in column 2 is less than 10% of the unit; classify the wetland using the class that represents more than 90% of the total area.

HGM classes within the wetland unit being rated	HGM class to use in rating
Slope + Riverine	Riverine
Slope + Depressional	Depressional
Slope + Lake Fringe	Lake Fringe
Depressional + Riverine along stream within boundary of depression	Depressional
Depressional + Lake Fringe	Depressional
Riverine + Lake Fringe	Riverine
Salt Water Tidal Fringe and any other class of freshwater wetland	Treat as ESTUARINE

If you are still unable to determine which of the above criteria apply to your wetland, or if you have ***more than 2 HGM classes*** *within a wetland boundary, classify the wetland as Depressional for the rating.*

NOTES and FIELD OBSERVATIONS:

RIVERINE AND FRESHWATER TIDAL FRINGE WETLANDS

Water Quality Functions - Indicators that the site functions to improve water quality

R 1.0. Does the site have the potential to improve water quality?		
R 1.1. Area of surface depressions within the Riverine wetland that can trap sediments during a flooding event:		0
Depressions cover > 3/4 area of wetland	points = 8	
Depressions cover > ½ area of wetland	points = 4	
Depressions present but cover < ½ area of wetland	points = 2	
No depressions present	points = 0	
R 1.2. Structure of plants in the wetland (areas with >90% cover at person height, **not** Cowardin classes)		6
Trees or shrubs > 2/3 area of the wetland	points = 8	
☐ Trees or shrubs > 1/3 area of the wetland	points = 6	
☑ Herbaceous plants (> 6 in high) > 2/3 area of the wetland	points = 6	
Herbaceous plants (> 6 in high) > 1/3 area of the wetland	points = 3	
Trees, shrubs, and ungrazed herbaceous < 1/3 area of the wetland	points = 0	
Total for R 1	Add the points in the boxes above	**6**

Rating of Site Potential If score is: ☐ **12 - 16 = H** ☑ **6 - 11 = M** ☐ **0 - 5 = L** *Record the rating on the first page*

R 2.0. Does the landscape have the potential to support the water quality function of the site?		
R 2.1. Is the wetland within an incorporated city or within its UGA?	Yes = 2 No = 0	0
R 2.2. Does the contributing basin to the wetland include a UGA or incorporated area?	Yes = 1 No = 0	0
R 2.3. Does at least 10% of the contributing basin contain tilled fields, pastures, or forests that have been clearcut within the last 5 years?	Yes = 1 No = 0	0
R 2.4. Is > 10% of the area within 150 ft of the wetland in land uses that generate pollutants?	Yes = 1 No = 0	0
R 2.5. Are there other sources of pollutants coming into the wetland that are not listed in questions R 2.1 - R 2.4? Other Sources <u>Creek/ditch draining ag fields</u>	Yes = 1 No = 0	1
Total for R 2	Add the points in the boxes above	**1**

Rating of Landscape Potential If score is: ☐ **3 - 6 = H** ☑ **1 or 2 = M** ☐ **0 = L** *Record the rating on the first page*

R 3.0. Is the water quality improvement provided by the site valuable to society?		
R 3.1. Is the wetland along a stream or river that is on the 303(d) list or on a tributary that drains to one within 1 mi?	Yes = 1 No = 0	1
R 3.2. Is the wetland along a stream or river that has TMDL limits for nutrients, toxics, or pathogens?	Yes = 1 No = 0	0
R 3.3. Has the site been identified in a watershed or local plan as important for maintaining water quality? (*answer YES if there is a TMDL for the drainage in which the unit is found*)	Yes = 2 No = 0	2
Total for R 3	Add the points in the boxes above	**3**

Rating of Value If score is: ☑ **2 - 4 = H** ☐ **1 = M** ☐ **0 = L** *Record the rating on the first page*

RIVERINE AND FRESHWATER TIDAL FRINGE WETLANDS

Hydrologic Functions - Indicators that site functions to reduce flooding and stream erosion

R 4.0. Does the site have the potential to reduce flooding and erosion?		
R 4.1. Characteristics of the overbank storage the wetland provides: *Estimate the average width of the wetland perpendicular to the direction of the flow and the width of the stream or river channel (distance between banks). Calculate the ratio: (average width of wetland)/(average width of stream between banks).* If the ratio is more than 20 If the ratio is 10 - 20 If the ratio is 5 - < 10 If the ratio is 1 - < 5 If the ratio is < 1	points = 9 points = 6 points = 4 points = 2 points = 1	2
R 4.2. Characteristics of plants that slow down water velocities during floods: *Treat large woody debris as forest or shrub. Choose the points appropriate for the best description (polygons need to have >90% cover at person height. These are NOT Cowardin classes).* Forest or shrub for > $^{1}/_{3}$ area OR emergent plants > $^{2}/_{3}$ area Forest or shrub for > $^{1}/_{10}$ area OR emergent plants > $^{1}/_{3}$ area Plants do not meet above criteria	points = 7 points = 4 points = 0	7
Total for R 4	Add the points in the boxes above	**9**

Rating of Site Potential If score is: ☐ **12 - 16 = H** ☑ **6 - 11 = M** ☐ **0 - 5 = L** *Record the rating on the first page*

R 5.0. Does the landscape have the potential to support the hydrologic functions of the site?		
R 5.1. Is the stream or river adjacent to the wetland downcut?	Yes = 0 No = 1	0
R 5.2. Does the up-gradient watershed include a UGA or incorporated area?	Yes = 1 No = 0	0
R 5.3 Is the up-gradient stream or river controlled by dams?	Yes = 0 No = 1	0
Total for R 5	Add the points in the boxes above	**0**

Rating of Landscape Potential If score is: ☐ **3 = H** ☐ **1 or 2 = M** ☑ **0 = L** *Record the rating on the first page*

R 6.0. Are the hydrologic functions provided by the site valuable to society?		
R 6.1. Distance to the nearest areas downstream that have flooding problems? *Choose the description that best fits the site.* The sub-basin immediately down-gradient of the wetland has flooding problems that result in damage to human or natural resources (e.g., houses or salmon redds) Surface flooding problems are in a sub-basin farther down-gradient No flooding problems anywhere downstream	points = 2 points = 1 points = 0	0
R 6.2. Has the site been identified as important for flood storage or flood conveyance in a regional flood control plan?	Yes = 2 No = 0	2
Total for R 6	Add the points in the boxes above	**2**

Rating of Value If score is: ☑ **2 - 4 = H** ☐ **1 = M** ☐ **0 = L** *Record the rating on the first page*

These questions apply to wetlands of all HGM classes.

HABITAT FUNCTIONS - Indicators that site functions to provide important habitat

H 1.0. Does the site have the potential to provide habitat?

H 1.1. Structure of plant community: *Indicators are Cowardin classes and strata within the Forested class.* Check the Cowardin plant classes in the wetland. *Up to 10 patches may be combined for each class to meet the threshold of ¼ ac or more than 10% of the unit if it is smaller than 2.5 ac. Add the number of structures checked.*

☐ Aquatic bed	4 structures or more: points = 4	0
☑ Emergent	3 structures: points = 2	
☐ Scrub-shrub (areas where shrubs have > 30% cover)	2 structures: points - 1	
☐ Forested (areas where trees have > 30% cover)	1 structure: points = 0	

If the unit has a Forested class, check if:

☐ The Forested class has 3 out of 5 strata (canopy, sub-canopy, shrubs, herbaceous, moss/ground-cover) that each cover 20% within the Forested polygon

H 1.2. Hydroperiods

Check the types of water regimes (hydroperiods) present within the wetland. The water regime has to cover more than 10% of the wetland or ¼ ac to count (*see text for descriptions of hydroperiods*).

☐ Permanently flooded or inundated	4 or more types present: points = 3	
☑ Seasonally flooded or inundated	3 types present: points = 2	1
☐ Occasionally flooded or inundated	2 types present: points = 1	
☐ Saturated only	1 types present: points = 0	
☑ Permanently flowing stream or river in, or adjacent to, the wetland		
☐ Seasonally flowing stream in, or adjacent to, the wetland		
☐ **Lake Fringe wetland**	**2 points**	
☐ **Freshwater tidal wetland**	**2 points**	

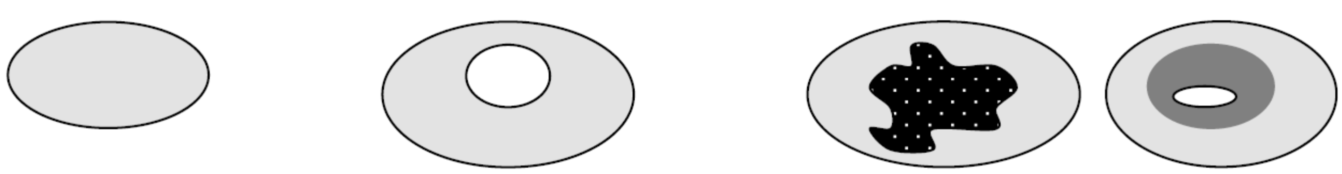
H 1.3. Richness of plant species

Count the number of plant species in the wetland that cover at least 10 ft^2.
Different patches of the same species can be combined to meet the size threshold and you do not have to name the species. ***Do not include Eurasian milfoil, reed canarygrass, purple loosestrife, Canadian thistle***

If you counted:	> 19 species	points = 2	1
	5 - 19 species	points = 1	
	< 5 species	points = 0	

H 1.4. Interspersion of habitats

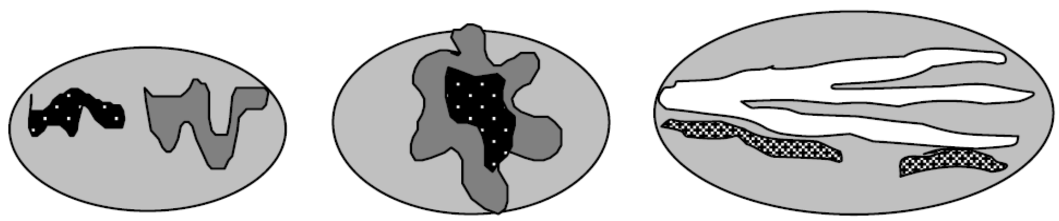
Decide from the diagrams below whether interspersion among Cowardin plants classes (described in H 1.1), or the classes and unvegetated areas (can include open water or mudflats) is high, moderate, low, or none. *If you have four or more plant classes or three classes and open water, the rating is always high.*



None = 0 points　　**Low** = 1 point　　**Moderate** = 2 points

0

All three diagrams in this row are **HIGH** = 3 points



H 1.5. Special habitat features: Check the habitat features that are present in the wetland. *The number of checks is the number of points.* ☐ Large, downed, woody debris within the wetland (> 4 in diameter and 6 ft long) ☐ Standing snags (dbh > 4 in) within the wetland ☐ Undercut banks are present for at least 6.6 ft (2 m) **and/or** overhanging plants extends at least 3.3 ft (1 m) over a stream (or ditch) in, or contiguous with the wetland, for at least 33 ft (10 m) ☐ Stable steep banks of fine material that might be used by beaver or muskrat for denning (> 30 degree slope) OR signs of recent beaver activity are present (*cut shrubs or trees that have not yet weathered where wood is exposed*) ☐ At least ¼ ac of thin-stemmed persistent plants or woody branches are present in areas that are permanently or seasonally inundated (*structures for egg-laying by amphibians*) ☐ Invasive plants cover less than 25% of the wetland area in every stratum of plants (*see H 1.1 for list of strata*)	
Total for H 1 — Add the points in the boxes above	**2**

Rating of Site Potential If Score is: ☐ **15 - 18 = H** ☐ **7 - 14 = M** ☑ **0 - 6 = L** *Record the rating on the first page*

H 2.0. Does the landscape have the potential to support the habitat function of the site?	
H 2.1 Accessible habitat (include *only habitat that directly abuts wetland unit*). *Calculate:* 0 % undisturbed habitat + (0 % moderate & low intensity land uses / 2) = 0% If total accessible habitat is: > 1/3 (33.3%) of 1 km Polygon — points = 3 20 - 33% of 1 km Polygon — points = 2 10 - 19% of 1 km Polygon — points = 1 < 10 % of 1 km Polygon — points = 0	0
H 2.2. Undisturbed habitat in 1 km Polygon around the wetland. *Calculate:* 12.6 % undisturbed habitat + (0 % moderate & low intensity land uses / 2) = 12.6% Undisturbed habitat > 50% of Polygon — points = 3 Undisturbed habitat 10 - 50% and in 1-3 patches — points = 2 Undisturbed habitat 10 - 50% and > 3 patches — points = 1 Undisturbed habitat < 10% of 1 km Polygon — points = 0	2
H 2.3 Land use intensity in 1 km Polygon: If > 50% of 1 km Polygon is high intensity land use — points = (-2) ≤ 50% of 1km Polygon is high intensity — points = 0	0
Total for H 2 — Add the points in the boxes above	**2**

Rating of Landscape Potential If Score is: ☐ **4 - 6 = H** ☑ **1 - 3 = M** ☐ **< 1 = L** *Record the rating on the first page*

H 3.0. Is the habitat provided by the site valuable to society?	
H 3.1. Does the site provide habitat for species valued in laws, regulations, or policies? *Choose only the highest score that applies to the wetland being rated*. Site meets ANY of the following criteria: — points = 2 ☐ It has 3 or more priority habitats within 100 m (see next page) ☐ It provides habitat for Threatened or Endangered species (any plant or animal on the state or federal lists) ☐ It is mapped as a location for an individual WDFW priority species ☐ It is a Wetland of High Conservation Value as determined by the Department of Natural Resources ☐ It has been categorized as an important habitat site in a local or regional comprehensive plan, in a Shoreline Master Plan, or in a watershed plan Site has 1 or 2 priority habitats (listed on next page) with in 100m — points = 1 Site does not meet any of the criteria above — points = 0	1

Rating of Value If Score is: ☐ **2 = H** ☑ **1 = M** ☐ **0 = L** *Record the rating on the first page*

WDFW Priority Habitats

Priority habitats listed by WDFW (see complete descriptions of WDFW priority habitats, and the counties in which they can be found, in: Washington Department of Fish and Wildlife. 2008. Priority Habitat and Species List. Olympia, Washington. 177 pp.
http://wdfw.wa.gov/publications/00165/wdfw00165.pdf or access the list from here:
http://wdfw.wa.gov/conservation/phs/list/

Count how many of the following priority habitats are within 330 ft (100 m) of the wetland unit: ***NOTE**: This question is independent of the land use between the wetland unit and the priority habitat.*

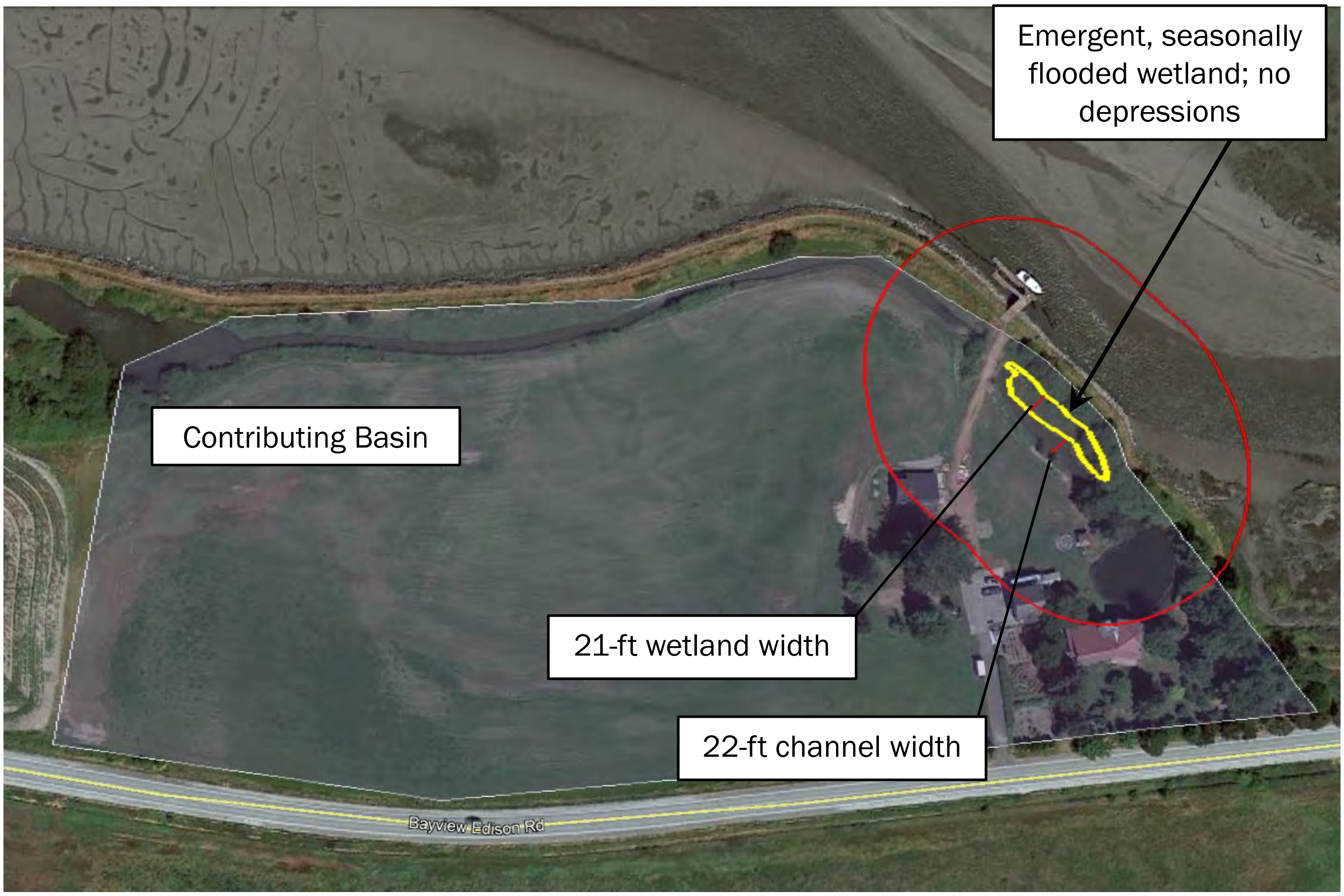
- ☐ **Aspen Stands**: Pure or mixed stands of aspen greater than 1 ac (0.4 ha).
- ☐ **Biodiversity Areas and Corridors**: Areas of habitat that are relatively important to various species of native fish and wildlife (*full descriptions in WDFW PHS report*).
- ☐ **Herbaceous Balds**: Variable size patches of grass and forbs on shallow soils over bedrock.
- ☐ **Old-growth/Mature forests**: Old-growth west of Cascade crest – Stands of at least 2 tree species, forming a multi-layered canopy with occasional small openings; with at least 8 trees/ac (20 trees/ha) > 32 in (81 cm) dbh or > 200 years of age. Mature forests – Stands with average diameters exceeding 21 in (53 cm) dbh; crown cover may be less than 100%; decay, decadence, numbers of snags, and quantity of large downed material is generally less than that found in old-growth; 80-200 years old west of the Cascade crest.
- ☐ **Oregon White Oak**: Woodland stands of pure oak or oak/conifer associations where canopy coverage of the oak component is important (*full descriptions in WDFW PHS report p. 158 – see web link above*).
- ☑ **Riparian**: The area adjacent to aquatic systems with flowing water that contains elements of both aquatic and terrestrial ecosystems which mutually influence each other.
- ☐ **Westside Prairies**: Herbaceous, non-forested plant communities that can either take the form of a dry prairie or a wet prairie (*full descriptions in WDFW PHS report p. 161 – see web link above*).
- ☑ **Instream**: The combination of physical, biological, and chemical processes and conditions that interact to provide functional life history requirements for instream fish and wildlife resources.
- ☐ **Nearshore**: Relatively undisturbed nearshore habitats. These include Coastal Nearshore, Open Coast Nearshore, and Puget Sound Nearshore. (*full descriptions of habitats and the definition of relatively undisturbed are in WDFW report – see web link on previous page*).
- ☐ **Caves**: A naturally occurring cavity, recess, void, or system of interconnected passages under the earth in soils, rock, ice, or other geological formations and is large enough to contain a human.
- ☐ **Cliffs**: Greater than 25 ft (7.6 m) high and occurring below 5000 ft elevation.
- ☐ **Talus**: Homogenous areas of rock rubble ranging in average size 0.5 - 6.5 ft (0.15 - 2.0 m), composed of basalt, andesite, and/or sedimentary rock, including riprap slides and mine tailings. May be associated with cliffs.
- ☐ **Snags and Logs**: Trees are considered snags if they are dead or dying and exhibit sufficient decay characteristics to enable cavity excavation/use by wildlife. Priority snags have a diameter at breast height of > 20 in (51 cm) in western Washington and are > 6.5 ft (2 m) in height. Priority logs are > 12 in (30 cm) in diameter at the largest end, and > 20 ft (6 m) long.

Note: All vegetated wetlands are by definition a priority habitat but are not included in this list because they are addressed elsewhere.

CATEGORIZATION BASED ON SPECIAL CHARACTERISTICS

Wetland Type *Check off any criteria that apply to the wetland. List the category when the appropriate criteria are met.*	**Category**
SC 1.0. Estuarine Wetlands Does the wetland meet the following criteria for Estuarine wetlands? ☐ The dominant water regime is tidal, ☐ Vegetated, and ☐ With a salinity greater than 0.5 ppt ☐ Yes - Go to **SC 1.1** ☐ No = **Not an estuarine wetland**	
SC 1.1. Is the wetland within a National Wildlife Refuge, National Park, National Estuary Reserve, Natural Area Preserve, State Park or Educational, Environmental, or Scientific Reserve designated under WAC 332-30-151? ☐ Yes = **Category I** ☐ No - Go to **SC 1.2**	
SC 1.2. Is the wetland unit at least 1 ac in size and meets at least two of the following three conditions? ☐ The wetland is relatively undisturbed (has no diking, ditching, filling, cultivation, grazing, and has less than 10% cover of non-native plant species. (If non-native species are *Spartina* , see page 25) ☐ At least ¾ of the landward edge of the wetland has a 100 ft buffer of shrub, forest, or un-grazed or un-mowed grassland. ☐ The wetland has at least two of the following features: tidal channels, depressions with open water, or contiguous freshwater wetlands. ☐ Yes = **Category I** ☐ No = **Category II**	
SC 2.0. Wetlands of High Conservation Value (WHCV) SC 2.1. Has the WA Department of Natural Resources updated their website to include the list of Wetlands of High Conservation Value? ☐ Yes - Go to **SC 2.2** ☐ No - Go to **SC 2.3** SC 2.2. Is the wetland listed on the WDNR database as a Wetland of High Conservation Value? ☐ Yes = **Category I** ☐ No = **Not WHCV** SC 2.3. Is the wetland in a Section/Township/Range that contains a Natural Heritage wetland? http://www1.dnr.wa.gov/nhp/refdesk/datasearch/wnhpwetlands.pdf ☐ Yes - **Contact WNHP/WDNR and to SC 2.4** ☐ No = **Not WHCV** SC 2.4. Has WDNR identified the wetland within the S/T/R as a Wetland of High Conservation Value and listed it on their website? ☐ Yes = **Category I** ☐ No = **Not WHCV**	
SC 3.0. Bogs Does the wetland (or any part of the unit) meet both the criteria for soils and vegetation in bogs? *Use the key below.* ***If you answer YES you will still need to rate the wetland based on its functions*** *.* SC 3.1. Does an area within the wetland unit have organic soil horizons, either peats or mucks, that compose 16 in or more of the first 32 in of the soil profile? ☐ Yes - Go to **SC 3.3** ☐ No - Go to **SC 3.2** SC 3.2. Does an area within the wetland unit have organic soils, either peats or mucks, that are less than 16 in deep over bedrock, or an impermeable hardpan such as clay or volcanic ash, or that are floating on top of a lake or pond? ☐ Yes - Go to **SC 3.3** ☐ No = **Is not a bog** SC 3.3. Does an area with peats or mucks have more than 70% cover of mosses at ground level, AND at least a 30% cover of plant species listed in Table 4? ☐ Yes = **Is a Category I bog** ☐ No - Go to **SC 3.4** **NOTE**: If you are uncertain about the extent of mosses in the understory, you may substitute that criterion by measuring the pH of the water that seeps into a hole dug at least 16 in deep. If the pH is less than 5.0 and the plant species in Table 4 are present, the wetland is a bog. SC 3.4. Is an area with peats or mucks forested (> 30% cover) with Sitka spruce, subalpine fir, western red cedar, western hemlock, lodgepole pine, quaking aspen, Engelmann spruce, or western white pine, AND any of the species (or combination of species) listed in Table 4 provide more than 30% of the cover under the canopy? ☐ Yes = **Is a Category I bog** ☐ No = **Is not a bog**	

SC 4.0. Forested Wetlands Does the wetland have at least 1 contiguous acre of forest that meets one of these criteria for the WA Department of Fish and Wildlife's forests as priority habitats? ***If you answer YES you will still need to rate the wetland based on its functions.*** ☐ **Old-growth forests** (west of Cascade crest): Stands of at least two tree species, forming a multi-layered canopy with occasional small openings; with at least 8 trees/ac (20 trees/ha) that are at least 200 years of age OR have a diameter at breast height (dbh) of 32 in (81 cm) or more. ☐ **Mature forests** (west of the Cascade Crest): Stands where the largest trees are 80-200 years old OR the species that make up the canopy have an average diameter (dbh) exceeding 21 in (53 cm). ☐ Yes = **Category I** ☐ No = **Not a forested wetland for this section**	
SC 5.0. Wetlands in Coastal Lagoons Does the wetland meet all of the following criteria of a wetland in a coastal lagoon? ☐ The wetland lies in a depression adjacent to marine waters that is wholly or partially separated from marine waters by sandbanks, gravel banks, shingle, or, less frequently, rocks ☐ The lagoon in which the wetland is located contains ponded water that is saline or brackish (> 0.5 ppt) during most of the year in at least a portion of the lagoon (*needs to be measured near the bottom*) ☐ Yes - Go to **SC 5.1** ☐ No = **Not a wetland in a coastal lagoon** SC 5.1. Does the wetland meet all of the following three conditions? ☐ The wetland is relatively undisturbed (has no diking, ditching, filling, cultivation, grazing), and has less than 20% cover of aggressive, opportunistic plant species (see list of species on p. 100). ☐ At least ¾ of the landward edge of the wetland has a 100 ft buffer of shrub, forest, or un-grazed or un-mowed grassland. ☐ The wetland is larger than $^{1}/_{10}$ ac (4350 ft^2) ☐ Yes = **Category I** ☐ No = **Category II**	
SC 6.0. Interdunal Wetlands Is the wetland west of the 1889 line (also called the Western Boundary of Upland Ownership or WBUO)? ***If you answer yes you will still need to rate the wetland based on its habitat functions.*** In practical terms that means the following geographic areas: ☐ Long Beach Peninsula: Lands west of SR 103 ☐ Grayland-Westport: Lands west of SR 105 ☐ Ocean Shores-Copalis: Lands west of SR 115 and SR 109 ☐ Yes - Go to **SC 6.1** ☐ No = **Not an interdunal wetland for rating** SC 6.1. Is the wetland 1 ac or larger and scores an 8 or 9 for the habitat functions on the form (rates H,H,H or H,H,M for the three aspects of function)? ☐ Yes = **Category I** ☐ No - Go to **SC 6.2** SC 6.2. Is the wetland 1 ac or larger, or is it in a mosaic of wetlands that is 1 ac or larger? ☐ Yes = **Category II** ☐ No - Go to **SC 6.3** SC 6.3. Is the unit between 0.1 and 1 ac, or is it in a mosaic of wetlands that is between 0.1 and 1 ac? ☐ Yes = **Category III** ☐ No = **Category IV**	
Category of wetland based on Special Characteristics If you answered No for all types, enter "Not Applicable" on Summary Form	



Notes:
1. These illustrations were interpreted based on aerial photograph and are approximate.
2. This illustration is for information purposes. It is intended to assist in showing features discussed in an attached wetland rating form. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files.

Data Source: Google Earth

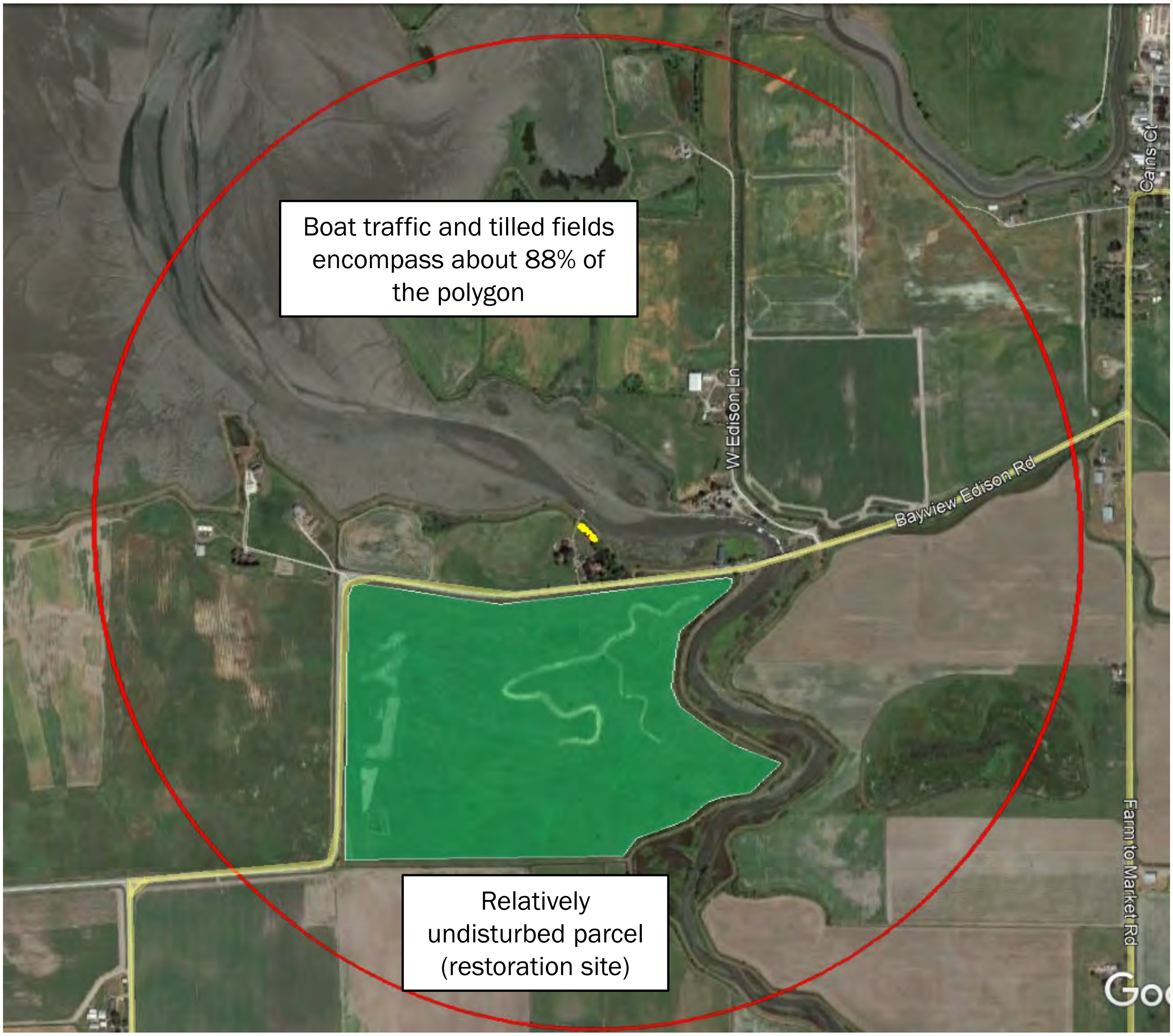
150-ft Polygon, Vegetation, and Hydrology

Samish River Floodgates
Skagit County, Washington

GEOENGINEERS

Figure 1

0022009700 Date Exported: 07/09/2018



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Data Source: Google Earth

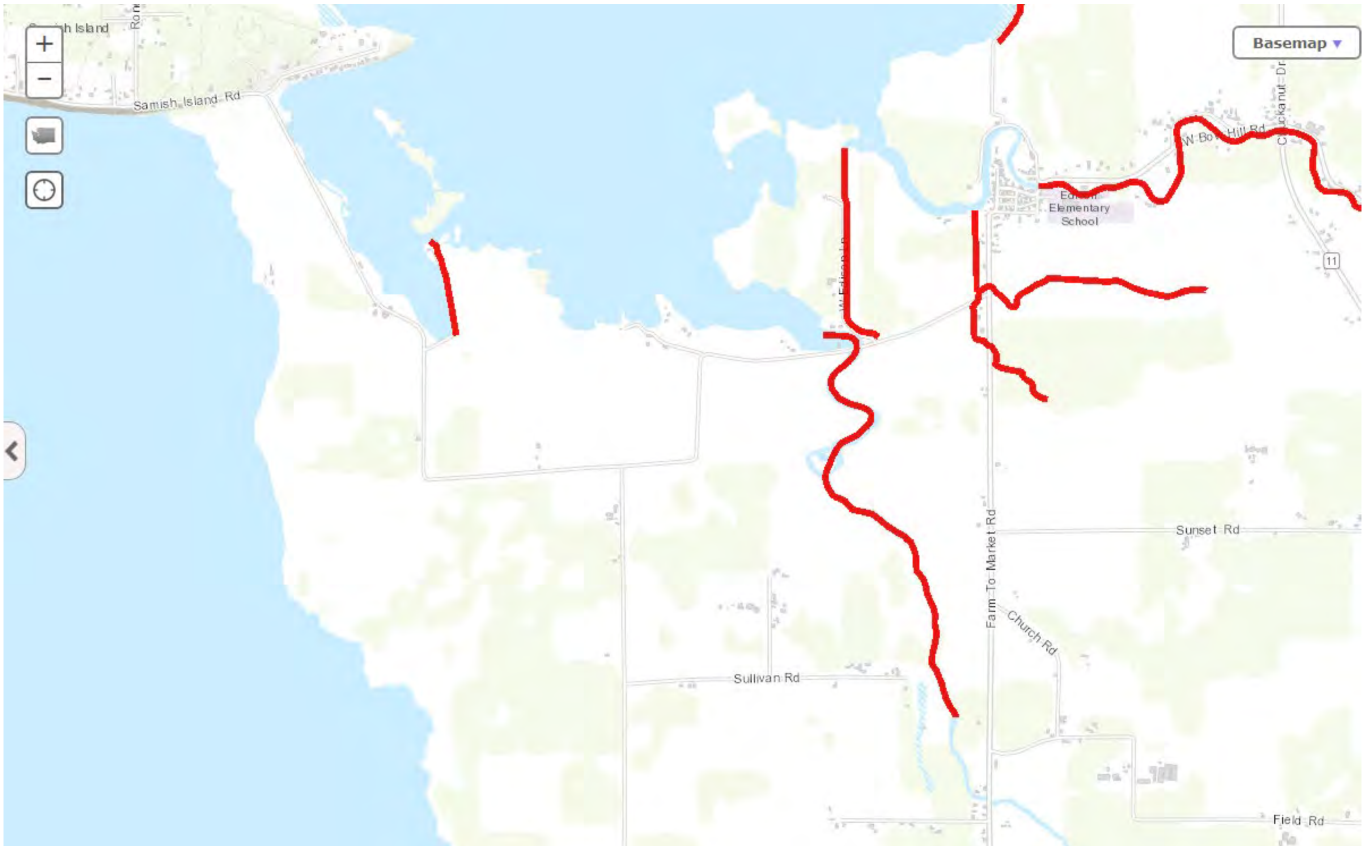
1km Polygon

Samish River Floodgates
Skagit County, Washington

GEOENGINEERS

Figure 2

0022009700 Date Exported: 07/09/2018



Screenshot from: https://fortress.wa.gov/ecy/waterqualityatlas/map.aspx

Notes:
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Data Source: Ecology Water Quality Atlas Map

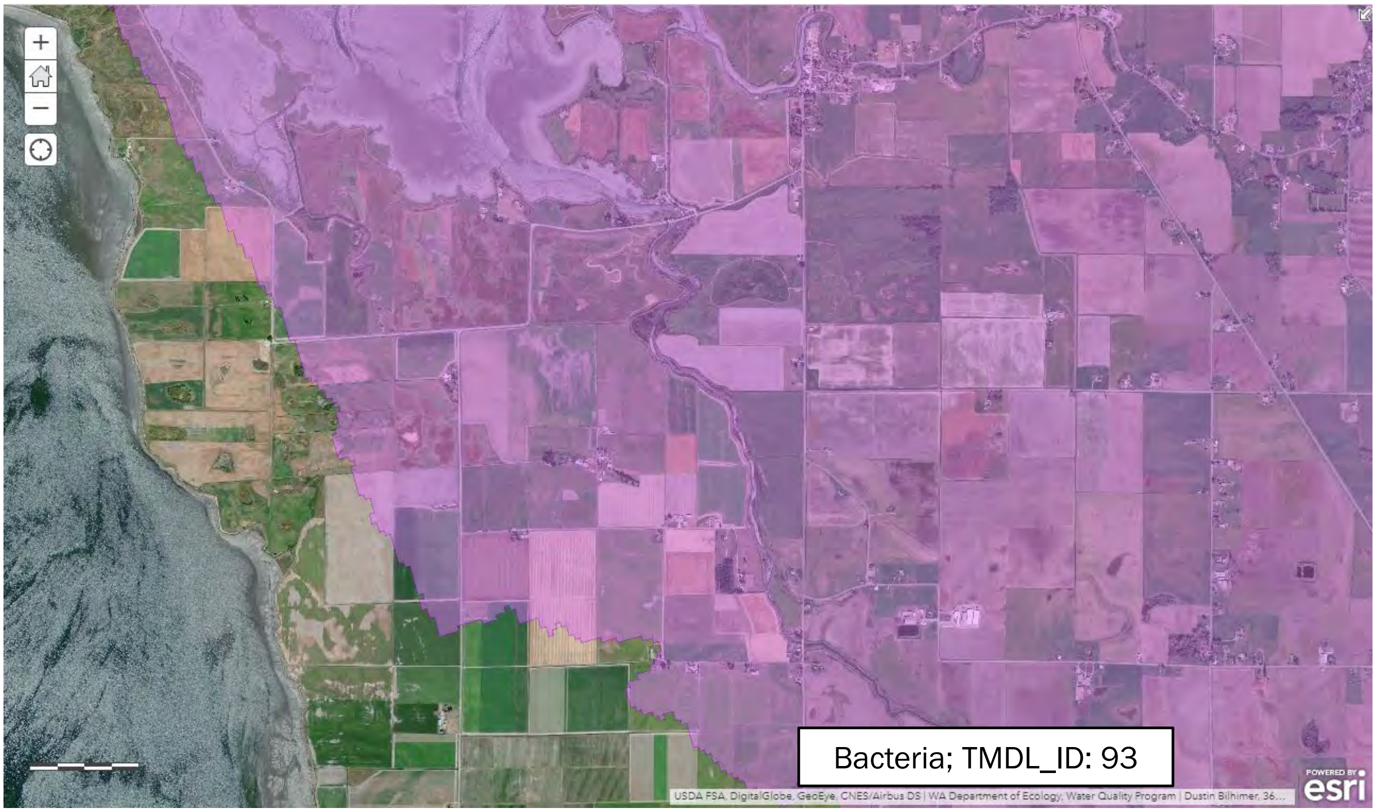
Screen Capture of 303(d) listed waters

Peter Western Bridge Replacement
Burien, Washington

GEOENGINEERS

Figure 3

0022009700 Date Exported: 07/09/2018



https://waecy.maps.arcgis.com/home/webmap/viewer.html?layers=016d27df46004d138cdda32259787400

0022009700 Date Exported: 07/09/2018

Notes:
1. These illustrations were interpreted based on aerial photograph and are approximate.
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Data Source: WAECY – TMDL Boundaries Map

Screen Capture of TMDL for WRIA

Peter Western Bridge Replacement
Burien, Washington

GeoEngineers

Figure 4

RATING SUMMARY – Western Washington

Name of wetland (or ID #): Wetland C   Date of site visit: 7-Jun

Rated by A. Wright   Trained by Ecology? ☑ Yes ☐ No   Date of training Apr-15

HGM Class used for rating Riverine & Fresh Water Tidal   Wetland has multiple HGM classes? ☐ Yes ☑ No

NOTE: Form is not complete with out the figures requested (*figures can be combined*).
Source of base aerial photo/map Google Earth

OVERALL WETLAND CATEGORY III (based on functions ☑ or special characteristics ☐)

1. Category of wetland based on FUNCTIONS

___ **Category I** - Total score = 23 - 27
___ **Category II** - Total score = 20 - 22
X **Category III** - Total score = 16 - 19
___ **Category IV** - Total score = 9 - 15

FUNCTION	Improving Water Quality	Hydrologic	Habitat	
	List appropriate rating (H, M, L)			
Site Potential	M	M	L	
Landscape Potential	M	M	L	
Value	H	H	M	**Total**
Score Based on Ratings	7	7	4	**18**

Score for each function based on three ratings (*order of ratings is not important*)

9 = H, H, H
8 = H, H, M
7 = H, H, L
7 = H, M, M
6 = H, M, L
6 = M, M, M
5 = H, L, L
5 = M, M, L
4 = M, L, L
3 = L, L, L

2. Category based on SPECIAL CHARACTERISTICS of wetland

CHARACTERISTIC	Category
Estuarine	
Wetland of High Conservation Value	
Bog	
Mature Forest	
Old Growth Forest	
Coastal Lagoon	
Interdunal	
None of the above	X

Maps and Figures required to answer questions correctly for Western Washington

Depressional Wetlands

Map of:	To answer questions:	Figure #
Cowardin plant classes	D 1.3, H 1.1, H 1.4	
Hydroperiods	D 1.4, H 1.2	
Location of outlet (*can be added to map of hydroperiods*)	D 1.1, D 4.1	
Boundary of area within 150 ft of the wetland (*can be added to another figure*)	D 2.2, D 5.2	
Map of the contributing basin	D 4.3, D 5.3	
1 km Polygon: Area that extends 1 km from entire wetland edge - including polygons for accessible habitat and undisturbed habitat	H 2.1, H 2.2, H 2.3	
Screen capture of map of 303(d) listed waters in basin (from Ecology website)	D 3.1, D 3.2	
Screen capture of list of TMDLs for WRIA in which unit is found (from web)	D 3.3	

Riverine Wetlands

Map of:	To answer questions:	Figure #
Cowardin plant classes	H 1.1, H 1.4	1
Hydroperiods	H 1.2	1
Ponded depressions	R 1.1	1
Boundary of area within 150 ft of the wetland (*can be added to another figure*)	R 2.4	1
Plant cover of trees, shrubs, and herbaceous plants	R 1.2, R 4.2	1
Width of unit vs. width of stream (*can be added to another figure*)	R 4.1	1
Map of the contributing basin	R 2.2, R 2.3, R 5.2	2
1 km Polygon: Area that extends 1 km from entire wetland edge - including polygons for accessible habitat and undisturbed habitat	H 2.1, H 2.2, H 2.3	3
Screen capture of map of 303(d) listed waters in basin (from Ecology website)	R 3.1	4
Screen capture of list of TMDLs for WRIA in which unit is found (from web)	R 3.2, R 3.3	5

Lake Fringe Wetlands

Map of:	To answer questions:	Figure #
Cowardin plant classes	L 1.1, L 4.1, H 1.1, H 1.4	
Plant cover of trees, shrubs, and herbaceous plants	L 1.2	
Boundary of area within 150 ft of the wetland (*can be added to another figure*)	L 2.2	
1 km Polygon: Area that extends 1 km from entire wetland edge - including polygons for accessible habitat and undisturbed habitat	H 2.1, H 2.2, H 2.3	
Screen capture of map of 303(d) listed waters in basin (from Ecology website)	L 3.1, L 3.2	
Screen capture of list of TMDLs for WRIA in which unit is found (from web)	L 3.3	

Slope Wetlands

Map of:	To answer questions:	Figure #
Cowardin plant classes	H 1.1, H 1.4	
Hydroperiods	H 1.2	
Plant cover of **dense** trees, shrubs, and herbaceous plants	S 1.3	
Plant cover of **dense, rigid** trees, shrubs, and herbaceous plants (*can be added to another figure*)	S 4.1	
Boundary of area within 150 ft of the wetland (*can be added to another figure*)	S 2.1, S 5.1	
1 km Polygon: Area that extends 1 km from entire wetland edge - including polygons for accessible habitat and undisturbed habitat	H 2.1, H 2.2, H 2.3	
Screen capture of map of 303(d) listed waters in basin (from Ecology website)	S 3.1, S 3.2	
Screen capture of list of TMDLs for WRIA in which unit is found (from web)	S 3.3	

HGM Classification of Wetland in Western Washington

For questions 1 -7, the criteria described must apply to the entire unit being rated.
If hydrologic criteria listed in each question do not apply to the entire unit being rated, you probably have a unit with multiple HGM classes. In this case, identify which hydrologic criteria in questions 1 - 7 apply, and go to Question 8.

1. Are the water levels in the entire unit usually controlled by tides except during floods?

☑ NO - go to 2 ☐ **YES** - the wetland class is **Tidal Fringe** - go to 1.1

1.1 Is the salinity of the water during periods of annual low flow below 0.5 ppt (parts per thousand)?

☐ **NO - Saltwater Tidal Fringe (Estuarine)** ☐ **YES - Freshwater Tidal Fringe**
*If your wetland can be classified as a Freshwater Tidal Fringe use the forms for **Riverine** wetlands. If it is Saltwater Tidal Fringe it is an **Estuarine** wetland and is not scored. This method **cannot** be used to score functions for estuarine wetlands.*

2. The entire wetland unit is flat and precipitation is the only source (>90%) of water to it. Groundwater and surface water runoff are NOT sources of water to the unit.

☑ NO - go to 3 ☐ **YES** - The wetland class is **Flats**
*If your wetland can be classified as a Flats wetland, use the form for **Depressional** wetlands.*

3. Does the entire wetland unit **meet all** of the following criteria?
☐ The vegetated part of the wetland is on the shores of a body of permanent open water (without any plants on the surface at any time of the year) at least 20 ac (8 ha) in size;
☐ At least 30% of the open water area is deeper than 6.6 ft (2 m).

☑ NO - go to 4 ☐ **YES** - The wetland class is **Lake Fringe** (Lacustrine Fringe)

4. Does the entire wetland unit **meet all** of the following criteria?
☐ The wetland is on a slope (*slope can be very gradual*),
☐ The water flows through the wetland in one direction (unidirectional) and usually comes from seeps. It may flow subsurface, as sheetflow, or in a swale without distinct banks.
☐ The water leaves the wetland **without being impounded.**

☑ NO - go to 5 ☐ **YES** - The wetland class is **Slope**

NOTE: Surface water does not pond in these type of wetlands except occasionally in very small and shallow depressions or behind hummocks (depressions are usually <3 ft diameter and less than 1 ft deep).

5. Does the entire wetland unit **meet all** of the following criteria?
☑ The unit is in a valley, or stream channel, where it gets inundated by overbank flooding from that stream or river,
☑ The overbank flooding occurs at least once every 2 years.

☐ NO - go to 6 ☑ **YES** - The wetland class is **Riverine**

NOTE: The Riverine unit can contain depressions that are filled with water when the river is not flooding.

6. Is the entire wetland unit in a topographic depression in which water ponds, or is saturated to the surface, at some time during the year? *This means that any outlet, if present, is higher than the interior of the wetland.*

☐ NO - go to 7 ☐ **YES** - The wetland class is **Depressional**

7. Is the entire wetland unit located in a very flat area with no obvious depression and no overbank flooding? The unit does not pond surface water more than a few inches. The unit seems to be maintained by high groundwater in the area. The wetland may be ditched, but has no obvious natural outlet.

☐ NO - go to 8 ☐ **YES** - The wetland class is **Depressional**

8. Your wetland unit seems to be difficult to classify and probably contains several different HGM classes. For example, seeps at the base of a slope may grade into a riverine floodplain, or a small stream within a Depressional wetland has a zone of flooding along its sides. GO BACK AND IDENTIFY WHICH OF THE HYDROLOGIC REGIMES DESCRIBED IN QUESTIONS 1-7 APPLY TO DIFFERENT AREAS IN THE UNIT (make a rough sketch to help you decide). Use the following table to identify the appropriate class to use for the rating system if you have several HGM classes present within the wetland unit being scored.

NOTE: Use this table only if the class that is recommended in the second column represents 10% or more of the total area of the wetland unit being rated. If the area of the HGM class listed in column 2 is less than 10% of the unit; classify the wetland using the class that represents more than 90% of the total area.

HGM classes within the wetland unit being rated	HGM class to use in rating
Slope + Riverine	Riverine
Slope + Depressional	Depressional
Slope + Lake Fringe	Lake Fringe
Depressional + Riverine along stream within boundary of depression	Depressional
Depressional + Lake Fringe	Depressional
Riverine + Lake Fringe	Riverine
Salt Water Tidal Fringe and any other class of freshwater wetland	Treat as ESTUARINE

*If you are still unable to determine which of the above criteria apply to your wetland, or if you have **more than 2 HGM classes** within a wetland boundary, classify the wetland as Depressional for the rating.*

NOTES and FIELD OBSERVATIONS:

RIVERINE AND FRESHWATER TIDAL FRINGE WETLANDS

Water Quality Functions - Indicators that the site functions to improve water quality

R 1.0. Does the site have the potential to improve water quality?		
R 1.1. Area of surface depressions within the Riverine wetland that can trap sediments during a flooding event:		
Depressions cover > 3/4 area of wetland	points = 8	0
Depressions cover > ½ area of wetland	points = 4	
Depressions present but cover < ½ area of wetland	points = 2	
No depressions present	points = 0	
R 1.2. Structure of plants in the wetland (areas with >90% cover at person height, **not** Cowardin classes)		
Trees or shrubs > 2/3 area of the wetland	points = 8	
☐ Trees or shrubs > 1/3 area of the wetland	points = 6	6
☑ Herbaceous plants (> 6 in high) > 2/3 area of the wetland	points = 6	
Herbaceous plants (> 6 in high) > 1/3 area of the wetland	points = 3	
Trees, shrubs, and ungrazed herbaceous < 1/3 area of the wetland	points = 0	
Total for R 1	Add the points in the boxes above	**6**

Rating of Site Potential If score is: ☐ **12 - 16 = H** ☑ **6 - 11 = M** ☐ **0 - 5 = L** *Record the rating on the first page*

R 2.0. Does the landscape have the potential to support the water quality function of the site?		
R 2.1. Is the wetland within an incorporated city or within its UGA?	Yes = 2 No = 0	0
R 2.2. Does the contributing basin to the wetland include a UGA or incorporated area?	Yes = 1 No = 0	1
R 2.3. Does at least 10% of the contributing basin contain tilled fields, pastures, or forests that have been clearcut within the last 5 years?	Yes = 1 No = 0	1
R 2.4. Is > 10% of the area within 150 ft of the wetland in land uses that generate pollutants?	Yes = 1 No = 0	0
R 2.5. Are there other sources of pollutants coming into the wetland that are not listed in questions R 2.1 - R 2.4? Other Sources	Yes = 1 No = 0	0
Total for R 2	Add the points in the boxes above	**2**

Rating of Landscape Potential If score is: ☐ **3 - 6 = H** ☑ **1 or 2 = M** ☐ **0 = L** *Record the rating on the first page*

R 3.0. Is the water quality improvement provided by the site valuable to society?		
R 3.1. Is the wetland along a stream or river that is on the 303(d) list or on a tributary that drains to one within 1 mi?	Yes = 1 No = 0	1
R 3.2. Is the wetland along a stream or river that has TMDL limits for nutrients, toxics, or pathogens?	Yes = 1 No = 0	0
R 3.3. Has the site been identified in a watershed or local plan as important for maintaining water quality? (*answer YES if there is a TMDL for the drainage in which the unit is found*)	Yes = 2 No = 0	2
Total for R 3	Add the points in the boxes above	**3**

Rating of Value If score is: ☑ **2 - 4 = H** ☐ **1 = M** ☐ **0 = L** *Record the rating on the first page*

RIVERINE AND FRESHWATER TIDAL FRINGE WETLANDS

Hydrologic Functions - Indicators that site functions to reduce flooding and stream erosion

R 4.0. Does the site have the potential to reduce flooding and erosion?		
R 4.1. Characteristics of the overbank storage the wetland provides: *Estimate the average width of the wetland perpendicular to the direction of the flow and the width of the stream or river channel (distance between banks). Calculate the ratio: (average width of wetland)/(average width of stream between banks).*		1
If the ratio is more than 20	points = 9	
If the ratio is 10 - 20	points = 6	
If the ratio is 5 - < 10	points = 4	
If the ratio is 1 - < 5	points = 2	
If the ratio is < 1	points = 1	
R 4.2. Characteristics of plants that slow down water velocities during floods: *Treat large woody debris as forest or shrub. Choose the points appropriate for the best description (polygons need to have >90% cover at person height. These are* <u>*NOT Cowardin*</u> *classes*).		7
Forest or shrub for > $^{1}/_{3}$ area OR emergent plants > $^{2}/_{3}$ area	points = 7	
Forest or shrub for > $^{1}/_{10}$ area OR emergent plants > $^{1}/_{3}$ area	points = 4	
Plants do not meet above criteria	points = 0	
Total for R 4	Add the points in the boxes above	**8**

Rating of Site Potential If score is: ☐ **12 - 16 = H** ☑ **6 - 11 = M** ☐ **0 - 5 = L** *Record the rating on the first page*

R 5.0. Does the landscape have the potential to support the hydrologic functions of the site?		
R 5.1. Is the stream or river adjacent to the wetland downcut?	Yes = 0 No = 1	0
R 5.2. Does the up-gradient watershed include a UGA or incorporated area?	Yes = 1 No = 0	1
R 5.3 Is the up-gradient stream or river controlled by dams?	Yes = 0 No = 1	0
Total for R 5	Add the points in the boxes above	**1**

Rating of Landscape Potential If score is: ☐ **3 = H** ☑ **1 or 2 = M** ☐ **0 = L** *Record the rating on the first page*

R 6.0. Are the hydrologic functions provided by the site valuable to society?		
R 6.1. Distance to the nearest areas downstream that have flooding problems? *Choose the description that best fits the site.*		2
The sub-basin immediately down-gradient of the wetland has flooding problems that result in damage to human or natural resources (e.g., houses or salmon redds)	points = 2	
Surface flooding problems are in a sub-basin farther down-gradient	points = 1	
No flooding problems anywhere downstream	points = 0	
R 6.2. Has the site been identified as important for flood storage or flood conveyance in a regional flood control plan?	Yes = 2 No = 0	2
Total for R 6	Add the points in the boxes above	**4**

Rating of Value If score is: ☑ **2 - 4 = H** ☐ **1 = M** ☐ **0 = L** *Record the rating on the first page*

These questions apply to wetlands of all HGM classes.

HABITAT FUNCTIONS - Indicators that site functions to provide important habitat

H 1.0. Does the site have the potential to provide habitat?

H 1.1. Structure of plant community: *Indicators are Cowardin classes and strata within the Forested class.* Check the Cowardin plant classes in the wetland. *Up to 10 patches may be combined for each class to meet the threshold of ¼ ac or more than 10% of the unit if it is smaller than 2.5 ac. Add the number of structures checked.*

		Score
☐ Aquatic bed	4 structures or more: points = 4	0
☑ Emergent	3 structures: points = 2	
☐ Scrub-shrub (areas where shrubs have > 30% cover)	2 structures: points - 1	
☐ Forested (areas where trees have > 30% cover)	1 structure: points = 0	

If the unit has a Forested class, check if :

☐ The Forested class has 3 out of 5 strata (canopy, sub-canopy, shrubs, herbaceous, moss/ground-cover) that each cover 20% within the Forested polygon

H 1.2. Hydroperiods

Check the types of water regimes (hydroperiods) present within the wetland. The water regime has to cover more than 10% of the wetland or ¼ ac to count (*see text for descriptions of hydroperiods*).

		Score
☐ Permanently flooded or inundated	4 or more types present: points = 3	1
☐ Seasonally flooded or inundated	3 types present: points = 2	
☑ Occasionally flooded or inundated	2 types present: points = 1	
☐ Saturated only	1 types present: points = 0	
☑ Permanently flowing stream or river in, or adjacent to, the wetland		
☐ Seasonally flowing stream in, or adjacent to, the wetland		
☐ **Lake Fringe wetland**	**2 points**	
☐ **Freshwater tidal wetland**	**2 points**	

H 1.3. Richness of plant species

Count the number of plant species in the wetland that cover at least 10 ft^2.
Different patches of the same species can be combined to meet the size threshold and you do not have to name the species. ***Do not include Eurasian milfoil, reed canarygrass, purple loosestrife, Canadian thistle***

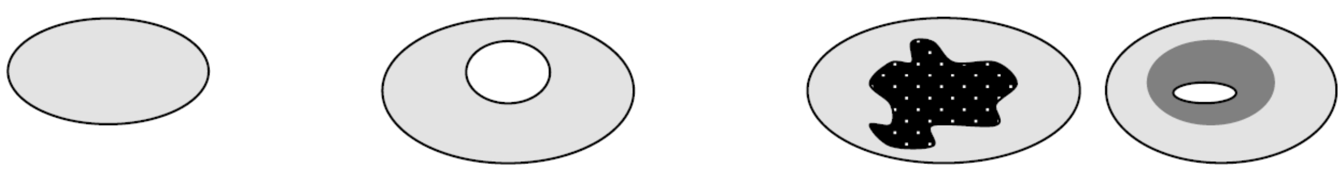
Score: 0

If you counted:		
	> 19 species	points = 2
	5 - 19 species	points = 1
	< 5 species	points = 0

H 1.4. Interspersion of habitats

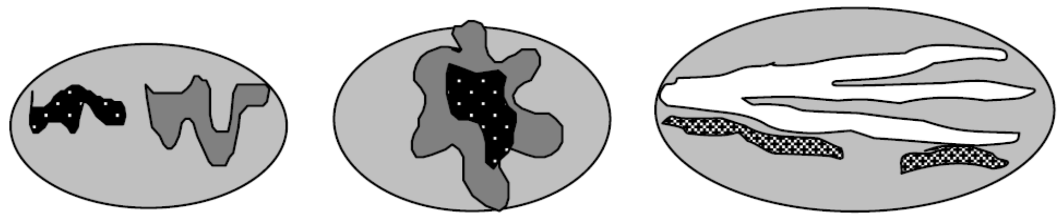
Decide from the diagrams below whether interspersion among Cowardin plants classes (described in H 1.1), or the classes and unvegetated areas (can include open water or mudflats) is high, moderate, low, or none. *If you have four or more plant classes or three classes and open water, the rating is always high.*

Score: 0



None = 0 points   **Low** = 1 point   **Moderate** = 2 points

All three diagrams in this row are **HIGH** = 3 points



H 1.5. Special habitat features: Check the habitat features that are present in the wetland. *The number of checks is the number of points.* ☐ Large, downed, woody debris within the wetland (> 4 in diameter and 6 ft long) ☐ Standing snags (dbh > 4 in) within the wetland ☑ Undercut banks are present for at least 6.6 ft (2 m) **and/or** overhanging plants extends at least 3.3 ft (1 m) over a stream (or ditch) in, or contiguous with the wetland, for at least 33 ft (10 m) ☐ Stable steep banks of fine material that might be used by beaver or muskrat for denning (> 30 degree slope) OR signs of recent beaver activity are present (*cut shrubs or trees that have not yet weathered where wood is exposed*) ☐ At least ¼ ac of thin-stemmed persistent plants or woody branches are present in areas that are permanently or seasonally inundated (*structures for egg-laying by amphibians*) ☐ Invasive plants cover less than 25% of the wetland area in every stratum of plants (*see H 1.1 for list of strata*)	1
Total for H 1 — Add the points in the boxes above	**2**

Rating of Site Potential If Score is: ☐ **15 - 18 = H** ☐ **7 - 14 = M** ☑ **0 - 6 = L** *Record the rating on the first page*

H 2.0. Does the landscape have the potential to support the habitat function of the site?	
H 2.1 Accessible habitat (include *only habitat that directly abuts wetland unit*). *Calculate:* 0 % undisturbed habitat + (0 % moderate & low intensity land uses / 2) = 0% If total accessible habitat is: > 1/3 (33.3%) of 1 km Polygon — points = 3 20 - 33% of 1 km Polygon — points = 2 10 - 19% of 1 km Polygon — points = 1 < 10 % of 1 km Polygon — points = 0	0
H 2.2. Undisturbed habitat in 1 km Polygon around the wetland. *Calculate:* 0 % undisturbed habitat + (0 % moderate & low intensity land uses / 2) = 0% Undisturbed habitat > 50% of Polygon — points = 3 Undisturbed habitat 10 - 50% and in 1-3 patches — points = 2 Undisturbed habitat 10 - 50% and > 3 patches — points = 1 Undisturbed habitat < 10% of 1 km Polygon — points = 0	0
H 2.3 Land use intensity in 1 km Polygon: If > 50% of 1 km Polygon is high intensity land use — points = (-2) ≤ 50% of 1km Polygon is high intensity — points = 0	0
Total for H 2 — Add the points in the boxes above	**0**

Rating of Landscape Potential If Score is: ☐ **4 - 6 = H** ☐ **1 - 3 = M** ☑ **< 1 = L** *Record the rating on the first page*

H 3.0. Is the habitat provided by the site valuable to society?	
H 3.1. Does the site provide habitat for species valued in laws, regulations, or policies? *Choose only the highest score that applies to the wetland being rated*. Site meets ANY of the following criteria: — points = 2 ☐ It has 3 or more priority habitats within 100 m (see next page) ☐ It provides habitat for Threatened or Endangered species (any plant or animal on the state or federal lists) ☐ It is mapped as a location for an individual WDFW priority species ☐ It is a Wetland of High Conservation Value as determined by the Department of Natural Resources ☐ It has been categorized as an important habitat site in a local or regional comprehensive plan, in a Shoreline Master Plan, or in a watershed plan Site has 1 or 2 priority habitats (listed on next page) with in 100m — points = 1 Site does not meet any of the criteria above — points = 0	1

Rating of Value If Score is: ☐ **2 = H** ☑ **1 = M** ☐ **0 = L** *Record the rating on the first page*

WDFW Priority Habitats

Priority habitats listed by WDFW (see complete descriptions of WDFW priority habitats, and the counties in which they can be found, in: Washington Department of Fish and Wildlife. 2008. Priority Habitat and Species List. Olympia, Washington. 177 pp.
http://wdfw.wa.gov/publications/00165/wdfw00165.pdf or access the list from here:
http://wdfw.wa.gov/conservation/phs/list/

Count how many of the following priority habitats are within 330 ft (100 m) of the wetland unit: ***NOTE**: This question is independent of the land use between the wetland unit and the priority habitat.*

- ☐ **Aspen Stands**: Pure or mixed stands of aspen greater than 1 ac (0.4 ha).
- ☐ **Biodiversity Areas and Corridors**: Areas of habitat that are relatively important to various species of native fish and wildlife (*full descriptions in WDFW PHS report*).
- ☐ **Herbaceous Balds**: Variable size patches of grass and forbs on shallow soils over bedrock.
- ☐ **Old-growth/Mature forests**: Old-growth west of Cascade crest – Stands of at least 2 tree species, forming a multi-layered canopy with occasional small openings; with at least 8 trees/ac (20 trees/ha) > 32 in (81 cm) dbh or > 200 years of age. Mature forests – Stands with average diameters exceeding 21 in (53 cm) dbh; crown cover may be less than 100%; decay, decadence, numbers of snags, and quantity of large downed material is generally less than that found in old-growth; 80-200 years old west of the Cascade crest.
- ☐ **Oregon White Oak**: Woodland stands of pure oak or oak/conifer associations where canopy coverage of the oak component is important (*full descriptions in WDFW PHS report p. 158 – see web link above*).
- ☑ **Riparian**: The area adjacent to aquatic systems with flowing water that contains elements of both aquatic and terrestrial ecosystems which mutually influence each other.
- ☐ **Westside Prairies**: Herbaceous, non-forested plant communities that can either take the form of a dry prairie or a wet prairie (*full descriptions in WDFW PHS report p. 161 – see web link above*).
- ☑ **Instream**: The combination of physical, biological, and chemical processes and conditions that interact to provide functional life history requirements for instream fish and wildlife resources.
- ☐ **Nearshore**: Relatively undisturbed nearshore habitats. These include Coastal Nearshore, Open Coast Nearshore, and Puget Sound Nearshore. (*full descriptions of habitats and the definition of relatively undisturbed are in WDFW report – see web link on previous page*).
- ☐ **Caves**: A naturally occurring cavity, recess, void, or system of interconnected passages under the earth in soils, rock, ice, or other geological formations and is large enough to contain a human.
- ☐ **Cliffs**: Greater than 25 ft (7.6 m) high and occurring below 5000 ft elevation.
- ☐ **Talus**: Homogenous areas of rock rubble ranging in average size 0.5 - 6.5 ft (0.15 - 2.0 m), composed of basalt, andesite, and/or sedimentary rock, including riprap slides and mine tailings. May be associated with cliffs.
- ☐ **Snags and Logs**: Trees are considered snags if they are dead or dying and exhibit sufficient decay characteristics to enable cavity excavation/use by wildlife. Priority snags have a diameter at breast height of > 20 in (51 cm) in western Washington and are > 6.5 ft (2 m) in height. Priority logs are > 12 in (30 cm) in diameter at the largest end, and > 20 ft (6 m) long.

Note: All vegetated wetlands are by definition a priority habitat but are not included in this list because they are addressed elsewhere.

CATEGORIZATION BASED ON SPECIAL CHARACTERISTICS

Wetland Type *Check off any criteria that apply to the wetland. List the category when the appropriate criteria are met.*	**Category**
SC 1.0. Estuarine Wetlands Does the wetland meet the following criteria for Estuarine wetlands? ☐ The dominant water regime is tidal, ☐ Vegetated, and ☐ With a salinity greater than 0.5 ppt ☐ Yes - Go to **SC 1.1** ☐ No = **Not an estuarine wetland**	
SC 1.1. Is the wetland within a National Wildlife Refuge, National Park, National Estuary Reserve, Natural Area Preserve, State Park or Educational, Environmental, or Scientific Reserve designated under WAC 332-30-151? ☐ Yes = **Category I** ☐ No - Go to **SC 1.2**	
SC 1.2. Is the wetland unit at least 1 ac in size and meets at least two of the following three conditions? ☐ The wetland is relatively undisturbed (has no diking, ditching, filling, cultivation, grazing, and has less than 10% cover of non-native plant species. (If non-native species are *Spartina* , see page 25) ☐ At least ¾ of the landward edge of the wetland has a 100 ft buffer of shrub, forest, or un-grazed or un-mowed grassland. ☐ The wetland has at least two of the following features: tidal channels, depressions with open water, or contiguous freshwater wetlands. ☐ Yes = **Category I** ☐ No = **Category II**	
SC 2.0. Wetlands of High Conservation Value (WHCV) SC 2.1. Has the WA Department of Natural Resources updated their website to include the list of Wetlands of High Conservation Value? ☐ Yes - Go to **SC 2.2** ☐ No - Go to **SC 2.3** SC 2.2. Is the wetland listed on the WDNR database as a Wetland of High Conservation Value? ☐ Yes = **Category I** ☐ No = **Not WHCV** SC 2.3. Is the wetland in a Section/Township/Range that contains a Natural Heritage wetland? http://www1.dnr.wa.gov/nhp/refdesk/datasearch/wnhpwetlands.pdf ☐ Yes - **Contact WNHP/WDNR and to SC 2.4** ☐ No = **Not WHCV** SC 2.4. Has WDNR identified the wetland within the S/T/R as a Wetland of High Conservation Value and listed it on their website? ☐ Yes = **Category I** ☐ No = **Not WHCV**	
SC 3.0. Bogs Does the wetland (or any part of the unit) meet both the criteria for soils and vegetation in bogs? *Use the key below.* ***If you answer YES you will still need to rate the wetland based on its functions*** *.* SC 3.1. Does an area within the wetland unit have organic soil horizons, either peats or mucks, that compose 16 in or more of the first 32 in of the soil profile? ☐ Yes - Go to **SC 3.3** ☐ No - Go to **SC 3.2** SC 3.2. Does an area within the wetland unit have organic soils, either peats or mucks, that are less than 16 in deep over bedrock, or an impermeable hardpan such as clay or volcanic ash, or that are floating on top of a lake or pond? ☐ Yes - Go to **SC 3.3** ☐ No = **Is not a bog** SC 3.3. Does an area with peats or mucks have more than 70% cover of mosses at ground level, AND at least a 30% cover of plant species listed in Table 4? ☐ Yes = **Is a Category I bog** ☐ No - Go to **SC 3.4** **NOTE**: If you are uncertain about the extent of mosses in the understory, you may substitute that criterion by measuring the pH of the water that seeps into a hole dug at least 16 in deep. If the pH is less than 5.0 and the plant species in Table 4 are present, the wetland is a bog. SC 3.4. Is an area with peats or mucks forested (> 30% cover) with Sitka spruce, subalpine fir, western red cedar, western hemlock, lodgepole pine, quaking aspen, Engelmann spruce, or western white pine, AND any of the species (or combination of species) listed in Table 4 provide more than 30% of the cover under the canopy? ☐ Yes = **Is a Category I bog** ☐ No = **Is not a bog**	

SC 4.0. Forested Wetlands

Does the wetland have at least 1 contiguous acre of forest that meets one of these criteria for the WA Department of Fish and Wildlife's forests as priority habitats? ***If you answer YES you will still need to rate the wetland based on its functions.***

☐ **Old-growth forests** (west of Cascade crest): Stands of at least two tree species, forming a multi-layered canopy with occasional small openings; with at least 8 trees/ac (20 trees/ha) that are at least 200 years of age OR have a diameter at breast height (dbh) of 32 in (81 cm) or more.

☐ **Mature forests** (west of the Cascade Crest): Stands where the largest trees are 80-200 years old OR the species that make up the canopy have an average diameter (dbh) exceeding 21 in (53 cm).

☐ Yes = **Category I** ☐ No = **Not a forested wetland for this section**

SC 5.0. Wetlands in Coastal Lagoons

Does the wetland meet all of the following criteria of a wetland in a coastal lagoon?

☐ The wetland lies in a depression adjacent to marine waters that is wholly or partially separated from marine waters by sandbanks, gravel banks, shingle, or, less frequently, rocks

☐ The lagoon in which the wetland is located contains ponded water that is saline or brackish (> 0.5 ppt) during most of the year in at least a portion of the lagoon (*needs to be measured near the bottom*)

☐ Yes - Go to **SC 5.1** ☐ No = **Not a wetland in a coastal lagoon**

SC 5.1. Does the wetland meet all of the following three conditions?

☐ The wetland is relatively undisturbed (has no diking, ditching, filling, cultivation, grazing), and has less than 20% cover of aggressive, opportunistic plant species (see list of species on p. 100).

☐ At least ¾ of the landward edge of the wetland has a 100 ft buffer of shrub, forest, or un-grazed or un-mowed grassland.

☐ The wetland is larger than $^{1}/_{10}$ ac (4350 ft^2)

☐ Yes = **Category I** ☐ No = **Category II**

SC 6.0. Interdunal Wetlands

Is the wetland west of the 1889 line (also called the Western Boundary of Upland Ownership or WBUO)? ***If you answer yes you will still need to rate the wetland based on its habitat functions.***

In practical terms that means the following geographic areas:

☐ Long Beach Peninsula: Lands west of SR 103

☐ Grayland-Westport: Lands west of SR 105

☐ Ocean Shores-Copalis: Lands west of SR 115 and SR 109

☐ Yes - Go to **SC 6.1** ☐ No = **Not an interdunal wetland for rating**

SC 6.1. Is the wetland 1 ac or larger and scores an 8 or 9 for the habitat functions on the form (rates H,H,H or H,H,M for the three aspects of function)?

☐ Yes = **Category I** ☐ No - Go to **SC 6.2**

SC 6.2. Is the wetland 1 ac or larger, or is it in a mosaic of wetlands that is 1 ac or larger?

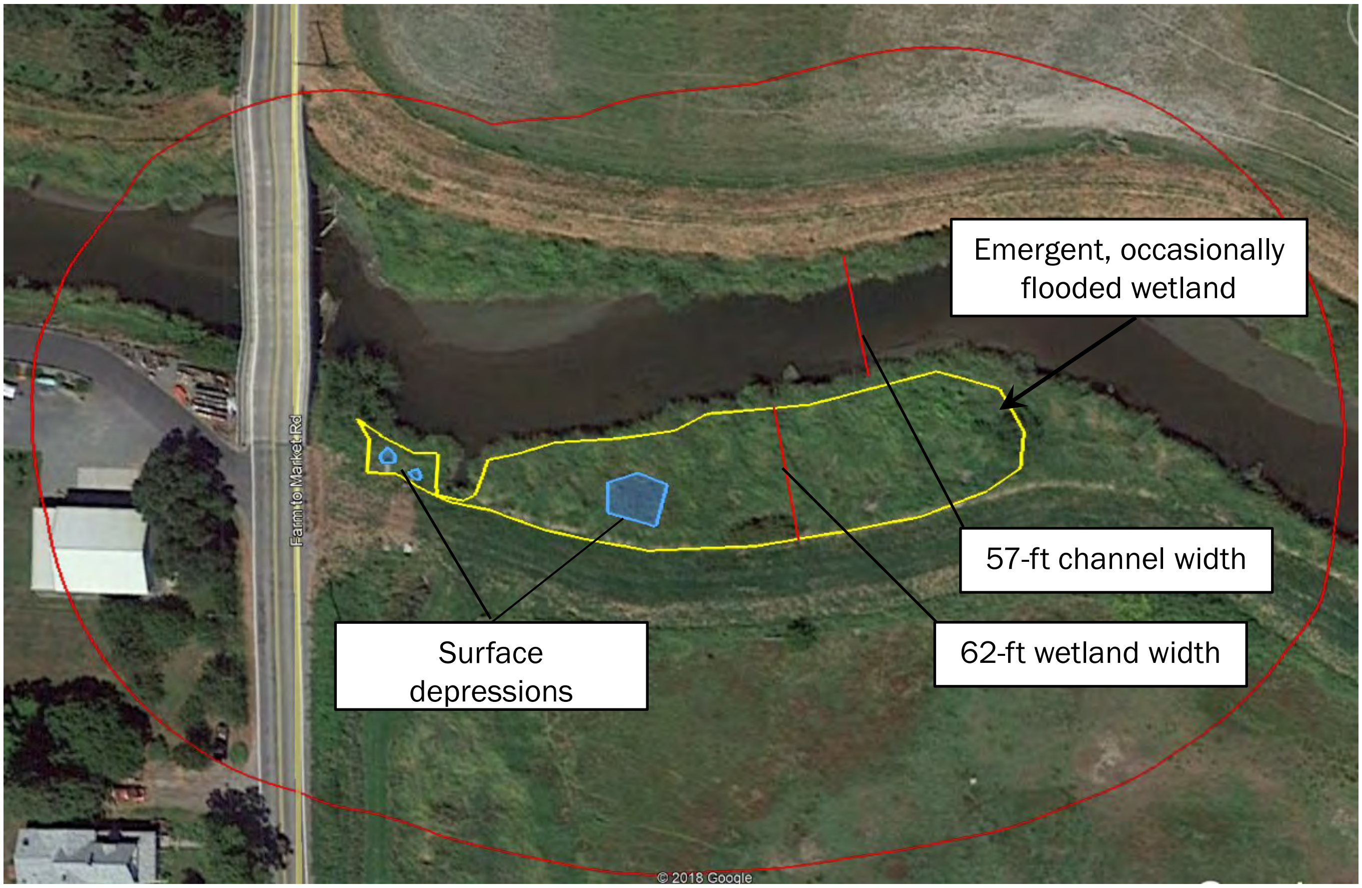
☐ Yes = **Category II** ☐ No - Go to **SC 6.3**

SC 6.3. Is the unit between 0.1 and 1 ac, or is it in a mosaic of wetlands that is between 0.1 and 1 ac?

☐ Yes = **Category III** ☐ No = **Category IV**

Category of wetland based on Special Characteristics

If you answered No for all types, enter "Not Applicable" on Summary Form



Notes:
1. These illustrations were interpreted based on aerial photograph and are approximate.
2. This illustration is for information purposes. It is intended to assist in showing features discussed in an attached wetland rating form. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files.

Data Source: Google Earth

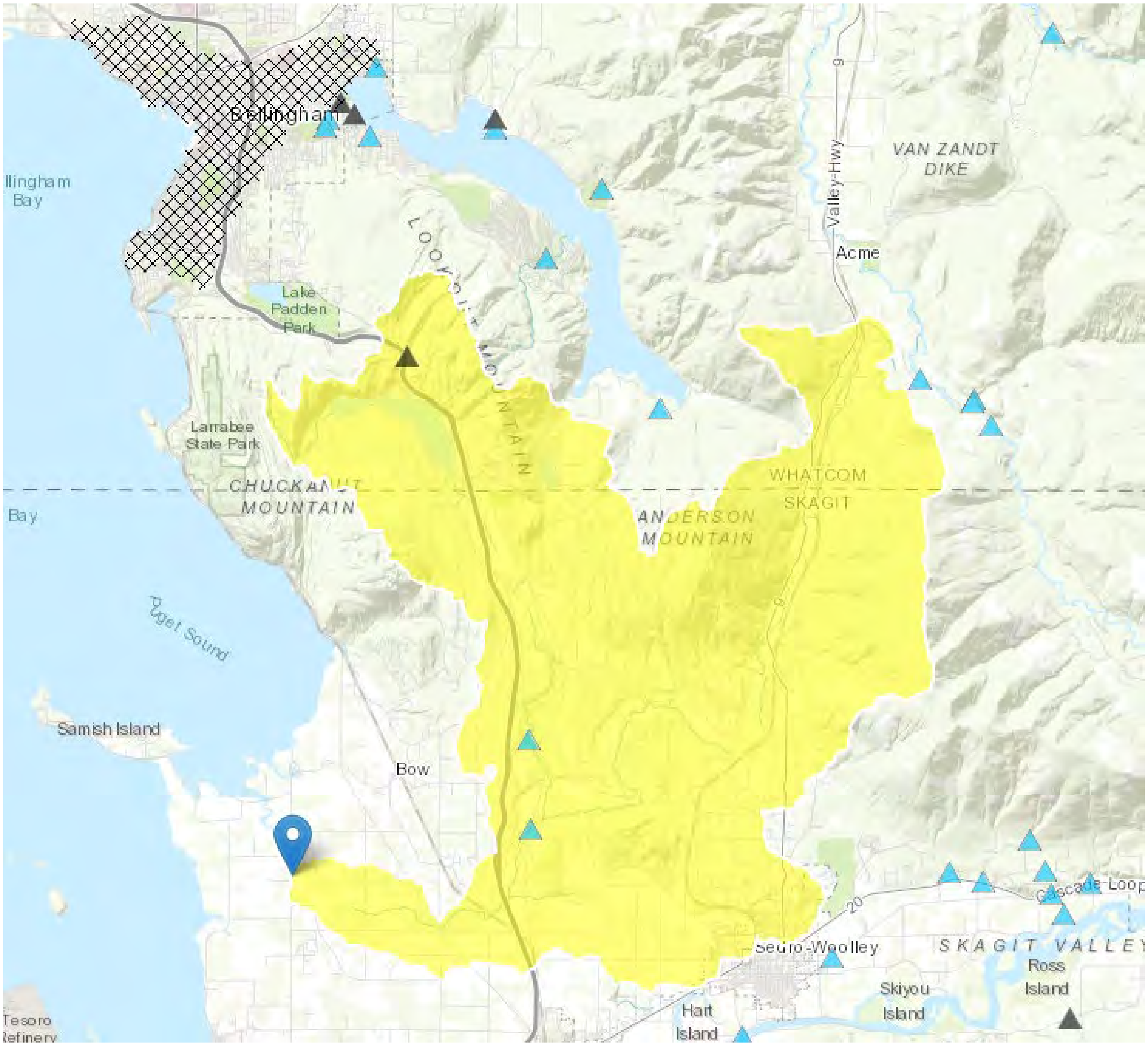
150-ft Polygon, Vegetation, and Hydrology

Samish River Floodgates
Skagit County, Washington

GeoEngineers

Figure 1

0022009700 Date Exported: 07/09/2018



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Data Source: Google Earth

1km Polygon

Samish River Floodgates
Skagit County, Washington

GEOENGINEERS

Figure 2

0022009700 Date Exported: 07/09/2018

Tilled fields, residences, and roads encompass entire polygon

Notes:

1. These illustrations were interpreted based on aerial photograph and are approximate.
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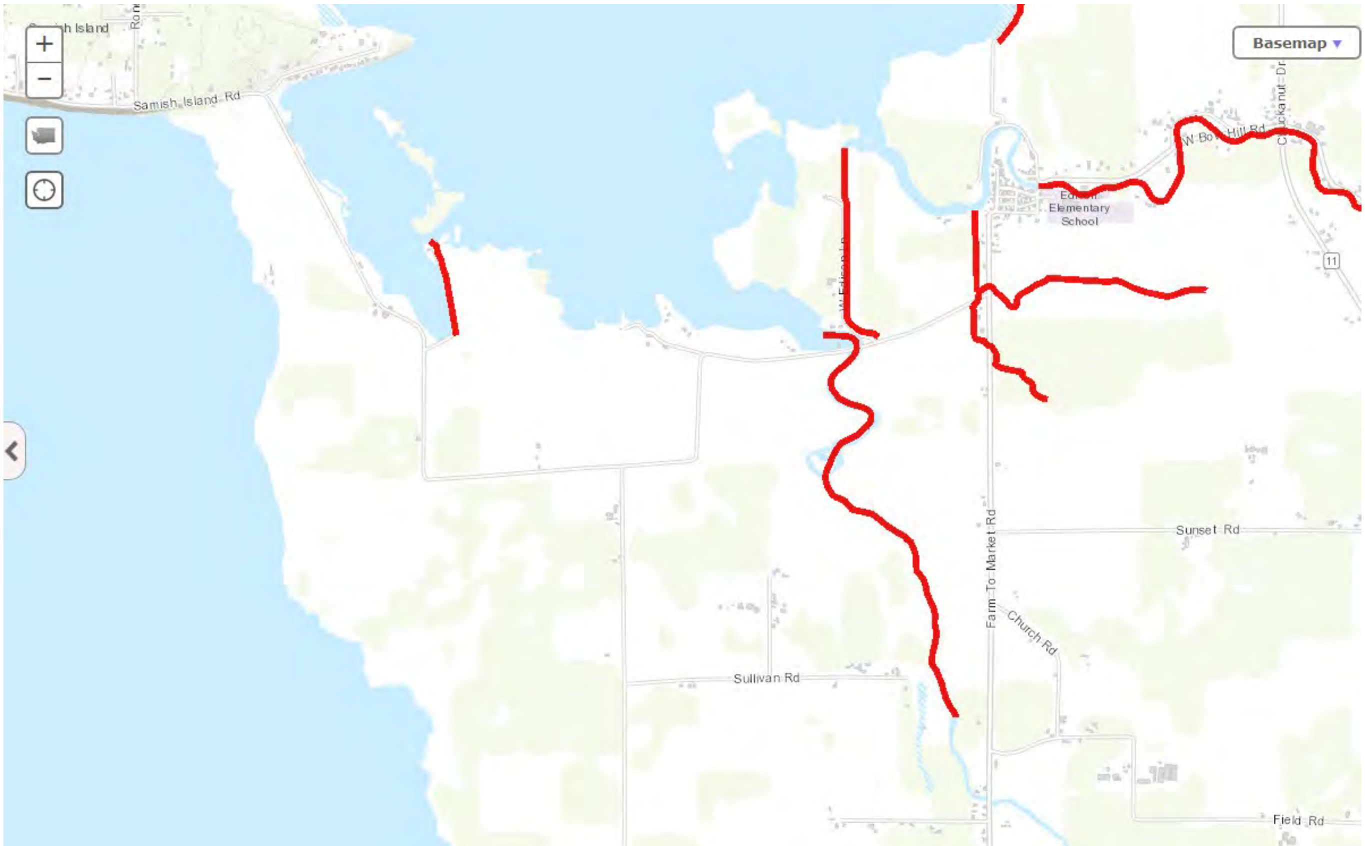
Data Source: Google Earth

1km Polygon	
Samish River Floodgates Skagit County, Washington	
GeoEngineers	**Figure 3**

0022009700 Date Exported: 07/09/2018



Screenshot from: https://fortress.wa.gov/ecy/waterqualityatlas/map.aspx

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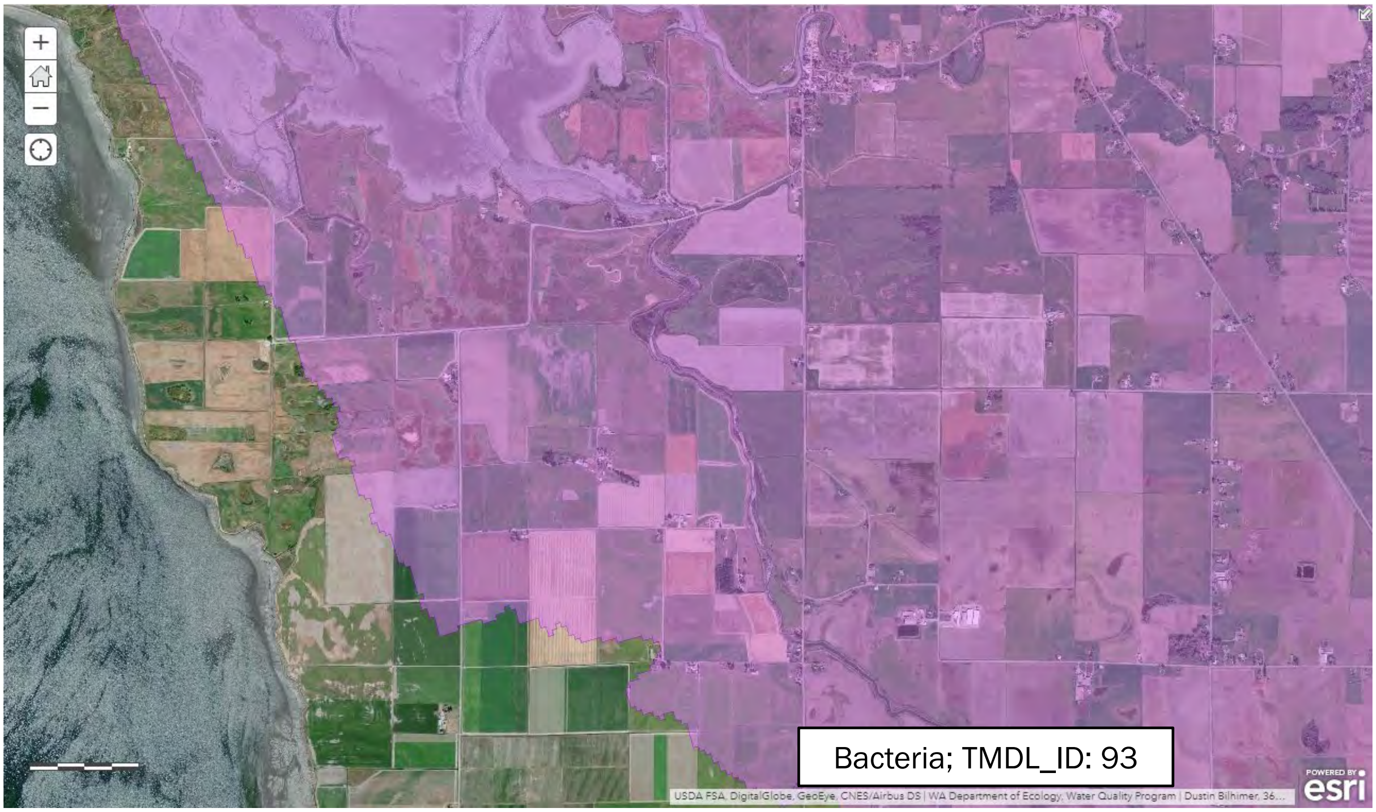
2. This illustration is for information purposes. It is intended to assist in showing features discussed in an attached wetland rating form. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files.

Data Source: Ecology Water Quality Atlas Map

0022009700 Date Exported: 07/09/2018

Screen Capture of 303(d) listed waters	
Peter Western Bridge Replacement Burien, Washington	
GEOENGINEERS	Figure 4



https://waecy.maps.arcgis.com/home/webmap/viewer.html?layers=016d27df46004d138cdda32259787400

Notes:

1. These illustrations were interpreted based on aerial photograph and are approximate.
2. This illustration is for information purposes. It is intended to assist in showing features discussed in an attached wetland rating form. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files.

Data Source: WAECY – TMDL Boundaries Map

Screen Capture of TMDL for WRIA

Peter Western Bridge Replacement
Burien, Washington

GeoEngineers

Figure 5

0022009700 Date Exported: 07/09/2018

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ATTACHMENT F

BE Report

Revised Biological Evaluation and Essential Fish Habitat Evaluation

Skagit River Bridge Modification and Interstate Highway Protection Project

Skagit County, Washington

for
Northwest Hydraulic Consultants

April 21, 2021

GeoEngineers

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Revised Biological Evaluation and Essential Fish Habitat Evaluation

Skagit River Bridge Modification and Interstate Highway Protection Project

Skagit County, Washington

File No. 0220-097-00

April 21, 2021

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APPENDICES

1.0 INTRODUCTION

The Skagit River Delta is a moderately developed area that has frequently experienced flooding issues. Due to its low-lying topography, an extensive network of dike systems has been constructed over the years to protect the agriculturally rich lands from river floods and high tidal levels. However, the dike systems also prevent drainage for precipitation falling on the lands within the Delta. Furthermore, a potential Skagit River dike breach would result in heavy inundation and incur flood hazard to the properties, livestock and community residing on the Delta. One-way tide gates have been installed to allow drainage during a low tide cycle while keeping saltwater from flowing in the landward direction. Skagit County Public Works (SCPW) is proposing to install additional flood relief structures (i.e. flood gates) to improve interior drainage and flood relief in the event of a severe river flood and/or Skagit River dike breach scenario commensurate with the 100-year return period flood.

SCPW proposes to install additional floodgates at three sites within the Samish River floodplain, one in Samish Bay and two along the left bank of the Samish River in Skagit County, Washington. The site in Samish Bay currently has no culverts or tide gates and the proposed project includes installation of new culverts and tide gate structures. The two sites along the bank of the Samish River have existing culverts and tide gates and the proposed project includes adding new culverts and tide gate structures. As currently planned, the new floodgate structures will consist of 4-foot-diameter corrugated polyethylene pipes (CPPs) with seepage collars. The floodgates will be designed to allow basin floodwaters to drain to the Samish River or Samish Bay and prevent back-flow from these water bodies during high tides.

GeoEngineers, Inc. (GeoEngineers) was retained to prepare this Biological Evaluation (BE) and Essential Fish Habitat (EFH) report to satisfy the requirement for Endangered Species Act (ESA) consultation related to the proposed project. This report analyzes the effects to species listed under the ESA and Magnuson-Stevens Fishery Management Act (MSA) from the proposed project. Temporary construction activities are anticipated to occur within Samish Bay and the Samish River, which are both considered navigable and waters of the US. The project will require a permit from the United States Army Corps of Engineers (USACE) under their authority to administer Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. Because of this federal nexus, the project is required to comply with Section 7 of the ESA of 1973 and the MSA. The purpose of this BE is to present a description of project effects and project-specific species and habitat information pertinent to the consultation process for ESA compliance. An EFH evaluation is included in Appendix A, Essential Fish Habitat (EFH) Evaluation.

2.0 PROJECT LOCATION AND SITE DESCRIPTION

The three sites proposed for floodgates and associated site description are provided in Table 1 below:

TABLE 1. SITE DESCRIPTION BY PROJECT SITE

Site Number	Site Name	Site Description	Willamette Meridian Location
1	Bayview Edison North	Located near the Samish River delta, at the northern limits of the property located at 6496 Bayview Edison Road. The site is bordered by Samish Bay and private properties.	Section 5, Township 35N, Range 3E
2	Bayview Edison South	Located on the west side/left bank of the Samish River, upstream of the Bayview Edison Road bridge. The site is bordered by the river and wetlands owned by Washington Department of Fish and Wildlife (WDFW).	
3	Farm to Market Road	Located about 1.5 miles upstream of Bayview Edison Road on the south side of the Samish River, upstream of the Farm to Market Road bridge. The site is bordered by the river and private properties.	Section 9, Township 35N, Range 3E

Figure 1, Vicinity Map shows the location of each site. The area is in Water Resources Inventory Area (WRIA) 3 (Lower Skagit/Samish), Hydraulic Unit Code (HUC) 17110002 (Strait of Georgia). An existing levee and floodgate system is located at each site and is proposed for upgrades. Land use surrounding the sites is predominantly agricultural production and sparse single-family residences. The wetland and stream assessment discusses the site-specific vegetation and habitat conditions (GeoEngineers 2018).

3.0 PROJECT DESCRIPTION

The overall project scope includes the installation of 16 new floodgates consisting of culverts with side-hinged tide gates. Project drawings are provided in Appendix B, Project Drawings. The project description presented below was derived from language provided by the design team, Northwest Hydraulic Consultants.

An overview of the proposed work at each site is presented in Table 2:

TABLE 2. PROPOSED SCOPE OF WORK BY PROJECT SITE

Site Name	Proposed Scope of Work
Bayview Edison North	■ Install four new culverts with tide gates at the dike.
Bayview Edison South	■ Install eight new culverts with tide gates at the dike. There are four existing 48-inch CPP culverts with top hinged tide gates that will remain.
Farm to Market Road	■ Install four new culverts with tide gates at the dike; There are two existing 48-inch corrugated metal pipe (CMP) culverts with top hinged tide gates, and one 36-inch CMP culvert at a lower elevation with no tide gate, that will remain.

3.1. Construction Sequence

The following is a proposed series of general construction actions to complete this project:

1. Site preparation and cap/cover and/or shut down utilities, if required.
2. Installation of erosion and sediment control measures.
3. Bayview Edison South and Farm to Market sites: Installation of a temporary cofferdam on the estuary/river side during a low tide in the dry. On the freshwater/drained side of the tide gates a cofferdam may be necessary to isolate the work area. No de-fishing will be required at these sites as work area isolation will occur during low tides in the dry.
4. Bayview Edison North site: All work will occur during a low tide and no cofferdam will be installed on the estuary side. On the freshwater/drained side of the tide gates a cofferdam will be installed in the ditch and the culvert under the access road will be plugged before dewatering the isolated work area in the ditch behind the tide gate. De-fishing is not proposed in the ditch as it is disconnected from the Samish River and the Samish River estuary via tide gates and dikes/berms.
5. During a low tide, removal of existing tide gate and culvert, if required.
6. Installation of new tide gates and culverts.
7. Regrading/restoration of the dike and riverbed within the temporary cofferdam, and removal of temporary cofferdam. Temporary cofferdams proposed at Bayview Edison South and Farm to Market only.
8. Site restoration/cleanup.

3.2. Construction Details

The following is additional information regarding the construction sequence as listed above, with proposed construction equipment listed in Table 3:

- Site preparation and cap/cover and/or shut down utilities.
  - Utilities preparation/shutdown: Preliminary investigation indicates that only the work area at Site 1 (Bayview Edison North) contains existing utilities – a domestic watermain and power line. The utility lines will be located and marked, turned off and capped throughout the project.
  - The project will require the removal of some existing native and non-native shrub and herbaceous vegetation. Clearing activities will be confined to the minimum area required.
- Installation of temporary erosion and sediment control (TESC) measures and spill prevention best management practices (BMPs).
  - General TESC BMPs that will be implemented for the project will include, but will not be limited to, the list below. For more project BMPs see Section 3.4 Impact and Minimization Measures below.
    - Construction limits and the extent of vegetation clearing will be kept to a minimum and will be marked prior to start of construction.
    - Stabilized construction entrances will be established and used throughout construction.
    - Runoff and run-on interception, diversion ditches and check dams will be installed.

- Accepted and approved erosion protection BMP measures, including silt fence, jute mat or similar slope protection matting, straw mulch, wattles or check dams will be used to prevent soil loss.
- Filter fence barriers will be established along toes of slopes and around staging and stockpile areas.
- Construction equipment hoses and fittings will be inspected and replaced, if necessary, before equipment is used.
- Distinct fueling areas outside the construction area will be identified and equipped with spill prevention and control devices.
- Adequate TESC materials will be placed on-site to respond to unanticipated weather conditions or accidental releases of materials (sediment, concrete or fuel).

TABLE 3. EQUIPMENT TO BE USED

Equipment to be Used	
Cranes	Loaders
Vibratory pile drivers	Compactor
Excavators	Electric submersible pump
Dump trucks	Baker tanks (if needed)
Backhoes	Various hand tools

- Installation of temporary cofferdam and dewatering of the isolated in-water work
  - Site 1: Bayview Edison North
    - No cofferdams will be required on the estuary/riverward side of the dike at the Bayview Edison North site. Culverts and tide gates will be installed during two low tide cycles, with one set of two pipes installed during a single low tide cycle and another set of two pipes installed during another single low tide cycle.
    - On the landward side of the dike a temporary cofferdam and a temporary plug in an existing culvert will be needed for work area isolation and dewatering in the ditch on the drained side of the dike. These features will also be installed during a low tide. No fish are anticipated within the adjacent ditch and therefore, no de-fishing or fish handling will be required at this location.
  - Sites 2 and 3: Bayview Edison South and Farm to Market
    - Cofferdams will be needed to isolate the work area at Bayview Edison South and Farm to Market. To prevent inundation of the work area, a gravel bag cofferdam, isolation dam or other method approved by the engineer, will be constructed. These cofferdams will be set above the low tide water surface elevation and installed "in the dry" during a low tide period. No fish handling will be required.
    - The cofferdam at Bayview Edison South and Farm to Market will be installed during a low tide the day of construction activities planned within the isolated work area. Construction activities will require multiple tide cycles, but the elevation of the cofferdam will not allow water to overtop the cofferdam.
  - Before the cofferdam(s) are removed levels of turbidity within the in-water work area will be returned to 5 nephelometric turbidity units (NTUs) over baseline levels.

- Tracks and drive trains for equipment will be kept out of flowing water, except as required for isolation dam installation and removal.
- Dewater soils in water isolation areas or excavated areas where groundwater presence prevents the contractor from establishing a stable foundation.
- Dewatering outlet location to be approved by the engineer or owner prior to dewatering.
- Contractor shall construct temporary flow isolation measures starting at the upstream end of the in-water work area to isolate and direct water away from the work area.
- Groundwater encountered during embankment or streambed excavation may be pumped as necessary to engineer or owner approved upland infiltration areas to allow construction and inspection.
- The plans show a suggested method for the contractor to isolate in-water work areas. Actual site conditions during construction may require adjustments to the plans shown and the contractor may elect to implement an alternative method with engineer's approval.
- Construction operations shall cease until further notice by the engineer if fish are distressed or killed or water quality problems develop.

- Removal of existing tide gate and culvert, if required.
- Installation of new tide gates and culverts.
- Site Restoration/Cleanup below the ordinary high water mark (OHWM) Bayview Edison North: regrading/restoration of the dike and riverbed at low tide without a cofferdam. Bayview Edison South and Farm to Market sites: regrading/restoration of the dike and riverbed within the temporary cofferdam, and removal of temporary cofferdam.
    - At all locations, in-water construction will be performed during a low tide in order for the work area to be dry during the construction. A formal TESC plan will be developed by the contractor to identify specific BMPs to be implemented when working in or adjacent to the river.
    - Bank armoring, in the form of angular rock, will be installed along the banks at the riverward side of the restored dike.
    - The temporary erosion control measures, BMPs and temporary cofferdam for work below the OHWM will be removed when regrading/restoration activities are completed.
    - Site restoration/cleanup activities below the OHWM, will consist of erosion control feature removal, and re-establishment of flow through isolated areas.
- Site Restoration/Cleanup above the OHWM.
    - Planting in the disturbed areas will be performed after grading work is completed, in order to provide the plants a better chance for survival. During the period of construction, a suitable temporary erosion control BMP, such as application of erosion-control grass seed, jute mat or other approved by Skagit County's construction manager, will be placed on the disturbed slopes until restoration planting is completed.
    - Once the construction and re-grading works is completed at Site 1 (Bayview Edison North), the temporary disconnected water and power line will be reconnected.
    - Native plants will be installed within all upland areas of disturbance above the OHWM by contractor. The plant species to be installed will be consistent with existing native species found adjacent to the stream. The species of proposed plants to be installed is summarized below in Table 4. Quantity of native plants will be determined after construction ensuring a replacement ratio of 5:1 for disturbed shrubs. No impacts to trees are anticipated.

- Hydroseeding will be installed by the contractor in all disturbed upland areas (above the OHWM) per Table 5 below. Exposed bare soils will be hydroseeded as needed and along steep slopes.
- The temporary erosion control measures and BMPs for work above the OHWM will be removed when it has been identified that side slopes are stable, and the bridge structure is functioning properly.

TABLE 4. NATIVE PLANT SPECIES FOR STREAM BANK RESTORATION

Common Name	Scientific Name	Container Size
Red osier dogwood	*Cornus sericea*	1-gallon or bareroot
Nootka rose	*Rosa nutkana*	
Pacific ninebark	*Physocarpus capitatus*	
Common snowberry	*Symphoricarpos albus*	

TABLE 5. NATIVE SPECIES FOR STREAM BANK RESTORATION

Common Name	Scientific Name	Mixture Proportion (Percentage)
Blue wildrye	*Elymus glaucus*	40
Red fescue	*Festuca rubra*	35
Meadow barley	*Hordeum brachyantherum*	15
Tufted hairgrass	*Deschampsia cespitosa*	10

3.3. Construction Schedule

Construction is planned to start during the summer of 2022 and will require approximately 1 to 2 months to complete. All work below the OHWM will be conducted during the approved in-water work window, as noted in agency permit conditions. Site mobilization, preparation and specific construction activities that do not require in-water work may be conducted outside of the in-water work window. The USACE in-water work window for the Samish River below hatchery rack is June 15 to August 15 (USACE 2012a). The combined USACE in-water work window for Tidal Reference Area 9 (Blaine) for salmon and bull trout is July 2 to February 15 (USACE 2012b). WDFW lists August 1 to September 15 as the times when spawning or incubating salmonids are least likely to be present in the Samish River (3.0005) (WDFW 2018). The final combined in-water work window will be determined by the WDFW and the USACE in permit conditions.

3.4. Impact and Minimization Measures

Minimization measures and BMPs will be used during work activities to avoid impacts to listed species and their habitat located downstream of the project work area. Conservation measures will focus on minimizing construction noise and the possibility of spills, preventing soil erosion and minimizing impacts to riparian vegetation. Special measures will be taken to ensure that all waste materials will be disposed of off-site and in accordance with applicable regulations, adequate materials and procedures are readily available on the site to respond to unanticipated weather conditions or accidental releases of materials. A protocol for contacting WDFW and Washington State Department of Ecology (Ecology) will be readily available in the unlikely event that activities are observed to result in fish kills, fish in distress or other water quality problems, in accordance with the Hydraulic Project Approval (HPA) for the project.

3.4.1. General Conservation Measures

- Work will be in compliance with all other local, state and federal regulations and restrictions.
- Excavation will be limited to those areas necessary for access to the work areas and construction activities. The construction limits will be marked in the field and equipment will not be allowed outside the work area. All excavation within the channel/below the OHWM will occur from the top of the existing dike, and no machinery will enter the river/estuary.
- A TESC plan will be fully implemented as part of Stormwater Pollution Prevention Plan (SWPPP) that will be generated by the contractor. Construction techniques will use BMPs such as those described in the 2018 version of WSDOT's *Standards and Specifications for Road, Bridge, and Municipal Construction* (WSDOT 2018) and *Ecology's Stormwater Management Manual for Western Washington* (Ecology 2014). Appropriate erosion control measures will be installed at appropriate locations.
- Site preparation and construction activities below the OHWM will be conducted during in-water work windows and all site preparation and construction activities will be conducted during the summer period of drier weather.
- A dewatering plan will be implemented for work within the stream and estuarine waters.
- Adequate materials will be maintained on-site to respond to weather conditions and modify the construction plan as needed to accommodate unanticipated events.
- Routine inspections of the erosion control measures will be conducted daily during construction to ensure the effectiveness of the measures and to identify the need for maintenance or additional control measures.
- Grading and construction will be phased to reduce the time that soil is exposed to the extent possible.
- Disturbance will be limited to the smallest area feasible for each phase of the project and element under construction and will stay within the limits of construction as identified on the site plans.
- Disturbed areas of the stream bank will be revegetated with native shrubs following construction.
- The contractor will prepare a Spill Prevention and Emergency Cleanup Plan (SPECP) for this project. Potential spills will be handled and disposed of in a manner that does not contaminate the surrounding area. Adequate materials and procedures to respond to unanticipated weather conditions or accidental releases of materials (sediment, petroleum hydrocarbons, etc.) will be available on-site. The SPECP also will ensure the proper management of oil, gasoline and solvents used in the operation and maintenance of construction equipment and that equipment remains free of external petroleum-based products prior to entering the work area and during the work and for making any necessary repairs prior to returning the equipment to operation in the work area.
- An emergency spill containment kit must be located on-site along with a pollution prevention plan detailing planned fueling, materials storage and equipment storage. Waste storage areas must be prepared to address prevention and cleanup of accidental spills.
- All construction-related debris will be cleaned up on a daily basis. Proper conservation measures will be taken to ensure that debris will not contaminate the stream waters.
- Waste materials, including any concrete, riprap, miscellaneous garbage and/or other debris removed from the project site, will be transported off-site for disposal in accordance with applicable regulations.

- Fueling areas will be distinctly identified and established outside of the construction area sensitive areas. These areas will be equipped with spill prevention and control devices.

3.4.2. Measures to Reduce Impacts to Species and Habitats

- The project will obtain and comply with conditions that will be outlined in the HPA permit issued for the project by WDFW. All work below the OHWM will be conducted during the approved work window for fish species that may be located within the project area.
- All debris resulting from construction shall be removed from the project area and prevented from entering Waters of the United States.
- Construction procedures have been designed to minimize the opportunity for erosion to occur or sediment-laden water to enter downstream areas.
- Silt fences will be installed along the perimeter of the work areas to help confine sediment and runoff. Straw bales will be added if concentrated surface water flow is observed.
- To avoid direct disturbances to the stream channel while working below the OHWM (e.g., tide gate and culvert installation) excavation equipment and other machinery will operate from up on the existing dike, so that only the excavator buckets will make contact with the stream channel/estuary bed.
- If at any time, as a result of project activities, fish are observed in distress, a fish kill occurs or water quality problems develop (including equipment leaks or spills), immediate notification shall be made to Ecology at 1.800.258.5990 and the WDFW Area Biologist listed in the HPA.
- At the Bayview Edison North site all work below the OHWM will be performed during a low tide in the dry.
- The work areas at the Bayview Edison South and Farm to Market sites will be isolated from the river/estuary via a gravel bag cofferdam, isolation dam or other method approved by the engineer.
- Installation of the cofferdam to establish the isolated work area at Bayview Edison South and Farm to Market sites will not commence until the tide is out and the work area is dry.
- Construction operations shall cease until further notice by the engineer if fish are distressed or killed or water quality problems develop.
- To reduce the potential for spills and leaks, an adequate supply of materials (such as a vacuum pump, booms, diapers and other absorbent material) to control and contain deleterious materials in the event of an accidental spill, will be kept on hand.
- All construction-related debris will be cleaned up daily. Proper conservation measures (e.g., containment devices such as scaffolding and tarps) will be taken to ensure that debris will not contaminate the waters.
- Waste materials, including any concrete, miscellaneous garbage and/or other debris removed from the project site, will be transported off-site for disposal in accordance with applicable regulations.
- Work will follow all other local, state and federal regulations and restrictions.
- Excavation will be limited to those areas necessary for access to the work areas and construction activities. The construction limits will be marked in the field and equipment will not be allowed outside the work area.

- Site preparation and construction activities near the water will be conducted during periods of drier weather.
- Adequate materials will be maintained on-site to respond to weather conditions and modify the construction plan as needed to accommodate unanticipated events.
- Routine inspections of the erosion control measures will be conducted daily during construction to ensure the effectiveness of the measures and to determine the need for maintenance or additional control measures.
- Grading and construction will be phased to reduce the time that soil is exposed to the extent possible.
- Disturbance will be limited to the smallest area feasible for each phase of the project and element under construction and will stay within the limits of construction as identified on the site plans.
- Fueling areas will be distinctly identified and established outside of sensitive areas, but within the construction area. These areas will be equipped with spill prevention and control devices.
- Construction procedures have been designed to minimize the opportunity for erosion to occur or sediment-laden water to enter downstream areas.
- Excavation equipment and other machinery will be used from the upland area (and not in the water) to avoid direct disturbance to the waters.

3.5. Interdependent and Interrelated Actions

Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action being considered. There are no interdependent or interrelated actions because of the proposed project.

4.0 ACTION AREA

The Action Area for the project is defined by the geographical effects of the action on the environment and will be identified by temporary construction-related noise (direct effect) and temporary habitat displacement (direct effect). Construction-related noise will occur as a result of operation of general construction equipment. Construction-related noise will permeate terrestrial (in-air) environments and may carry into the surrounding environment beyond the project site.

For this project, the Action Area was identified as the floodgate construction footprint at each site as well as the surrounding area within 3,459 feet from each site, as shown on Figure 2, Action Area Map. Site 1 and 2 has an extended Action Area within the estuarine waters of Samish River delta due to the difference of how noise travels over water (hard site conditions) versus land, extending an additional 9,976 feet.

Potential impacts to water quality, such as spilling hazardous materials, petroleum-based products associated with construction machinery, or dust or debris from the project actions, will be controlled through proper implementation of the Spill Prevention, Control and Countermeasures (SPCC) plan and BMPs, including working in the dry, and are not expected to have negative impacts on the environment.

Project-specific effects that were considered to identify the Action Area for the project include:

- Construction-related noise (direct effect, short-term temporary impact);

- Degradation of water quality (direct and indirect effects, potential for both short-term and long-term impacts); and
- Habitat alteration (direct and indirect effects, potential for both short-term and long-term impacts).

The spatial extents of these effects are used in total to identify the Action Area, as discussed in the following sections.

4.1. Construction-Related Noise

Construction-related noise will occur as a result of operation of general construction equipment. This effect is limited to the construction period and will not persist once construction is complete. Construction-related noise will permeate terrestrial (in-air) environments and may carry into the surrounding environment beyond the project site. Construction-related noise will not affect aquatic (underwater) environments because construction will generally be above OHWM; in-water work associated with floodgates, will be completed during low tides, or in the dry with cofferdams and will not generate underwater noise.

The extent that in-air noise will permeate the surrounding environment was estimated using guidance provided by WSDOT (2019). Construction equipment will include typical machinery such as backhoes, graders, excavators and compactor. A combined noise level using backhoes, excavators and compactors resulted in a max noise level of 86 dBA (at 50 feet from the source) and is used to estimate the maximum extent of construction noise (WSDOT 2019). Background noise levels surrounding the site are dependent on the agricultural/pasture setting of the area. Based on this information, background noise at the project site is estimated to be 40 dBA. The project site is surrounded by roads, farm fields and trees creating a "soft-site" that would attenuate noise at an approximate rate of 7.5 dBA per doubling distance (WSDOT 2019). Therefore, potential noise impacts were calculated for a "soft-site." However, Site 1 (Bayview Edison North) is adjacent to the Samish River delta which creates a "hard-site" condition, as noise travels further over water than land with attenuation at a rate of 6.0 dBA per doubling distance (WSDOT 2019). Within these parameters, the distance from the project at which construction equipment noise is expected to become indistinguishable from background ambient noise conditions is 3,459 feet over land, for Site 3 (Farm to Market Road) and Site 2 (Bayview Edison South), and 9,976 feet over water (in the case of Site 1 [Bayview Edison North]) Table 6 below).

TABLE 6. IN-AIR DISTANCES TO ATTENUATION

Location	Distance to Attenuation
Over Land (soft-site conditions)	3,459 feet
Over Water (hard-site conditions)	9,976 feet

Notes:

[1] Determined using the practical spreading loss method within the WSDOT *BA Manual* (WSDOT 2019).

4.2. Habitat Alteration and Displacement

Habitat alteration may include direct impacts to riparian vegetation and to fish migratory pathways from isolation areas necessary for floodgate construction activities within the channel or nearshore. Both of these activities are considered temporary as native plants will be installed in disturbed upland areas and flow will be re-established through isolation areas following construction activities. Long-term alteration of stream/estuary habitats is not anticipated.

4.3. Water Quality Degradation

The project has the potential to temporarily impact the water quality of Samish River and estuarine waters within the Samish River delta from hazardous materials associated with construction equipment, construction debris and increased turbidity from installation of the cofferdams and tidal inundation of the work areas (only at Site 1 and Site 2). Installation of the cofferdams has the potential to create a temporary increase in turbidity when the bottom substrate is directly disturbed.

Installation of the cofferdam at Sites 2 and 3 will occur the day prior to floodgate construction. The cofferdam will be installed during a low tide in the dry. This area may be inundated following cofferdam installation, depending on the tide cycle. Sediments will be allowed to settle out of the water within the isolation area before pumping and discharging water back into the estuary, or water will be pumped to baker tanks to settle out before discharging back into the estuary. The potential for sediments to travel out of the Action Area is unlikely because work below the OHWM/High Tide Line (HTL)/Mean High Water (MHW) will only occur in the dry during low tides and appropriate BMPs will be implemented to contain fine sediments, such as working at low tide and isolation of the work area below the OHWM using a cofferdam.

Risks of spilling hazardous materials or petroleum-based products associated by construction machinery, will be controlled through proper implementation of BMPs. Construction debris entering the water is unlikely through proper implementation of the TESC Plan and considered a potential impact since these activities are temporary.

4.4. Action Area Summary

The overall Action Area includes the spatial extent of all project effects on the environment and is presented in Figure 2. The Action Area includes the zones of influence for areas affected by construction-related noise and potential habitat alteration. The Action Area is three dimensional and the spatial extent of project effects differs between upland, shoreline and over-water areas. Because of the construction sequencing and the planned BMPs, sediments will be contained within the work area and are not expected to be transported away from the work area. The three sites will not be constructed at the same time but in an order to be determined by the contractor. Therefore, the extent of the Action Area will be limited as a result (Figure 2).

Noise effects will extend the furthest and set the boundary for the Action Area. Construction-related noise will travel above soft surfaces approximately 3,459 feet and approximately 9,976 feet above hard surfaces (water and paved areas), encompassing the zones of influence for in-air noise and habitat alteration. The Action Area includes urban areas, residential areas, roads and water. The project will not include in-water mechanized work as all work below the OHWM/HTL/MHW will be conducted in the dry; therefore, in-water noise impacts are not expected.

5.0 SPECIES AND HABITAT INFORMATION

Species listed under the ESA fall under the jurisdiction of one of two federal agencies: the USFWS for terrestrial and freshwater species, and the National Oceanographic and Atmospheric Administration (NOAA) Fisheries for marine species. We obtained a list of listed or proposed species and designated or proposed critical habitat for the project area from the USFWS (2021). We also obtained lists of listed or proposed species and designated or proposed critical habitat for marine species in the Puget Sound from NOAA

Fisheries/NMFS (NOAA Fisheries 2016; NOAA Fisheries 2006). These official species lists and critical habitat maps are included in Appendix C, Species Lists.

According to WDFW Priority Habitats and Species (PHS) data and USFWS Information for Planning and Consultation (IPaC) data, the project site potentially contains numerous fish species. Washington State Department of Natural Resources (DNR) shows no sensitive plant records in the vicinity of the project (DNR 2019).

5.1. Species and Critical Habitat that May be Present in the Action Area

The USFWS and NOAA Fisheries lists identify species and critical habitat potentially present in Skagit County. Consequently, not all species in these lists are expected to occur within the Action Area. Additionally, information regarding the presence of listed species within the Action Area was obtained from the WDFW PHS online mapper (WDFW 2019a) and USFWS IPaC (USFWS 2021). A summary of listed species and critical habitat status found in the Action Area is listed in Table 7. Life histories of these species are included in Appendix D, ESA Listing Status and Species Life Histories.

TABLE 7. SPECIES AND CRITICAL HABITAT THAT MAY OCCUR IN THE ACTION AREA

Common Name	Scientific Name	Jurisdiction	Status	Critical Habitat
Bull Trout	*Salvelinus confluentus*	USFWS	Threatened	Designated
Marbled murrelet	*Brachyramphus marmoratus*		Endangered	Designated
Puget Sound Chinook Salmon	*Oncorhynchus tshawytscha*	NOAA Fisheries	Threatened	Designated
Puget Sound Steelhead	*Oncorhynchus mykiss*		Threatened	Designated
Southern Resident Killer Whale (SRKW)	*Orcinus orca*		Endangered	Designated

5.2. Species and Critical Habitat Not Addressed in the Biological Evaluation

The following ESA-listed species may occur in Skagit County and/or Puget Sound, but are not expected to occur in the Action Area and are, therefore, not addressed in this BE.

- **Gray wolf (*Canis lupus*).** Gray wolf are not reported nor expected to occur in or near the Action Area. While this species is listed as occurring in Skagit County, it is likely only present in forested, more remote and higher elevation habitats. Therefore, **no effect** to gray wolf are expected to occur from project activities.
- **North American wolverine (*Gulo luscus*).** There are no known North American wolverines inhabiting the lowlands of Skagit County. Wolverines are not expected to occur in the agricultural setting that dominates the Action Area. The likelihood of a wolverine entering the Action Area is minimal to none. Therefore, **no effect** to North American wolverine are expected to occur from project activities.
- **Streaked Horned Lark (*Eremophila alpestris strigata*)** and associated critical habitat. There have been no recent sightings of streaked horned larks within the project area (WDFW 2019a). This species typically utilizes open spaces dominated by grasses and other herbaceous vegetation (WDFW 2005). Although habitat within the project area potentially meets this criteria, there are no documented populations within Skagit County and streaked horned larks are not expected to be within the project area. Therefore, **no effect** to streaked horned lark are expected to occur from project activities.

- **Yellow-billed cuckoo (*Coccyzus americanus*).** Yellow-billed cuckoos are associated with open deciduous woodlands and deciduous forests that are at least 25 acres in size (NatureServe 2019). Yellow-billed cuckoos are not expected to occur in the Action Area where there are limited to no forested areas. The likelihood of a yellow-billed cuckoo entering the Action Area is minimal to none. Therefore, **no effect** to yellow-billed cuckoo are expected to occur from project activities.
- **Dolly Varden (*Salvelinus malma*).** Dolly Varden are listed as proposed by the USFWS based on similarity of appearance to bull trout. None of the effects of this project would discriminate ESA species based on appearance; therefore, effects of the project on Dolly Varden are covered in this BE through discussion of bull trout. Dolly Varden are not addressed in the remainder of this document.
- **Oregon Spotted Frog (*Rana pretiosa*).** There have been no recorded Oregon spotted frog sightings within the vicinity of the project (WDFW 2019a). According to the critical habitat listing (81 FR 29335), this species is found in or near perennial bodies of water with moderately vegetated pools for both adult and juvenile survival in the dry season and perennial water overlying emergent vegetation for protection during cold wet weather. Critical habitat is designated within the Samish River watershed but on the east side of Interstate-5. There is no designated critical habitat for Oregon spotted frog within the Action Area. Therefore, **no effect** to Oregon spotted frog are expected to occur from project activities.

5.3. Utilization of Habitats by Listed Species

Land use surrounding the sites features predominantly agricultural production and sparse single-family residences. Vegetation consists mostly of herbaceous plants as part of a developed agricultural landscape with limited terrestrial habitat. Within the Action Area of Site 1, estuarine zone habitats are mapped by the PHS online mapper within the marine waters of Samish Bay (WDFW 2019a).

Samish River and Samish River delta are part of a migratory corridor for salmonid species and nearshore habitat may be used by salmonids for rearing. Designated critical habitat within the project vicinity and the Action Area is for bull trout, Chinook salmon, steelhead salmon and SRKW.

5.3.1. Marbled murrelet (*Brachyramphus marmoratus*)

Marbled murrelets are mapped by USFWS as being potentially located within the estuarine portions of the Action Area for Site 1 (USFWS 2021). The presence of marbled murrelets is possible, though not particularly likely due to the limited extent of the Action Area within the marine environment. Construction activities at Site 1 are proposed only during low tides when subtidal portions of the Action Area are very shallow further limiting the suitable depth for foraging during instances of in-air noise traveling above the waters of Samish Bay. In addition, there is no critical habitat designated for the marbled murrelet in the project Action Area as the nesting/critical habitat consists of mature forests, which are not found within the Action Area or in the vicinity of the project (61 FR 26255). Marbled murrelets are, therefore, not likely to occur within the Action Area.

5.3.2. Bull Trout (*Salvelinus confluentus*)

Bull trout are mapped by WDFW as being within the Samish River (WDFW 2019a and 2019b). Because the Samish River also empties into Samish Bay, presence of these species in the marine areas near the project site is possible. The likelihood of bull trout occurring in the Action Area during the in-water work window is substantially reduced, but still possible.

Nearshore marine areas in Puget Sound are designated as critical habitat for bull trout (70 FR 56212). The Primary Constituent Elements (PCEs) identified for bull trout critical habitat include: (1) water temperatures that support bull trout use; (2) complex stream channels with features such as woody debris, side channels, pools and undercut banks to provide a variety of depths, velocities and in-stream structures; (3) substrates of sufficient amount, size and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival; (4) a natural hydrograph, including peak, high, low and base flows within historic ranges or, if regulated, currently operate under a biological opinion that addresses bull trout, or a hydrograph that demonstrates the ability to support bull trout populations by minimizing daily and day-to-day fluctuations and minimizing departures from the natural cycle of flow levels corresponding with seasonal variation; (5) springs, seeps, groundwater sources and subsurface water to contribute to water quality and quantity as a cold water source; (6) migratory corridors with minimal physical, biological or water quality impediments between spawning, rearing, overwintering and foraging habitats, including intermittent or seasonal barriers induced by high water temperatures or low flows; (7) an abundant food base including terrestrial organisms of riparian origin, aquatic macroinvertebrates and forage fish; and (8) permanent water of sufficient quantity and quality such that normal reproduction, growth and survival are not inhibited.

Freshwater-specific PCEs for bull trout are not present in the Action Area (i.e., PCEs 2, 3, 4 and 5). Water temperature in Samish River poses a problem for bull trout use as elevated temperatures are recognized as a concern in the portion of the river within Sites 2 and 3. Water quality and fecal coliform contamination in these associated waterbodies and have been known to suppress immune systems in salmonids and be lethal to benthic organisms, which provide food for salmonids (Smith 2002). Near-shore habitats at the project site are, therefore, unlikely to provide suitable habitat for bull trout.

5.3.3. Puget Sound Chinook Salmon (*Oncorhynchus tshawytscha*)

Puget Sound Chinook salmon are mapped in Samish River (WDFW 2019a). The nearshore habitat of Samish Bay associated with Site 1 and Site 2, are mapped critical habitat for Chinook salmon. Therefore, the presence of Chinook salmon is possible at each of the three sites. However, by conducting in-water work during the approved work window, the chance of Chinook salmon occurring in the Action Area during construction is significantly reduced.

As discussed above, designated critical habitat for Chinook salmon includes near-shore marine areas of the Puget Sound (70 FR 52630) and is within the Action Area for construction activities at Site 1. The PCEs for Chinook salmon critical habitat include: (1) freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development; (2) freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility, water quality and forage supporting juvenile development, natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels and undercut banks; (3) freshwater migration corridors free of obstruction with water quantity and quality conditions and natural cover, such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival; (4) estuarine areas free of obstruction with water quality, water quantity and salinity conditions supporting juvenile and adult physiological transitions between fresh and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation; (5) near-shore marine areas free of obstruction with water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and (6) offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.

The Samish River meets freshwater-specific PCE 3 regarding migration corridors for Chinook salmon; however, water temperature and other water quality parameters pose a problem within Samish Bay (further discussion presented in Section 6.4 Hydrology and Floodplain Characteristics). Water quality in Samish River is a known concern for fish and other aquatic life. Poor water quality has known impacts to immune systems in salmonids and be lethal to benthic organisms, which provide food for salmonids (Smith 2002). Site 1 and Site 2 have estuarine conditions and therefore potentially meet PCE 4 and 5; however, because the project sites are within modified/armored shoreline in areas adjacent to the existing floodgates they are unlikely providing suitable habitat for Chinook salmon that meets all PCE criteria.

5.3.4. Puget Sound Steelhead (*Oncorhynchus mykiss*)

Puget Sound steelhead occur in the Samish River (WDFW 2019a and 2019b). It is likely that steelhead are located along the shoreline within the project area and Action Area. Critical habitat for Puget Sound steelhead has been designated within Samish River within the Action Area (81 FR 9252). The PCEs for steelhead critical habitat are the same as Chinook salmon (listed above).

5.3.5. Southern Resident Killer Whale *(Orcinus orca)*

SRKW may be found in the project vicinity during the in-water work period, which occurs in summer. SRKW have been observed year-round in inland waters of Puget Sound and the portion of Samish Bay within the Action Area is mapped as “Area 1 – Summer Core Area” (NOAA Fisheries 2006). However, the NOAA occurrence map indicates only one observation of a SRKW near Samish Bay in a compilation of sightings from 1990 through 2013; this animal was observed in December (NOAA 2013). Although it is possible that SRKW would occur in Samish Bay in the summer, it is not likely that they will occur within the Action Area when in-air noise would travel over marine waters due to construction activities being limited to low tides, and subtidal areas within the Action Area being less than 20 feet deep.

Designated critical habitat for SRKW includes all marine waters in Samish Bay deeper than 20 feet relative to extreme high tide (71 FR 69054). NOAA has proposed revision to the critical habitat designation for SRKW which would expand designated critical habitat for the species (84 FR 49214). The proposed critical habitat expansion does not include estuary areas in waters shallower than 20 feet MLLW, and therefore proposed project activities will not affect proposed SRKW critical habitat. The Summer Core Area is specifically focused on Haro Strait, which is located along the international border between Vancouver Island and San Juan Island, and the waters surrounding the San Juan Islands, not Samish Bay. Specific PCEs that have been identified for SRKW critical habitat include: (1) space for individual and population growth, and for normal behavior; (2) food, water, air, light, minerals, or other nutritional or physiological requirements; (3) cover or shelter; (4) sites for breeding, reproduction, rearing of offspring, germination or seed dispersal; and generally, (5) habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species. Habitat at the project site or within the Action Area generally does not provide these PCEs and, therefore, is not considered suitable for SRKW.

6.0 ENVIRONMENTAL BASELINE

There are three sites that are proposed for floodgates with Site 1 located on the nearshore of the Samish River delta and Site 2 and Site 3 located on the banks of the Samish River. The Action Area includes terrestrial, freshwater, estuarine, riparian and wetland habitats. Environmental conditions in these habitats are discussed below. Site photographs are provided in Appendix E, Site Photographs.

6.1. Terrestrial Habitat

Terrestrial environments within the Action Area are primarily developed and do not provide habitat for terrestrial or avian species. There is no suitable nesting habitat for marbled murrelets within the Action Area. There is only sparse, weedy vegetation within the project area.

6.2. Freshwater, Estuarine and Riparian Habitats

The Samish River and associated Samish River delta support numerous species of fish. Table 8 presents the fish species mapped within the project area:

TABLE 8. MAPPED FISH SPECIES WITHIN THE PROJECT AREA

Documented Fish Species within Samish River and Samish Bay	
Chum (*Onchorhynchus keta*)	Coho (*Onchorhynchus kisutch*)
Cutthroat (*Onchorhynchus clarki*)	Dolly Varden/bull trout (*Salvelinus malma*)
Fall Chinook (*Onchorhynchus tshawytscha*)	Kokanee (*Onchorhynchus nerka*)
Pink salmon (*Onchorhynchus gorbuscha*)	Rainbow trout (*Onchorhynchus mykiss*)
Sockeye (*Onchorhynchus nerka*)	Steelhead (*Onchorhynchus mykiss*)

As mentioned above, nearshore habitats of Samish River delta and the Samish River are designated as critical habitat for listed salmonids and bull trout.

Marine habitat within the Action Area could possibly provide foraging habitat for marbled murrelets and/or SRKWs, but neither of these species is very likely to occur in nearshore portions of Samish Bay.

Intertidal areas (between mean lower low water [MLLW] and HTL/OHWM) in the vicinity of each of the project sites are generally degraded. Vegetation is generally lacking, with riprap, and in some cases, other debris are present. This area generally does not provide good habitat for fish or their prey species. The upland conditions at each of the sites consist of limited vegetation

6.3. Wetland Habitat

Wetland features were documented in the vicinity of the proposed project activities at each of the three sites. Site 1 and Site 3 have wetlands that are along the backside of the levee (GeoEngineers 2018). Site 2 has an adjacent wetland feature that is owned by WDFW. Appendix F, Delineated Wetland Habitat includes figures from this report that show these mapped features. Construction activities at Site 1 and Site 3 will have minor and temporary wetland impacts. Site 2 has an emergent wetland in the vicinity that will be temporarily disturbed. Impacted areas will be replanted as presented in Section 3.2 Construction Details.

6.4. Hydrology and Floodplain Characteristics

The Samish River is approximately 25 miles long and drains an area of approximately 139 square miles between the Skagit River basin on the south and Nooksack River basin on the north. The river originates in Whatcom County and flows southwest through Skagit County, discharging into Samish Bay. Major land uses surrounding the Samish River include agriculture and forestry leading to sedimentation, elevated temperature and fecal coliform impacts within the river.

Average river discharge is approximately 245 cubic feet per second. National Weather Service has established flood warning level of 3,000 cubic feet per second (USGS 2019).

The Samish basin has continued to have problems with high fecal coliform leading to repeated closures of the commercial and recreational fisheries in Samish Bay. The Skagit County Water Quality Monitoring Program (SCMP), has established 11 sampling sites in the basin to identify more precisely the locations that are contributing the fecal coliform exceedances (Skagit County 2019).

Table 9 summarizes the water quality assessment for the sites along the Samish River (Ecology 2016).

TABLE 9. WATER QUALITY ASSESSMENT DATA FOR SITES ON SAMISH RIVER

Project Site	Water Quality Category	Water Quality Parameter in Exceedance
Site 2: Bayview Edison South	Category 5	Temperature
	Category 4A	Bacteria
	Category 2	Dissolved Oxygen
Site 3: Farm to Market Road	Category 4A	Bacteria
	Category 2	pH and temperature
	Category 1	Ammonia-N

7.0 EFFECTS ANALYSIS

Effects of the proposed action are defined as “the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with the action, that will be added to the environmental baseline” (50 Code of Federal Regulations [CFR] §402.02). Project-related effects are confined to the project Action Area, defined in Section 4.0 Action Area of this report. This section provides an analysis of the anticipated effects outlined in the Action Area section: temporary construction-related noise, temporary habitat displacement and potential water quality degradation.

This section provides an analysis of the anticipated effects of the project, with a focus on potential effects to fish. There will be no permanent alteration of habitat used by fish resulting from the project. As described in Section 5.3 Utilization of Habitats by Listed Species, spawning habitats are not anticipated to be directly affected by the project because there is no spawning habitat within the Action Area. Impacts to migratory habitats are anticipated as there will be work below the OHWM within the migratory corridors.

Effects of project activities on fish habitat were evaluated relative to the "Pathways and Indicators" of salmon habitat for Puget Sound Chinook salmon, Puget Sound steelhead, coastal-Puget Sound bull trout[1] and SRKW populations in accordance with guidance documents provided by the NMFS and the USFWS (NOAA 1996 and 1999; USFWS 1998).

7.1. Direct Effects

Direct effects are those that occur during construction and immediately upon conclusion of project activities. This proposed action may cause the following direct effects:

- **Construction-related noise.** Construction activity and noise in excess of background conditions generated during the project could permeate residential and vegetated habitats for up to approximately 3,459 feet and permeate over water and paved areas for up to approximately 9,976 feet around the project site (Figure 2). This effect will be temporary in nature and will not persist upon project completion as well as be limited to the site at which construction activities are occurring. There will be no in-water work that could potentially increase noise levels affecting ESA-listed fish species or killer whales. Therefore, there will be **no effect** of noise on ESA-listed fish species or SKRW resulting from the project. In-air noise may affect marbled murrelets foraging within the Samish River delta or marine waters of Samish Bay, however the likelihood of these birds utilizing these habitats is unlikely.
- **Habitat displacement.** Habitat displacement and alteration consists of temporary and permanent effects. Habitat displacement associated with in-water work will be temporary and last through construction. The zone of habitat alteration is the same as the project footprint and associated isolation/dewatering areas, for each site.
- **Water quality degradation.**
    - **Hazardous material spills.** Potential impacts to water quality, such as spilling hazardous materials or petroleum-based products associated with construction machinery, will be controlled through proper implementation of BMPs and are, therefore, not expected to have negative impacts on the environment.
    - **Sediments and construction debris.** There is potential for temporary water quality impacts to occur as a result of sediments or construction debris traveling in the water. The potential for sediments and debris to travel out of the Action Area is unlikely though, because appropriate BMPs to contain fine sediments will be established. Potential impacts are expected to be temporary and minor, and will partially be controlled through proper implementation of the TESC Plan, including isolation of the work area below the OHWM with a cofferdam, pumping sediment laden water to upland areas and allowing suspended sediments to settle out of estuarine water in the work area before pumping back into the estuary..

7.2. Indirect Effects

The installation of the floodgate structures at the three sites are designed to reduce flooding in the adjacent lands. Reducing the flooding frequency and intensity in the surrounding areas has the potential to indirectly benefit streams that flow through these adjacent areas and fish that occupy them. Replacement of

[1] Although bull trout are the purview of the USFWS not the NMFS, this assessment has included them because they are an ESA-listed species and the parameters assessed are, to a large degree, if not entirely, applicable to them as well.

disturbed bank vegetation with native species has the potential for indirectly affecting habitat quality for ESA-listed fish species that occupy the adjacent waters.

7.3. Pathways and Indicators of Bull Trout and Salmon Habitat

The following sections address the "Pathways and Indicators" of bull trout and salmon habitat developed by NOAA (1996) and the USFWS (1998). The matrices developed by each agency are very similar though not identical (the USFWS matrix was developed subsequently and was based on the NOAA matrix, with some revision specific to bull trout). For simplicity, we have adopted the format presented by NOAA.

The pathways evaluated include water quality (temperature, sediment/turbidity, chemical contamination/nutrients); habitat access (physical access); habitat elements (substrate, large woody debris [LWD], pool frequency, pool quality, off-channel habitat, refugia); channel condition and dynamics (width/depth ratio, streambank condition, floodplain connectivity); and flow/hydrology (altered peak/base flows, drainage network increase). Each pathway identified in the following sections is comprised of one or more indicators, which may be affected by one or more of the potential project effects identified in Section 4.0 Action Area (construction-related noise, habitat alteration and displacement, and water quality degradation).

TABLE 10. SUMMARY OF ENVIRONMENTAL BASELINE FUNCTIONING CONDITIONS AND PROJECT EFFECTS

Pathways	Indicators	Environmental Baseline			Effects of the Action(s)		
		Properly Functioning[1]	At Risk[1]	Not Properly Functioning[1]	Restore[2]	Maintain[3]	Degrade[4]
Water Quality	Temperature		X			X	
	Sediment/ Turbidity		X			X	
	Chemistry		X			X	
	Contamination/ Nutrients		X			X	
Habitat Access	Physical Access	X				X	
Habitat Elements	Substrate		X			X	
	Large Woody Debris			X		X	
	Pool Frequency and Pool Quality			X		X	
	Off-Channel Habitat			X		X	
	Refugia			X		X	
Channel Condition and Dynamics	Width/ Depth Ratio	X				X	
	Streambank Condition			X		X	
	Floodplain Connectivity			X		X	
Flow / Hydrology	Altered Peak/ Base Flows			X		X	
	Drainage Network Increase			X		X	

Notes:

[1] The three categories of function and their thresholds are defined for each indicator in the NMFS Matrix of Pathways and Indicators (NOAA 1996).

[2] For this assessment, "restore" means to change the function of an "at risk" indicator to "properly functioning," or to change the function of a "not properly functioning" indicator to "at risk" or "properly functioning". “Restore” does not apply to "properly functioning" indicators.

[3] For this assessment, "maintain" means that the function of an indicator is not changed.

[4] For this assessment, "degrade" means the function of an indicator is changed for the worse.

7.3.1. Water Quantity and Quality

Project activities will have some effect on water quantity within the Samish River, as the new floodgates will release high floodwaters from behind the levees more quickly, into the Samish River. At Site 3 the Samish River is tidally influenced and Sites 1 and 2 are fully tidally inundated such that the effect of high floodwaters releasing into the Samish River and Samish Bay will be negligible compared to tidal backwatering. Wetlands associated with Site 1 and Site 3 will experience less extreme depth of inundation, however the tide gates are so high up that inundation areas and saturated areas will not be affected. This project will have some beneficial effect on water quantity for ESA-listed species as flood waters will return in a more natural way compared to existing conditions.

Water quality within Samish River and Samish River delta is currently considered impaired with respect to several water quality parameters related to the associated land-use by agriculture and residential septic systems. There is potential for short-term impacts from construction activities (namely cofferdam installation, regrading, excavation) on water quality, but these effects are considered **insignificant** as a result of proposed BMPs. Therefore, the measurable water quality impact to ESA-listed species is *discountable.* There are no long-term impacts to water quality

7.3.1. Physical Access

The proposed project activities will only have short-term impacts to the migratory pathways of the nearshore portion of Samish River delta associated with Site 1 and the Samish River migratory pathway for Site 2 and 3. The construction areas will be isolated from the adjacent waterbodies by cofferdams. These isolation areas are temporary, small relative to the adjacent waterbody (Samish River and Samish Bay) and will not have a significant impact on available habitat. Therefore, the current project activities will have **insignificant** effects on physical access.

7.3.2. Flood Storage Capacity and Related Impacts

The purpose of these additional floodgate structures is to is to allow flood waters that build up behind the dikes along the Samish River to drain to the Samish River/Samish Estuary thus reducing flooding in the adjacent farms fields and roads. Improvement of the floodgate system along the Samish River provides protection to the interior river delta from inundation and potential hazards to the community. Flood management reduces impact to habitat both within the Samish River and the streams within the interior of the river delta during high flows. As a result, fish residing within these waterbodies during high flows are more likely to be able to navigate and survive during peak flows.

7.3.3. Riparian Vegetation

Riparian vegetation has numerous functions throughout the watershed by creating shade, stabilizing streambanks, attenuating flood flows, and providing allochthonous and large woody debris. Riparian vegetation within the project site is very limited, with most areas dominated by herbaceous vegetation. Disturbance to vegetation from construction activities are considered **discountable** and proposed replanting activities are designed to replant with native streambank vegetation. These actions have the potential to create a long-term **beneficial** effect within the riparian buffer.

7.3.4. Habitat Forming Processes and Refuge from Higher Velocity Floodwater

Current project activities will have no effect on recruitment of LWD or other habitat forming processes such as bank alteration or channelization.

Results of the NMFS matrix of pathways and indicators, summarizing the environmental parameters affecting ESA-listed bull trout and salmonids, indicate **maintenance** of 15 of the pathways and indicators.

8.0 EFFECT DETERMINATIONS

Based on species and critical habitat occurrence information and project effects discussions presented in in the above sections of this report, we have made effect determinations for each species and its critical habitat, as applicable. Effect determinations for each species and critical habitat consider the possible project effects. These determinations are summarized in Table 11 and discussed in the following sections.

TABLE 11. EFFECT DETERMINATIONS FOR LISTED SPECIES AND CRITICAL HABITAT

Common Name	Jurisdiction	Federal Status	Effect Determination	
			Species	Critical Habitat
Marbled murrelet	USFWS	E	NLAA	--
Bull trout		T	NLAA	NLAA
Puget Sound Chinook salmon	NOAA Fisheries	T	NLAA	NLAA
Puget Sound steelhead		T	NLAA	NLAA
SRKW		E	NE	NE

Notes:

T = Threatened; E = Endangered; NE = No Effect; NLAA = Not Likely to Adversely Affect

8.1. Marbled Murrelet

The project **may affect** marbled murrelet because:

- Foraging habitat is potentially within the marine areas of Samish Bay where construction-related noise potentially may extend above the water surface and affect communication between pairs.
- Construction-related noise will only permeate these marine/estuarine waters when construction is occurring at Site 1 and to a very limited extent at Site 2. The action areas for Site 3 does not include marine/estuarine waters and therefore will likely have no effect on marbled murrelets.

The project is **not likely to adversely affect** marbled murrelet because:

- Construction activities will be limited to only occur during low tides, thus reducing the likelihood of the marine/estuarine waters within the Action Area being suitable depths for foraging

8.2. Designated Critical Habitat for Marbled Murrelet

There is no designated critical habitat for marbled murrelets in the Action Area.

8.3. Bull Trout, Chinook Salmon and Steelhead

The project **may affect** bull trout, Chinook salmon and/or steelhead because:

- Water quality may be temporarily impacted during construction activities.

The project is **not likely to adversely affect** bull trout, Chinook salmon and/or steelhead because:

- Water quality in the long-term is expected to have no effect since there is no change in amount of impervious surface areas as a result of this project.
- The project will be conducted within the appropriate fish windows to reduce the potential for bull trout to be in the vicinity of the project during construction.
- All work below the OHWM will be conducted at low tide, in the dry.
- Cofferdams for the work area at Sites 2 and 3 will be installed at low tide such that fish will not need to be removed/handled. .
- Site 1 construction will occur in the dry and not directly affect aquatic species.
- Other impacts are either temporary in nature or will not affect aquatic species.

8.4. Designated Critical Habitat for Bull Trout, Chinook Salmon and Steelhead

The project is located in nearshore marine environments of the Puget Sound, which are designated critical habitat for bull trout and Chinook salmon and within Samish River, which is designated critical habitat for steelhead. This project is **not likely to adversely affect** designated critical habitats for bull trout, Chinook salmon and/or steelhead because:

- Potential habitat impacts within the proposed critical habitat area will not negatively affect PCEs.
- The project will not negatively affect the quality of marine and freshwater habitats at or around the project site, because an existing riprap shoreline will be replaced with like material.
- The project will not impact water quantity or floodplain connectivity.
- The project will not obstruct migration corridors.

8.5. Southern Resident Killer Whale

The project will have **no effect** on SRKWs because:

- SRKWs are highly unlikely to occur in the project vicinity.
- All work below the OHWM will occur in the dry.
- Excavation equipment and other machinery used for installation of the floodgate structures will be within isolated work areas or will occur at low tide only to avoid direct disturbance to Samish Bay.

8.6. Designated Critical Habitat for SRKW

The project will have **no effect** on designated critical habitat for SRKWs because:

- Habitat within the Action Area does not provide the PCEs identified for killer whale habitat and is, therefore, not considered suitable habitat for SRKW.

- Project effects are not anticipated to have a negative impact on PCEs for killer whale critical habitat.

9.0 CONCLUSIONS

Skagit County Public Works proposes to install 16 new one-way tide gate structure at three sites: Bayview Edison North, Bayview Edison South and Farm to Market Road. Construction activities at these sites will require isolation of estuarine waters of Samish River delta and Samish River. Within the Action Area, marbled murrelet, bull trout, Chinook salmon, steelhead and SRKWs are the ESA-listed species that may be present. The project area contains critical habitat for bull trout, steelhead, Chinook salmon and SRKWs. No other critical habitat for other aquatic species or terrestrial species is designated within the Action Area.

The effect determination for this project is "*may affect, not likely to adversely affect*" listed marbled murrelet, bull trout, Chinook salmon, and steelhead, that may be present in the project area and "*no effect*" for listed SRKWs. The effect determination for critical habitat (bull trout, steelhead, Chinook salmon and SRKW) within the Action Area of the project is, "*no effect*."

10.0 REFERENCES

61 FR 26255-26320. 50 CFR Part 17. Endangered and Threatened Wildlife and Plants; Final Designation of Critical Habitat for the Marbled Murrelet; Final Rule. Federal Register, Vol. 62, No. 102. 1996.

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FIGURES

GEOENGINEERS

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2,000 0 2,000

Feet

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Mapbox Open Street Map, 2016

Projection: NAD 1983 UTM Zone 10N

Vicinity Map	
Skagit River Bridge Modification and Interstate Highway Protection Project Skagit County, Washington	
GEOENGINEERS	Figure 1

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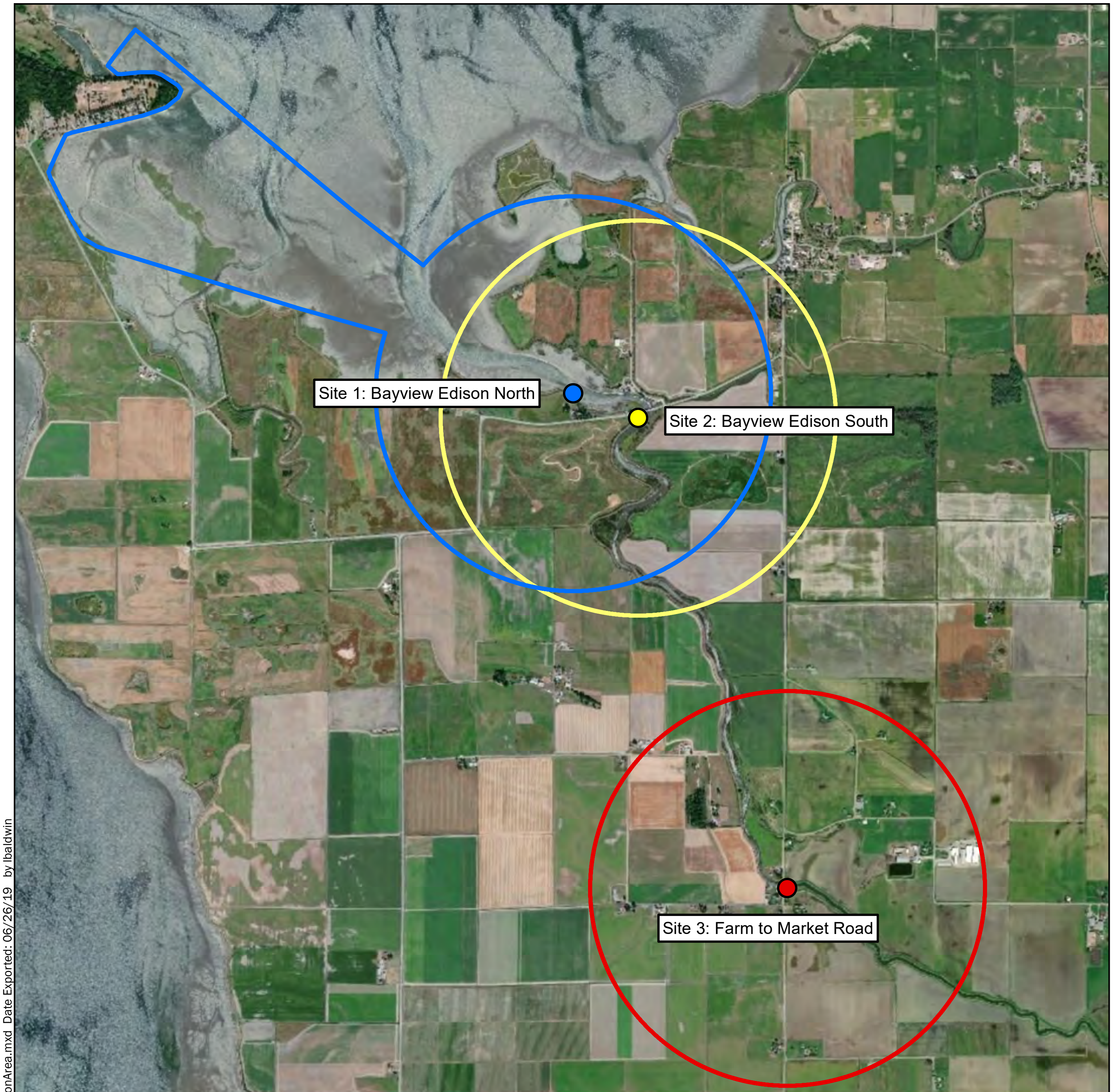

Legend

- Project Location
- Action Area

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Feet

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Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source:

Projection: WGS 1984 Web Mercator Auxiliary Sphere

Action Area Map

Skagit River Bridge Modifications and Interstate Highway Protection Project
Skagit County, Washington

GEOENGINEERS

Figure 2

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APPENDICES

APPENDIX A
Essential Fish Habitat (EFH) Evaluation

APPENDIX A
ESSENTIAL FISH HABITAT (EFH) EVALUATION

The Magnuson-Stevens Fishery Conservation Management Act (MSA), as amended by the Sustainable Fisheries Act of 1996, established procedures designed to identify, conserve, and enhance EFH for those species regulated under a Federal Fisheries Management Plan (FMP). EFH is defined by the MSA as "*those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity*." For the Pacific West Coast, there are three FMPs covering (1) groundfish; (2) coastal pelagic species; and (3) Pacific salmon.

The objective of this EFH evaluation is to describe potential adverse impacts to designated EFH for federally managed fish species within the proposed Action Area. It also describes conservation measures proposed to avoid, minimize or otherwise offset potential adverse impacts to designated EFH resulting from the proposed action.

The project is located over shoreline habitat within Samish Bay and Samish River. Groundfish and Pacific salmon, but not coastal pelagic species, may occur in these waters. Pacific salmon that may occur at the project site include Puget Sound chinook (*Oncorhynchus tshawytscha*), Puget Sound coho (*Oncorhynchus kisutch*) and Pink salmon (*Oncorhynchus gorbuscha*). Groundfish species that may occur at the project site include starry flounder (*Platichthys stellatus*), English sole (*Parophrys vetulus*) and Dover sole (*Microstomus pacificus*). This assessment focuses on potential project impacts to these species, which are covered by the Pacific salmon and groundfish FMPs.

Proposed Action

For more details concerning the proposed actions for the project, please refer to Section 3.0 Project Description in the main text of the Biological Evaluation (BE).

Potential Effects of Proposed Action on EFH

Effects on Pacific Salmon EFH

As described above and in the main body of the BE, the project site includes near-shore marine and riverine environments which could support adult or juvenile salmon, including shoreline, intertidal and subtidal habitats. The project actions include installation of additional culverts within an area that already contains culverts, and riprap. The existing riprap will be replaced as part of the culvert construction and the existing footprint will not be expanded. There is very limited vegetation within the project footprint, and it consists predominantly of herbaceous species. Therefore, habitat alterations are expected to be minimal to none.

Effects of the project on designated critical habitat for Chinook salmon, which includes near-shore marine areas in Puget Sound, is covered in the main text of the BE. Conservation measures that will be implemented to offset project impacts on Pacific salmon, as described in the BE and below, will result in no change to the EFH of Pacific salmon. The project effects were determined to be may affect, but not likely to adversely affect designated critical habitat for Chinook salmon. Effects of the project on EFH for Pacific salmon will be the same as those for Chinook salmon critical habitat. Therefore, an effect determination of **will not adversely affect** applies to EFH for Pacific salmon.

Effects on Groundfish EFH

Activities at Site 1 (Bayview Edison North) includes shoreline and intertidal marine habitats. Groundfish species that may occur at the project site include starry flounder (*Platichthys stellatus*), English sole (*Parophrys vetulus*) and Dover sole (*Microstomus pacificus*). These flatfish species generally prefer sandy or muddy bottom substrates. Juvenile flatfish prefer shallow water near rivers and estuaries in eelgrass beds while adult flatfish generally prefer deeper waters. Due to the shallow waters of the site and lack of eelgrass beds in the project footprint, groundfish are not expected in the project site.

Conservation measures that will be implemented to offset project impacts, as described in the BE and below, will result in no change to the EFH for groundfish species. Therefore, the project **will not adversely affect** groundfish EFH.

Effects on Coastal Pelagic Species EFH

No effects on the coastal pelagic EFH are anticipated for the project. EFH for coastal pelagic species does not occur in the project Action Area.

EFH Conservation Measures

A number of measures will be implemented to minimize the potential adverse effects to fish habitat in general. These measures are listed below:

- The contractor will develop and implement a temporary erosion and sedimentation control (TESC) Plan and a Source Control Plan. The contractor will use the best management practices (BMPs) to control sediments from all ground disturbing activities.
- The contractor shall prepare a Spill Prevention, Control and Countermeasures (SPCC) Plan prior to beginning construction. The SPCC Plan shall identify the appropriate spill containment materials, which will be available at the project site at all times.
- All equipment used for construction activities will be cleaned and inspected prior to arriving at the project site to ensure no potentially hazardous materials are exposed, no leaks are present, and the equipment is functioning properly.
- All work below the OHWM will be conducted in the dry (through isolation), during low tides and during the approved work windows for fish species that may occur in the project area.
- All in-water work will be performed according to the requirements and conditions of the USACE permit and Hydraulic Project Approval (HPA) issued by the Washington Department of Fish and Wildlife (WDFW).

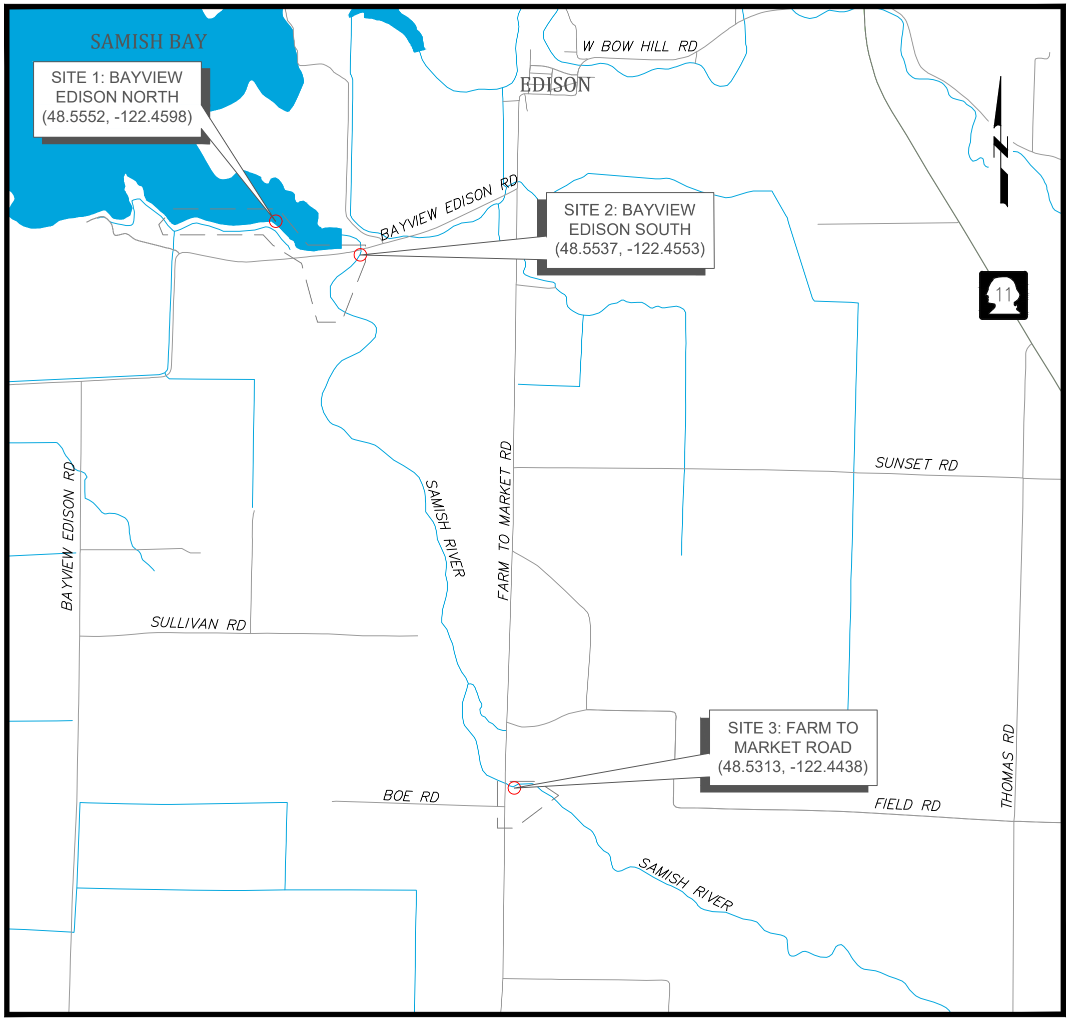
See the main text of this report for additional information regarding conservation measures.

Conclusions

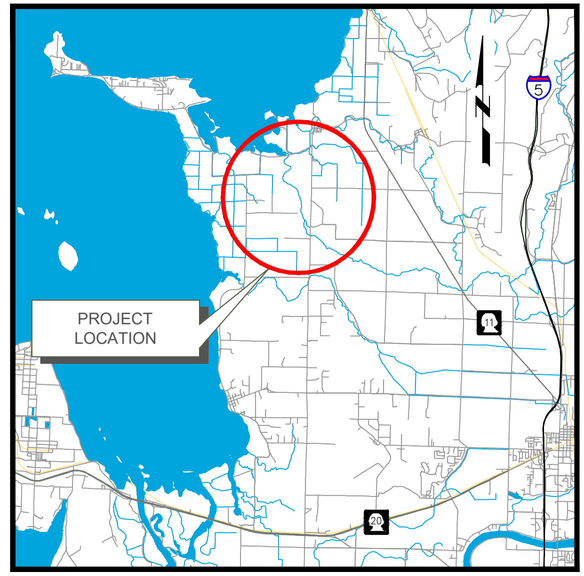
The proposed action **will not adversely affect** EFH for Pacific salmon, groundfish, or coastal pelagic species, including both managed species and prey species, occurring at or near the project site. If more detailed information is desired concerning the determination of effect of all listed species occurring within the Action Area, please refer to Section 8.0 Effect Determinations in the main text of the BE.

APPENDIX B
Project Drawings

SKAGIT RIVER BRIDGE MODIFICATION AND INTERSTATE HIGHWAY PROTECTION PROJECT



VICINITY MAP NTS



PROJECT LOCATION MAP NTS

PLAN SHEET INDEX

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SKAGIT COUNTY PUBLIC WORKS
1800 CONTINENTAL PLACE
MOUNT VERNON, WA 98273-5625
(360) 336-9400 FAX (360) 336 9478

SKAGIT RIVER BRIDGE MODIFICATION AND INTERSTATE HIGHWAY PROTECTION PROJECT

SHEET NAME:	PROJECT LOCATED NEAR:
COVER SHEET	EDISON, WA (SKAGIT COUNTY)

NHC PROJECT NO.: 2002084
FED. AID NO.: HPP-2029(040)
LAT/LONG: 48.554, -122.455
WATERBODY: SAMISH RIVER
APPLICANT: SKAGIT COUNTY
REFERENCE #:

NO.	REVISIONS	DATE
1	JARPA APPLICATION	03/29/21

DATUM
NAVD 88

nhc northwest hydraulic consultants
301 west holly street, suite u3
bellingham, washington 98225
phone: (206) 241-6000
www.nhcweb.com

0.5 INCH SCALE BAR ADJUST SCALE ACCORDINGLY

SHEET 1 OF 17

LEGEND

EXISTING FEATURES:

- ROAD CENTERLINE
- ASPHALT EDGE
- GRAVEL EDGE
- BRIDGE
- 20 MAJOR CONTOUR
- MINOR CONTOUR
- CULVERT
- FENCE

SURVEY:

- PARCEL LINE
- RIGHT-OF-WAY LINE
- RIGHT-OF-WAY LINE CENTERLINE
- TP TEST PIT

HYDROLOGY:

- OHW ORDINARY HIGH WATER
- WETLAND AREA

NOTE:

1. RIVERWARD OHWM DELINEATED BASED ON THE GREATER OF:
   - DELINEATION BY GEOENGINEERS INC. USING RECENT LIDAR DATA COMBINED WITH FIELD OBSERVATIONS DATED JUNE 7, 2018.
   - MHHW OBSERVED BY NHC MONITORING EQUIPMENT AT FARM TO MARKET ROAD BRIDGE BETWEEN DECEMBER 11, 2017 AND MARCH 20, 2018.
2. LANDWARD OHWM DELINEATED BY GEOENGINEERS INC. USING RECENT LIDAR DATA COMBINED WITH FIELD OBSERVATIONS DATED JUNE 7, 2018.

N

0' 20' 40'

SCALE 1"=40'

NOT FOR CONSTRUCTION

SKAGIT COUNTY PUBLIC WORKS

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MOUNT VERNON, WA 98273-5625
(360) 336-9400 FAX (360) 336 9478

SKAGIT RIVER BRIDGE MODIFICATION AND INTERSTATE HIGHWAY PROTECTION PROJECT

SHEET NAME:	PROJECT LOCATED NEAR:
SITE 1 - BAYVIEW EDISON NORTH EXISTING PLAN	EDISON, WA (SKAGIT COUNTY)

NHC PROJECT NO.: 2002084
FED. AID NO.: HPP-2029(040)
LAT/LONG: 48.554, -122.455
WATERBODY: SAMISH RIVER
APPLICANT: SKAGIT COUNTY
REFERENCE #:

NO.	REVISIONS	DATE
1	JARPA APPLICATION	03/29/21

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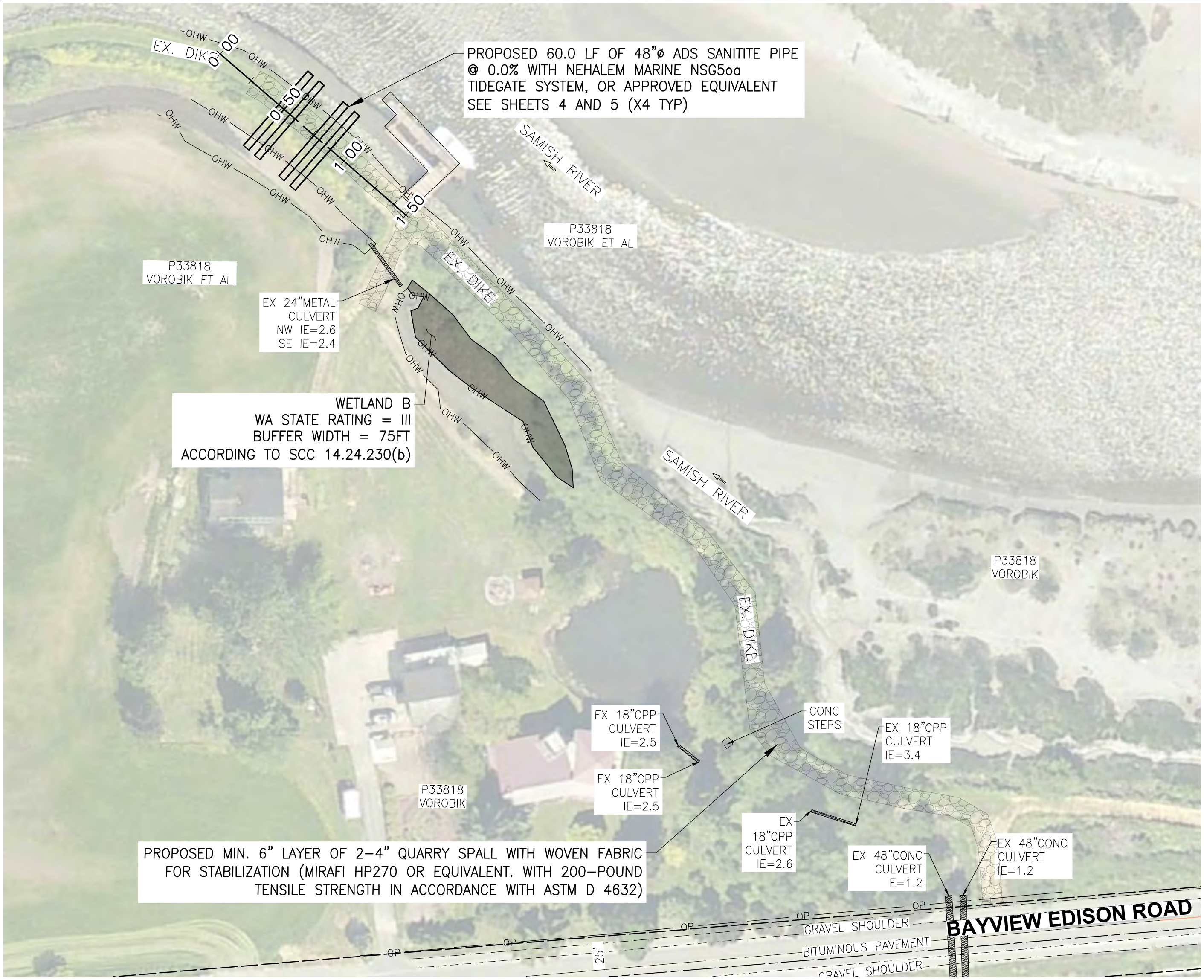
301 west holly street, suite u3
bellingham, washington 98225
phone: (206) 241-6000
www.nhcweb.com

0.5 INCH SCALE BAR
ADJUST SCALE ACCORDINGLY

SHEET 2 OF 17



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LEGEND

EXISTING FEATURES:

- ROAD CENTERLINE
- ASPHALT EDGE
- GRAVEL EDGE
- BRIDGE
- 20 — MAJOR CONTOUR
- MINOR CONTOUR
- CULVERT
- FENCE

PROPOSED FEATURES:

- ALIGNMENT LINE
- 20 — MAJOR CONTOUR
- MINOR CONTOUR
- CULVERT
- FENCE
- SF — SILT FENCE
- GRUB — CLEARING AND GRUBBING LIMIT
- GRAVEL ACCESS ROAD

SURVEY:

- PARCEL LINE
- RIGHT-OF-WAY LINE
- RIGHT-OF-WAY LINE CENTERLINE

HYDROLOGY:

- OHW — ORDINARY HIGH WATER
- WETLAND AREA

NOTE:
1. RIVERWARD OHWM DELINEATED BASED ON THE GREATER OF:
   - DELINEATION BY GEOENGINEERS INC. USING RECENT LIDAR DATA COMBINED WITH FIELD OBSERVATIONS DATED JUNE 7, 2018.
   - MHHW OBSERVED BY NHC MONITORING EQUIPMENT AT BAYVIEW EDISON BRIDGE BETWEEN DECEMBER 11, 2017 AND MARCH 20, 2018.
2. LANDWARD OHWM DELINEATED BY GEOENGINEERS INC. USING RECENT LIDAR DATA COMBINED WITH FIELD OBSERVATIONS DATED JUNE 7, 2018.
3. WETLAND AND OHW NOT DELINEATED OUTSIDE OF PROJECT EXTENTS.

0' 50' 100'
SCALE 1"=100'

NOT FOR CONSTRUCTION

SKAGIT COUNTY PUBLIC WORKS
1800 CONTINENTAL PLACE
MOUNT VERNON, WA 98273-5625
(360) 336-9400 FAX (360) 336 9478

SKAGIT RIVER BRIDGE MODIFICATION AND INTERSTATE HIGHWAY PROTECTION PROJECT

SHEET NAME: SITE 1 - BAYVIEW EDISON NORTH PROPOSED PLAN

PROJECT LOCATED NEAR: EDISON, WA (SKAGIT COUNTY)

NHC PROJECT NO.: 2002084
FED. AID NO.: HPP-2029(040)
LAT/LONG: 48.554, -122.455
WATERBODY: SAMISH RIVER
APPLICANT: SKAGIT COUNTY
REFERENCE #:

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0.5 INCH SCALE BAR
ADJUST SCALE ACCORDINGLY

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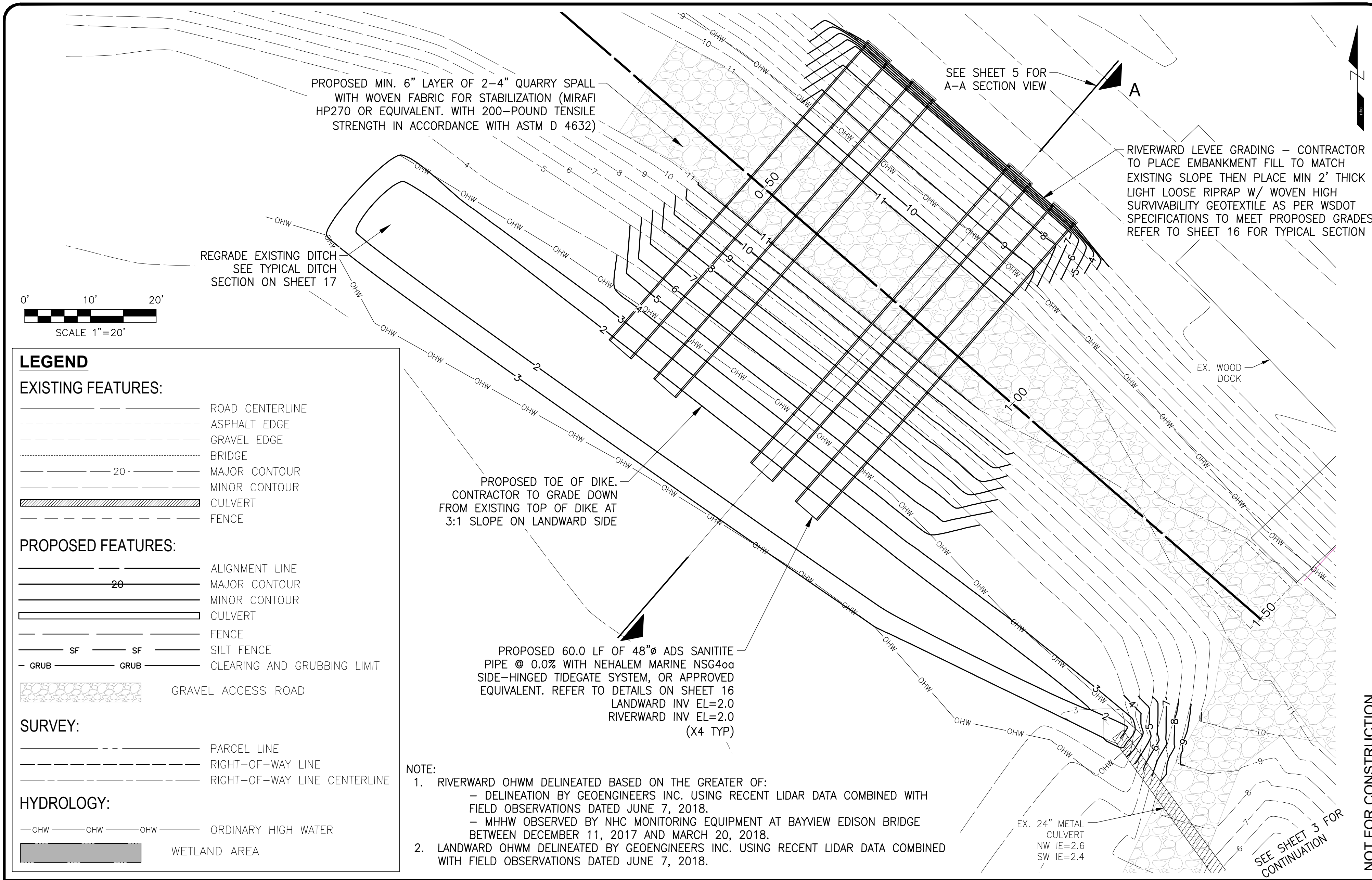

LEGEND

EXISTING FEATURES:

- ROAD CENTERLINE
- ASPHALT EDGE
- GRAVEL EDGE
- BRIDGE
- MAJOR CONTOUR (20)
- MINOR CONTOUR
- CULVERT
- FENCE

PROPOSED FEATURES:

- ALIGNMENT LINE
- MAJOR CONTOUR (20)
- MINOR CONTOUR
- CULVERT
- FENCE
- SILT FENCE (SF)
- CLEARING AND GRUBBING LIMIT (GRUB)
- GRAVEL ACCESS ROAD

SURVEY:

- PARCEL LINE
- RIGHT–OF–WAY LINE
- RIGHT–OF–WAY LINE CENTERLINE

HYDROLOGY:

- ORDINARY HIGH WATER (OHW)
- WETLAND AREA

NOTE:

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SKAGIT RIVER BRIDGE MODIFICATION AND INTERSTATE HIGHWAY PROTECTION PROJECT

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SITE 1 - BAYVIEW EDISON NORTH PROPOSED PLAN	EDISON, WA (SKAGIT COUNTY)

NHC PROJECT NO.: 2002084
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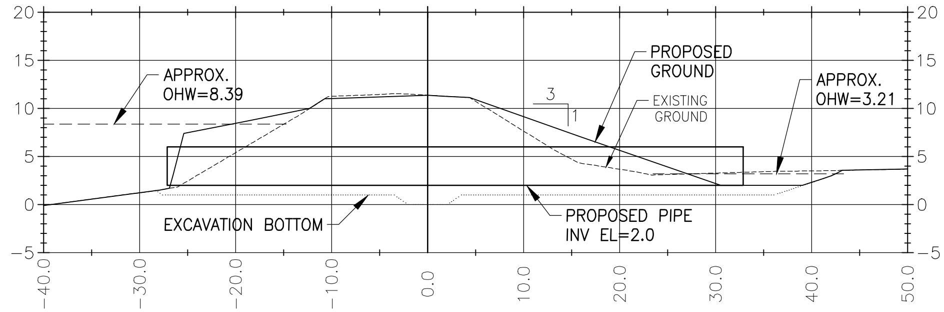

SECTION A-A

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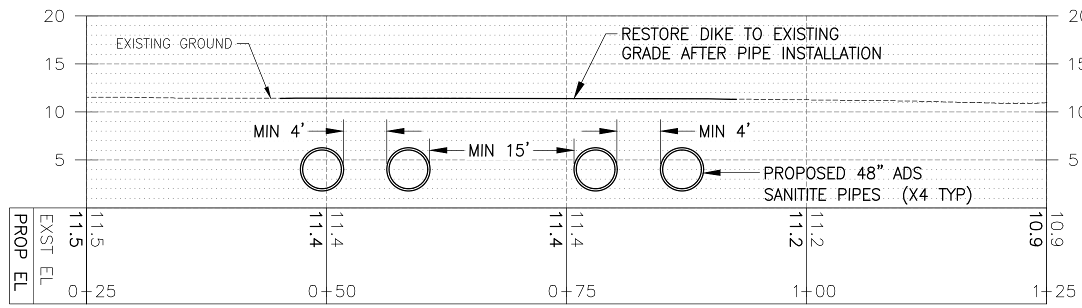

BAYVIEW EDISON NORTH DIKE PROFILE

HORIZ 1"=20', VERT. 1"=20'

NOT FOR CONSTRUCTION

0' 10' 20'

SCALE 1"=20'

NOTE:

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SKAGIT RIVER BRIDGE MODIFICATION AND INTERSTATE HIGHWAY PROTECTION PROJECT

SHEET NAME: SITE 1 - BAYVIEW EDISON NORTH SECTION & PROFILE VIEWS

PROJECT LOCATED NEAR: EDISON, WA (SKAGIT COUNTY)

NHC PROJECT NO.: 2002084
FED. AID NO.: HPP-2029(040)
LAT/LONG: 48.554, -122.455
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APPLICANT: SKAGIT COUNTY
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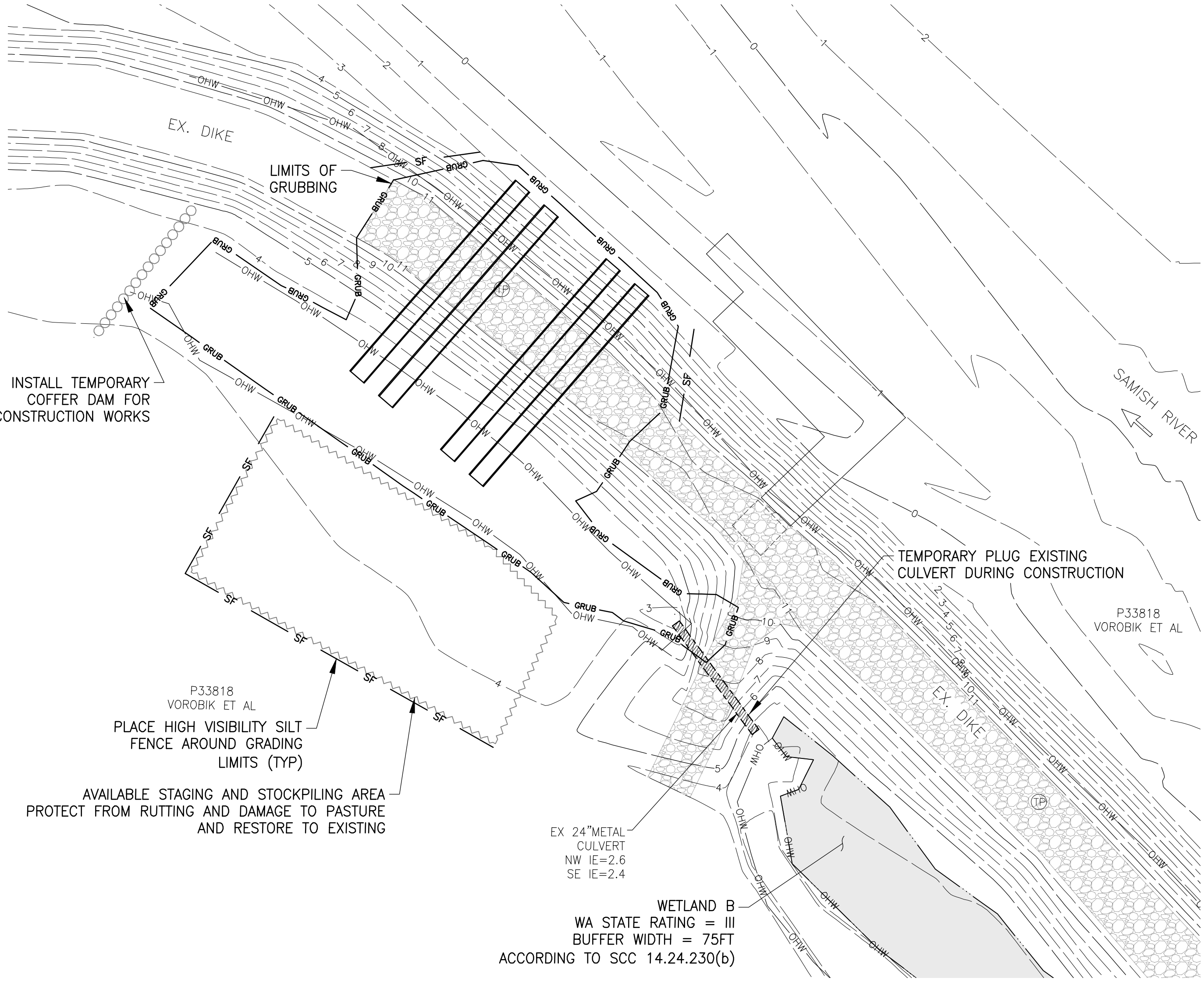
0.5 INCH SCALE BAR ADJUST SCALE ACCORDINGLY

SHEET 5 OF 17



LEGEND

EXISTING FEATURES:
- ROAD CENTERLINE
- ASPHALT EDGE
- GRAVEL EDGE
- BRIDGE
- MAJOR CONTOUR
- MINOR CONTOUR
- CULVERT
- FENCE

PROPOSED FEATURES
- ALIGNMENT LINE
- MAJOR CONTOUR
- MINOR CONTOUR
- CULVERT
- FENCE
- SILT FENCE
- CLEARING AND GRUBBING LIMIT
- TEMPORARY COFFER DAM
- CONSTRUCTION STAGING AREA
- GRAVEL ACCESS ROAD

SURVEY:
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- RIGHT-OF-WAY LINE
- RIGHT-OF-WAY LINE CENTERLINE

HYDROLOGY:
- ORDINARY HIGH WATER
- WETLAND AREA

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SCALE 1"=40'

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MOUNT VERNON, WA 98273-5625
(360) 336-9400 FAX (360) 336 9478

SKAGIT RIVER BRIDGE MODIFICATION AND INTERSTATE HIGHWAY PROTECTION PROJECT

SHEET NAME: SITE 1 - BAYVIEW EDISON NORTH TESC
PROJECT LOCATED NEAR: EDISON, WA (SKAGIT COUNTY)

NHC PROJECT NO.: 2002084
FED. AID NO.: HPP-2029(040)
LAT/LONG: 48.554, -122.455
WATERBODY: SAMISH RIVER
APPLICANT: SKAGIT COUNTY
REFERENCE #:

NO.	REVISIONS	DATE
1	JARPA APPLICATION	03/29/21

DATUM NAVD 88

nhc northwest hydraulic consultants
301 west holly street, suite u3
bellingham, washington 98225
phone: (206) 241-6000
www.nhcweb.com

0.5 INCH SCALE BAR ADJUST SCALE ACCORDINGLY

SHEET 6 OF 17

VLAM - April 1, 2021 - 5:49 PM - B:\2002084_SKAGIT_RIVER_DELTA_FLOOD_DRAINAGE\96_CAD\DWG\SAMISH RIVER FD TESC JARPA.DWG

NOTES:

1. RIVERWARD OHWM DELINEATED BASED ON THE GREATER OF:
   - DELINEATION BY GEOENGINEERS INC. USING RECENT LIDAR DATA COMBINED WITH FIELD OBSERVATIONS DATED JUNE 7, 2018.
   - MHHW OBSERVED BY NHC MONITORING EQUIPMENT AT FARM TO MARKET ROAD BRIDGE BETWEEN DECEMBER 11, 2017 AND MARCH 20, 2018.
2. LANDWARD OHWM DELINEATED BY GEOENGINEERS INC. USING RECENT LIDAR DATA COMBINED WITH FIELD OBSERVATIONS DATED JUNE 7, 2018.

LEGEND

EXISTING FEATURES:
- ROAD CENTERLINE
- ASPHALT EDGE
- GRAVEL EDGE
- BRIDGE
- MAJOR CONTOUR (20)
- MINOR CONTOUR
- CULVERT
- FENCE

SURVEY:
- PARCEL LINE
- RIGHT-OF-WAY LINE
- RIGHT-OF-WAY LINE CENTERLINE
- TEST PIT (TP)

HYDROLOGY:
- ORDINARY HIGH WATER (OHW)
- WETLAND AREA

0' 20' 40'
SCALE 1"=40'

NOT FOR CONSTRUCTION

SKAGIT COUNTY PUBLIC WORKS
1800 CONTINENTAL PLACE
MOUNT VERNON, WA 98273-5625
(360) 336-9400 FAX (360) 336 9478

SKAGIT RIVER BRIDGE MODIFICATION AND INTERSTATE HIGHWAY PROTECTION PROJECT

SHEET NAME: SITE 2 - BAYVIEW EDISON SOUTH EXISTING CONDITION

PROJECT LOCATED NEAR: EDISON, WA (SKAGIT COUNTY)

NHC PROJECT NO.: 2002084
FED. AID NO.: HPP-2029(040)
LAT/LONG: 48.554, -122.455
WATERBODY: SAMISH RIVER
APPLICANT: SKAGIT COUNTY
REFERENCE #:

NO.	REVISIONS	DATE
1	JARPA APPLICATION	03/29/21

DATUM NAVD 88

nhc northwest hydraulic consultants
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bellingham, washington 98225
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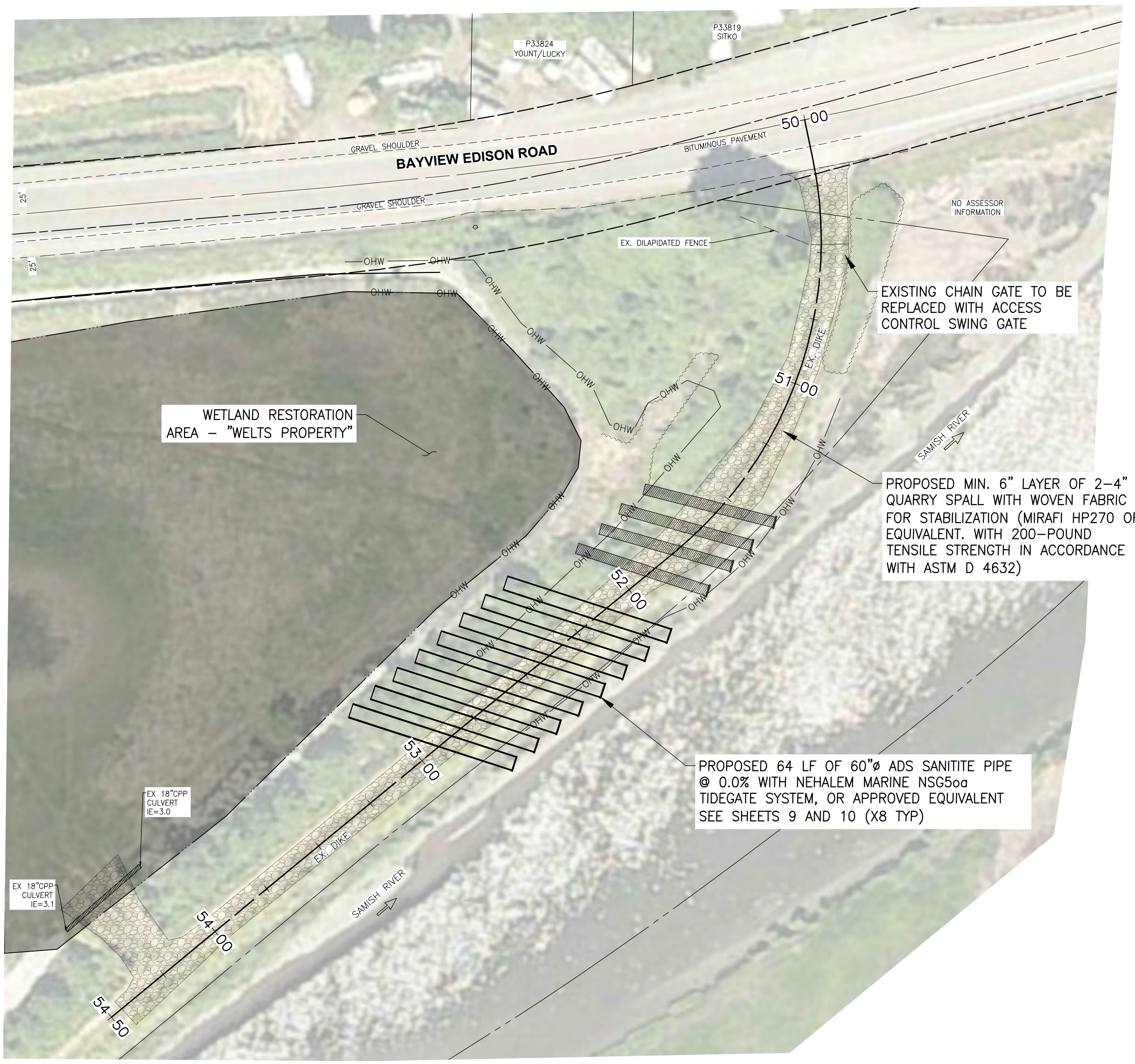
0.5 INCH SCALE BAR ADJUST SCALE ACCORDINGLY

SHEET 7 OF 17



NOTE:

1. RIVERWARD OHWM DELINEATED BASED ON THE GREATER OF:
   - DELINEATION BY GEOENGINEERS INC. USING RECENT LIDAR DATA COMBINED WITH FIELD OBSERVATIONS DATED JUNE 7, 2018.
   - MHHW OBSERVED BY NHC MONITORING EQUIPMENT AT BAYVIEW EDISON BRIDGE BETWEEN DECEMBER 11, 2017 AND MARCH 20, 18.
2. LANDWARD OHWM DELINEATED BY GEOENGINEERS INC. USING RECENT LIDAR DATA COMBINED WITH FIELD OBSERVATIONS DATED JUNE 7, 2018.

N

LEGEND

EXISTING FEATURES:

- ROAD CENTERLINE
- ASPHALT EDGE
- GRAVEL EDGE
- BRIDGE
- MAJOR CONTOUR (20)
- MINOR CONTOUR
- CULVERT
- FENCE

PROPOSED FEATURES

- ALIGNMENT LINE
- MAJOR CONTOUR (20)
- MINOR CONTOUR
- CULVERT
- FENCE
- SILT FENCE (SF)
- CLEARING AND GRUBBING LIMIT (GRUB)
- GRAVEL ACCESS ROAD

SURVEY:

- PARCEL LINE
- RIGHT–OF–WAY LINE
- RIGHT–OF–WAY LINE CENTERLINE

HYDROLOGY:

- ORDINARY HIGH WATER (OHW)
- WETLAND AREA

0' 30' 60'
SCALE 1"=60'

NOT FOR CONSTRUCTION

SKAGIT COUNTY PUBLIC WORKS
1800 CONTINENTAL PLACE
MOUNT VERNON, WA 98273-5625
(360) 336-9400 FAX (360) 336 9478

SKAGIT RIVER BRIDGE MODIFICATION AND INTERSTATE HIGHWAY PROTECTION PROJECT

SHEET NAME:	PROJECT LOCATED NEAR:
SITE 2 - BAYVIEW EDISON SOUTH PROPOSED PLAN	EDISON, WA (SKAGIT COUNTY)

NHC PROJECT NO.: 2002084
FED. AID NO.: HPP-2029(040)
LAT/LONG: 48.554, -122.455
WATERBODY: SAMISH RIVER
APPLICANT: SKAGIT COUNTY
REFERENCE #:

NO.	REVISIONS	DATE
1	JARPA APPLICATION	03/29/21

DATUM
NAVD 88

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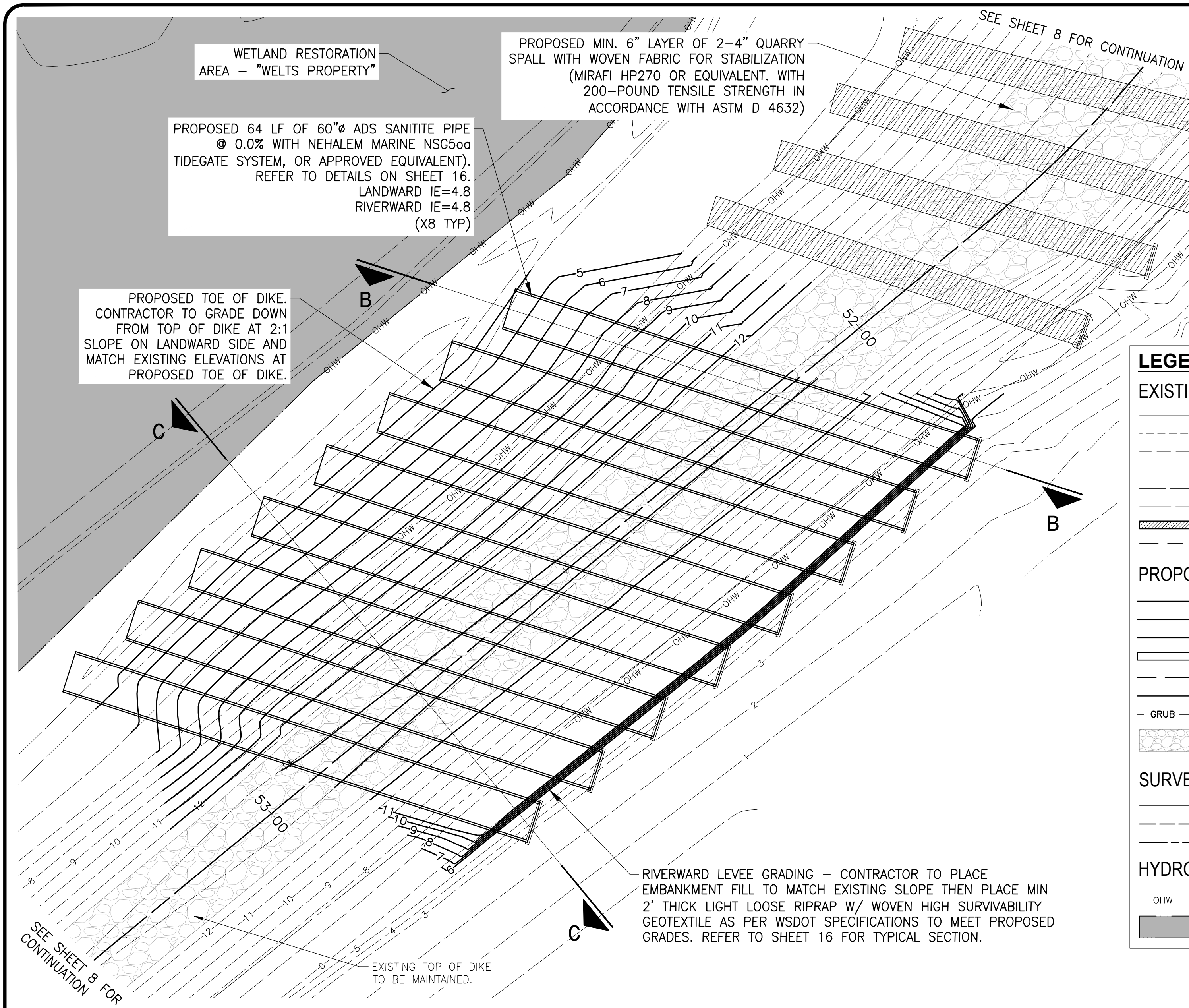
0.5 INCH SCALE BAR ADJUST SCALE ACCORDINGLY

SHEET 8 OF 17

VLAM - March 31, 2021 - 6:45 AM - B:\2002084_SKAGIT_RIVER_DELTA_FLOOD_DRAINAGE\96_CAD\DWG\SAMISH RIVER FD JARPA.DWG



NOTE:
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   - DELINEATION BY GEOENGINEERS INC. USING RECENT LIDAR DATA COMBINED WITH FIELD OBSERVATIONS DATED JUNE 7, 2018.
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2. LANDWARD OHWM DELINEATED BY GEOENGINEERS INC. USING RECENT LIDAR DATA COMBINED WITH FIELD OBSERVATIONS DATED JUNE 7, 2018.

LEGEND

EXISTING FEATURES:
ROAD CENTERLINE
ASPHALT EDGE
GRAVEL EDGE
BRIDGE
MAJOR CONTOUR (20)
MINOR CONTOUR
CULVERT
FENCE

PROPOSED FEATURES:
ALIGNMENT LINE
MAJOR CONTOUR (20)
MINOR CONTOUR
CULVERT
FENCE
SILT FENCE (SF)
CLEARING AND GRUBBING LIMIT (GRUB)
GRAVEL ACCESS ROAD

SURVEY:
PARCEL LINE
RIGHT-OF-WAY LINE
RIGHT-OF-WAY LINE CENTERLINE

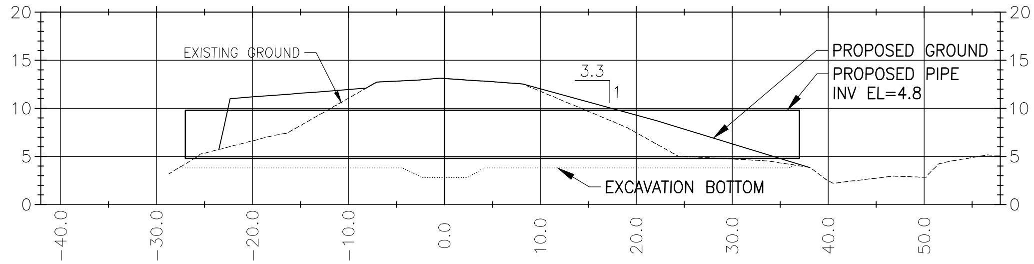
HYDROLOGY:
ORDINARY HIGH WATER (OHW)
WETLAND AREA

0' 10' 20'
SCALE 1"=20'

NOT FOR CONSTRUCTION

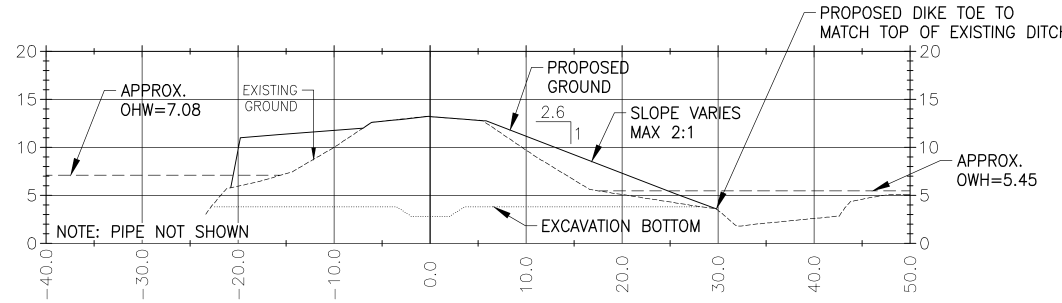
SKAGIT COUNTY PUBLIC WORKS 1800 CONTINENTAL PLACE MOUNT VERNON, WA 98273-5625 (360) 336-9400 FAX (360) 336 9478	SKAGIT RIVER BRIDGE MODIFICATION AND INTERSTATE HIGHWAY PROTECTION PROJECT SHEET NAME: SITE 2 - BAYVIEW EDISON SOUTH PROPOSED PLAN PROJECT LOCATED NEAR: EDISON, WA (SKAGIT COUNTY)	NHC PROJECT NO.: 2002084 FED. AID NO.: HPP-2029(040) LAT/LONG: 48.554, -122.455 WATERBODY: SAMISH RIVER APPLICANT: SKAGIT COUNTY REFERENCE #:	NO. 1 — JARPA APPLICATION — 03/29/21 NO. / REVISIONS / DATE	DATUM NAVD 88 nhc northwest hydraulic consultants, 301 west holly street, suite u3, bellingham, washington 98225, phone: (206) 241-6000, www.nhcweb.com 0.5 INCH SCALE BAR ADJUST SCALE ACCORDINGLY SHEET 9 OF 17

VLAM - March 31, 2021 - 6:45 AM - B:\2002084_SKAGIT_RIVER_DELTA_FLOOD_DRAINAGE\96_CAD\DWG\SAMISH RIVER FD JARPA.DWG



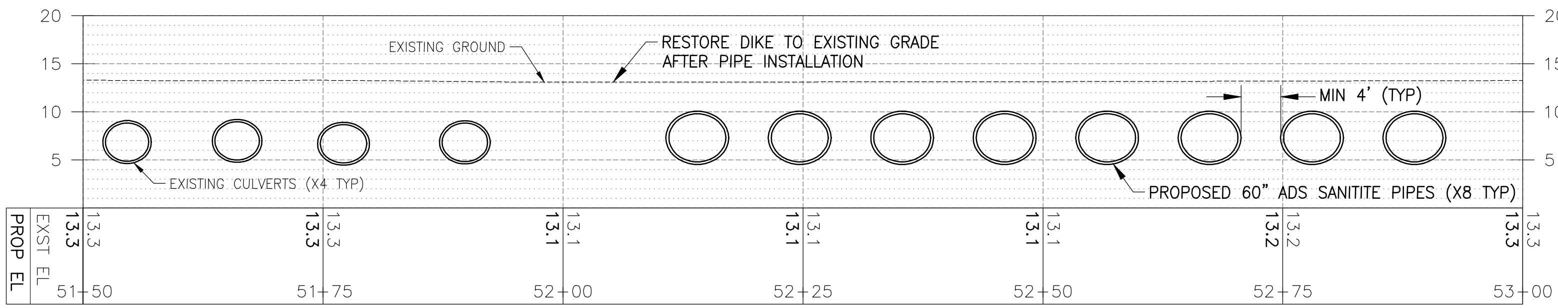
SECTION B-B

HORIZ 1"=20', VERT. 1"=20'



SECTION C-C

HORIZ 1"=20', VERT. 1"=20'



BAYVIEW EDISON SOUTH - DIKE PROFILE

HORIZ 1"=20', VERT. 1"=20'

NOTE:
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0' 10' 20'
SCALE 1"=20'

NOT FOR CONSTRUCTION

SKAGIT COUNTY PUBLIC WORKS
1800 CONTINENTAL PLACE
MOUNT VERNON, WA 98273-5625
(360) 336-9400 FAX (360) 336 9478

SKAGIT RIVER BRIDGE MODIFICATION AND INTERSTATE HIGHWAY PROTECTION PROJECT

SHEET NAME: SITE 2 - BAYVIEW EDISON SOUTH SECTION & PROFILE VIEWS

PROJECT LOCATED NEAR: EDISON, WA (SKAGIT COUNTY)

NHC PROJECT NO.: 2002084
FED. AID NO.: HPP-2029(040)
LAT/LONG: 48.554, -122.455
WATERBODY: SAMISH RIVER
APPLICANT: SKAGIT COUNTY
REFERENCE #:

NO.	REVISIONS	DATE
1	JARPA APPLICATION	03/29/21

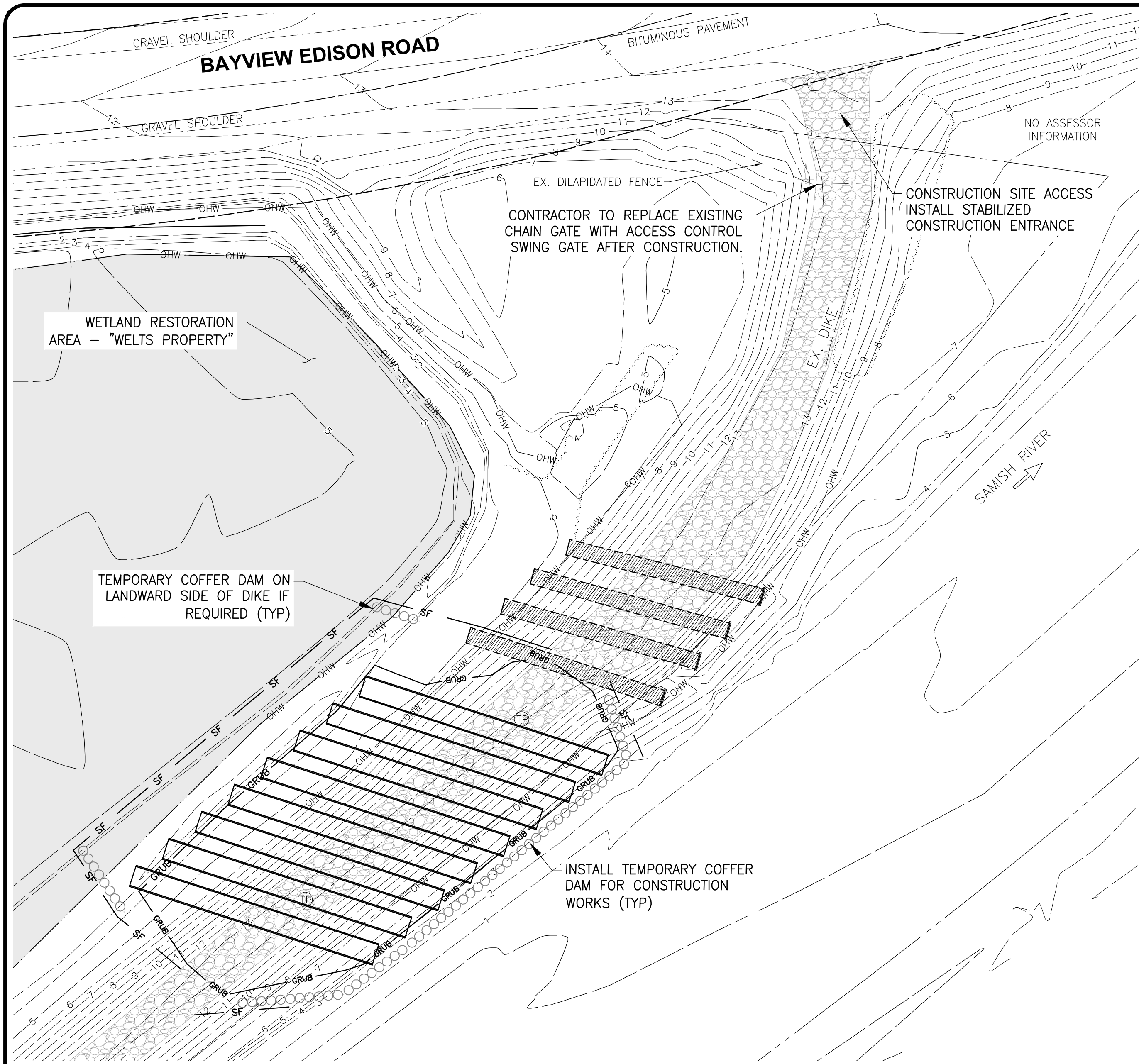
DATUM
NAVD 88

nhc
northwest hydraulic consultants
301 west holly street, suite u3
bellingham, washington 98225
phone: (206) 241-6000
www.nhcweb.com

0.5 INCH SCALE BAR
ADJUST SCALE ACCORDINGLY

SHEET
10 OF 17

VLAM - March 31, 2021 - 6:45 AM - B:\2002084_SKAGIT_RIVER_DELTA_FLOOD_DRAINAGE\96_CAD\DWG\SAMISH RIVER FD JARPA.DWG



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2. LANDWARD OHWM DELINEATED BY GEOENGINEERS INC. USING RECENT LIDAR DATA COMBINED WITH FIELD OBSERVATIONS DATED JUNE 7, 2018.

N

LEGEND

EXISTING FEATURES:

- ROAD CENTERLINE
- ASPHALT EDGE
- GRAVEL EDGE
- BRIDGE
- 20 MAJOR CONTOUR
- MINOR CONTOUR
- CULVERT
- FENCE

PROPOSED FEATURES

- ALIGNMENT LINE
- 20 MAJOR CONTOUR
- MINOR CONTOUR
- CULVERT
- FENCE
- SF SILT FENCE
- GRUB CLEARING AND GRUBBING LIMIT
- TEMPORARY COFFER DAM
- CONSTRUCTION STAGING AREA
- GRAVEL ACCESS ROAD

SURVEY:

- PARCEL LINE
- RIGHT–OF–WAY LINE
- RIGHT–OF–WAY LINE CENTERLINE

HYDROLOGY:

- OHW ORDINARY HIGH WATER
- WETLAND AREA

0' 20' 40'
SCALE 1"=40'

NOT FOR CONSTRUCTION

SKAGIT COUNTY PUBLIC WORKS
1800 CONTINENTAL PLACE
MOUNT VERNON, WA 98273-5625
(360) 336-9400 FAX (360) 336 9478

SKAGIT RIVER BRIDGE MODIFICATION AND INTERSTATE HIGHWAY PROTECTION PROJECT

SHEET NAME: SITE 2 - BAYVIEW EDISON SOUTH TESC

PROJECT LOCATED NEAR: EDISON, WA (SKAGIT COUNTY)

NHC PROJECT NO.: 2002084
FED. AID NO.: HPP-2029(040)
LAT/LONG: 48.554, -122.455
WATERBODY: SAMISH RIVER
APPLICANT: SKAGIT COUNTY
REFERENCE #:

NO.	REVISIONS	DATE
1	JARPA APPLICATION	03/29/21

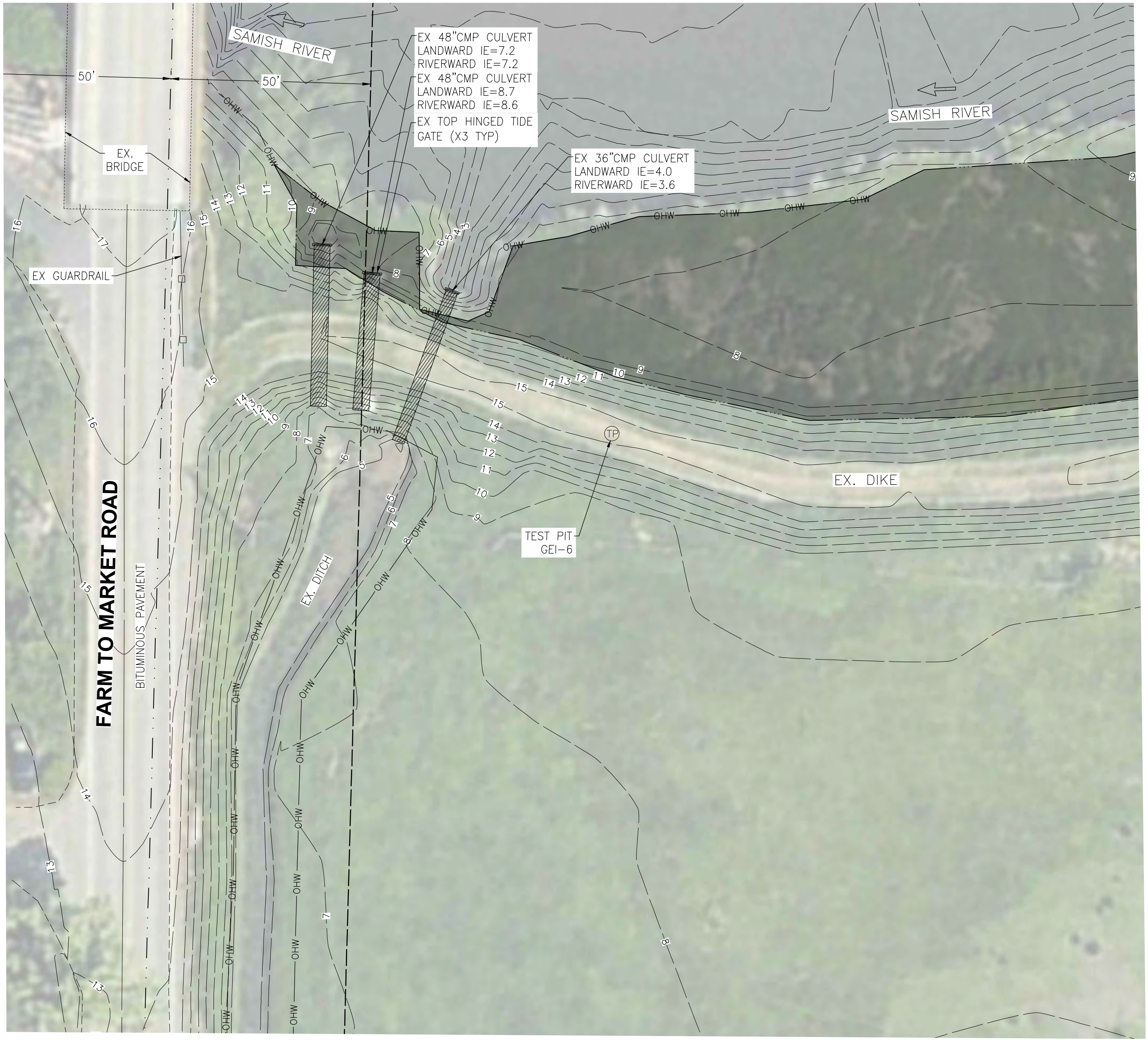
DATUM NAVD 88

nhc northwest hydraulic consultants
301 west holly street, suite u3
bellingham, washington 98225
phone: (206) 241-6000
www.nhcweb.com

0.5 INCH SCALE BAR ADJUST SCALE ACCORDINGLY

SHEET 11 OF 17

VLAM - March 31, 2021 - 6:45 AM - B:\2002084_SKAGIT_RIVER_DELTA_FLOOD_DRAINAGE\96_CAD\DWG\SAMISH RIVER FD TESC JARPA.DWG



NOTES:

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   - MHHW OBSERVED BY NHC MONITORING EQUIPMENT AT FARM TO MARKET ROAD BRIDGE BETWEEN DECEMBER 11, 2017 AND MARCH 20, 2018.
2. LANDWARD OHWM DELINEATED BY GEOENGINEERS INC. USING RECENT LIDAR DATA COMBINED WITH FIELD OBSERVATIONS DATED JUNE 7, 2018.

LEGEND

EXISTING FEATURES:

- ROAD CENTERLINE
- ASPHALT EDGE
- GRAVEL EDGE
- BRIDGE
- 20 MAJOR CONTOUR
- MINOR CONTOUR
- CULVERT
- FENCE

SURVEY:

- PARCEL LINE
- RIGHT-OF-WAY LINE
- RIGHT-OF-WAY LINE CENTERLINE
- TP TEST PIT

HYDROLOGY:

- OHW OHW OHW ORDINARY HIGH WATER
- WETLAND AREA

0' 20' 40'
SCALE 1"=40'

NOT FOR CONSTRUCTION

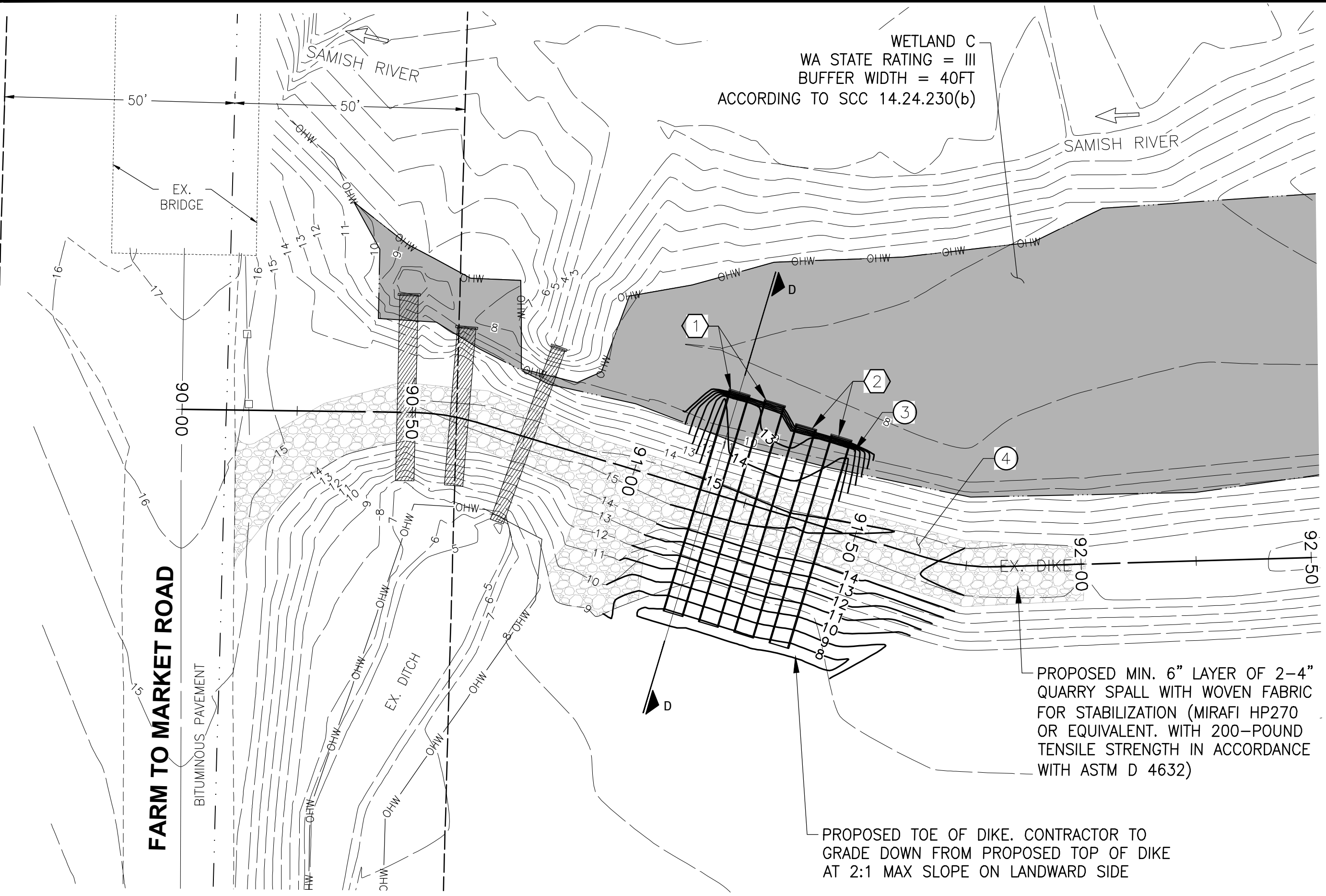
SKAGIT COUNTY PUBLIC WORKS 1800 CONTINENTAL PLACE MOUNT VERNON, WA 98273-5625 (360) 336-9400 FAX (360) 336 9478	**SKAGIT RIVER BRIDGE MODIFICATION AND INTERSTATE HIGHWAY PROTECTION PROJECT** SHEET NAME: SITE 3 - FARM TO MARKET ROAD EXISTING CONDITION PROJECT LOCATED NEAR: EDISON, WA (SKAGIT COUNTY)	NHC PROJECT NO.: 2002084 FED. AID NO.: HPP-2029(040) LAT/LONG: 48.554, -122.455 WATERBODY: SAMISH RIVER APPLICANT: SKAGIT COUNTY REFERENCE #:	NO. 1	REVISIONS: JARPA APPLICATION	DATE 03/29/21	DATUM NAVD 88

nhc northwest hydraulic consultants
301 west holly street, suite u3
bellingham, washington 98225
phone: (206) 241-6000
www.nhcweb.com

0.5 INCH SCALE BAR
ADJUST SCALE ACCORDINGLY

SHEET 12 OF 17

VLAM - March 31, 2021 - 6:45 AM - B:\2002084_SKAGIT_RIVER_DELTA_FLOOD_DRAINAGE\96_CAD\DWG\XREF-SAMISH RIVER FD EX SITEPLAN JARPA.DWG



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LEGEND

EXISTING FEATURES:

- ROAD CENTERLINE
- ASPHALT EDGE
- GRAVEL EDGE
- BRIDGE
- MAJOR CONTOUR (20)
- MINOR CONTOUR
- CULVERT
- FENCE

PROPOSED FEATURES

- ALIGNMENT LINE
- MAJOR CONTOUR (20)
- MINOR CONTOUR
- CULVERT
- FENCE
- SILT FENCE (SF)
- CLEARING AND GRUBBING LIMIT (GRUB)
- GRAVEL ACCESS ROAD

SURVEY:

- PARCEL LINE
- RIGHT-OF-WAY LINE
- RIGHT-OF-WAY LINE CENTERLINE

HYDROLOGY:

- ORDINARY HIGH WATER (OHW)
- WETLAND AREA

(1) PROPOSED 50 LF OF 48"ø ADS SANITITE PIPE @ 0.0% WITH NEHALEM MARINE NSG4oa TIDEGATE SYSTEM
LANDWARD INV EL=8.6
RIVERWARD INV EL=8.6

(2) PROPOSED 47 LF OF 48"ø ADS SANITITE PIPE @ 0.0% WITH NEHALEM MARINE NSG4oa TIDEGATE SYSTEM
LANDWARD INV EL=8.6
RIVERWARD INV EL=8.6

(3) RIVERWARD LEVEE GRADING – CONTRACTOR TO PLACE EMBANKMENT FILL UP TO EXISTING ELEVATIONS AND PLACE MIN 2' THICK LIGHT LOOSE RIPRAP W/ WOVEN HIGH SURVIVABILITY GEOTEXTILE AS PER WSDOT SPECIFICATIONS TO MEET PROPOSED GRADES. REFER TO SHEET 16 FOR TYPICAL DIKE SECTION.

(4) PROPOSED MIN. 6" LAYER OF 2-4" QUARRY SPALL WITH GEOTEXTILE. REFER TO TYPICAL DIKE SECTION ON SHEET 16.

0' 20' 40'
SCALE 1"=40'

NOT FOR CONSTRUCTION

SKAGIT COUNTY PUBLIC WORKS
1800 CONTINENTAL PLACE
MOUNT VERNON, WA 98273-5625
(360) 336-9400 FAX (360) 336 9478

SKAGIT RIVER BRIDGE MODIFICATION AND INTERSTATE HIGHWAY PROTECTION PROJECT

SHEET NAME:	PROJECT LOCATED NEAR:
SITE 3 - FARM TO MARKET ROAD PROPOSED PLAN	EDISON, WA (SKAGIT COUNTY)

NHC PROJECT NO.: 2002084
FED. AID NO.: HPP-2029(040)
LAT/LONG: 48.554, -122.455
WATERBODY: SAMISH RIVER
APPLICANT: SKAGIT COUNTY
REFERENCE #:

NO.	REVISIONS	DATE
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DATUM
NAVD 88

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0.5 INCH SCALE BAR
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SHEET 13 OF 17

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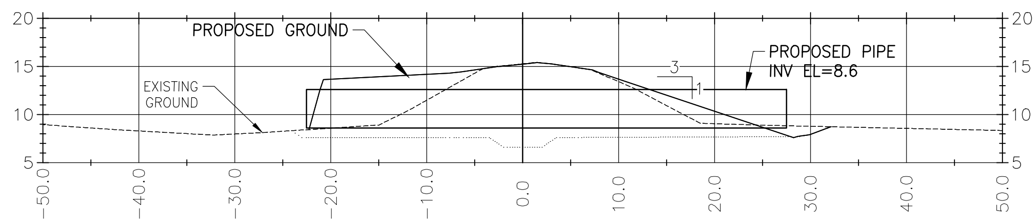
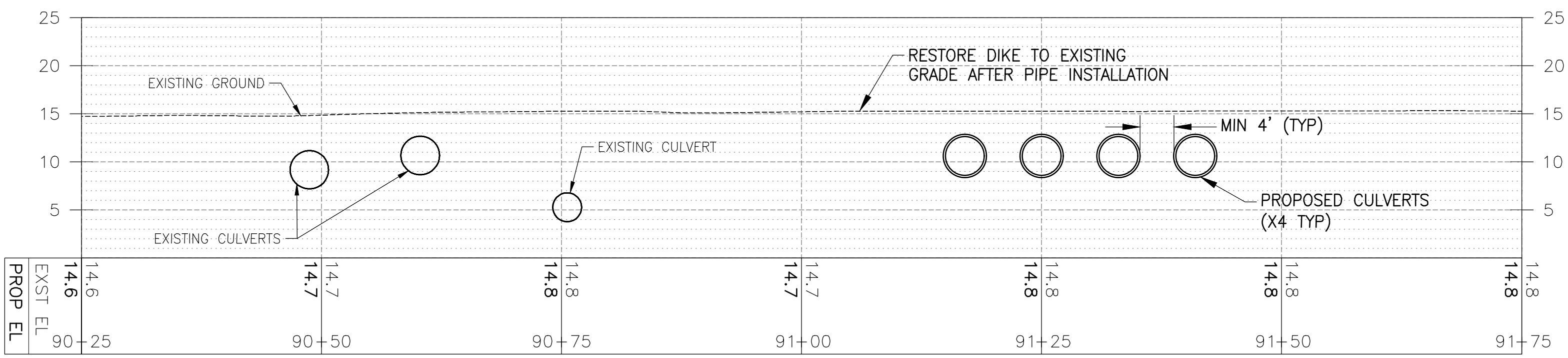


SECTION D-D

HORIZ 1"=20', VERT. 1"=20'



FARM TO MARKET ROAD - DIKE PROFILE

HORIZ 1"=20', VERT. 1"=20'

NOTE:
1. RIVERWARD OHWM DELINEATED BASED ON THE GREATER OF:
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0' 10' 20'
SCALE 1"=20'

NOT FOR CONSTRUCTION

SKAGIT COUNTY PUBLIC WORKS

1800 CONTINENTAL PLACE
MOUNT VERNON, WA 98273-5625
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SKAGIT RIVER BRIDGE MODIFICATION AND INTERSTATE HIGHWAY PROTECTION PROJECT

SHEET NAME: SITE 3 - FARM TO MARKET ROAD SECTION & PROFILE VIEWS

PROJECT LOCATED NEAR: EDISON, WA (SKAGIT COUNTY)

NHC PROJECT NO.: 2002084
FED. AID NO.: HPP-2029(040)
LAT/LONG: 48.554, -122.455
WATERBODY: SAMISH RIVER
APPLICANT: SKAGIT COUNTY
REFERENCE #:

NO.	REVISIONS	DATE
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DATUM
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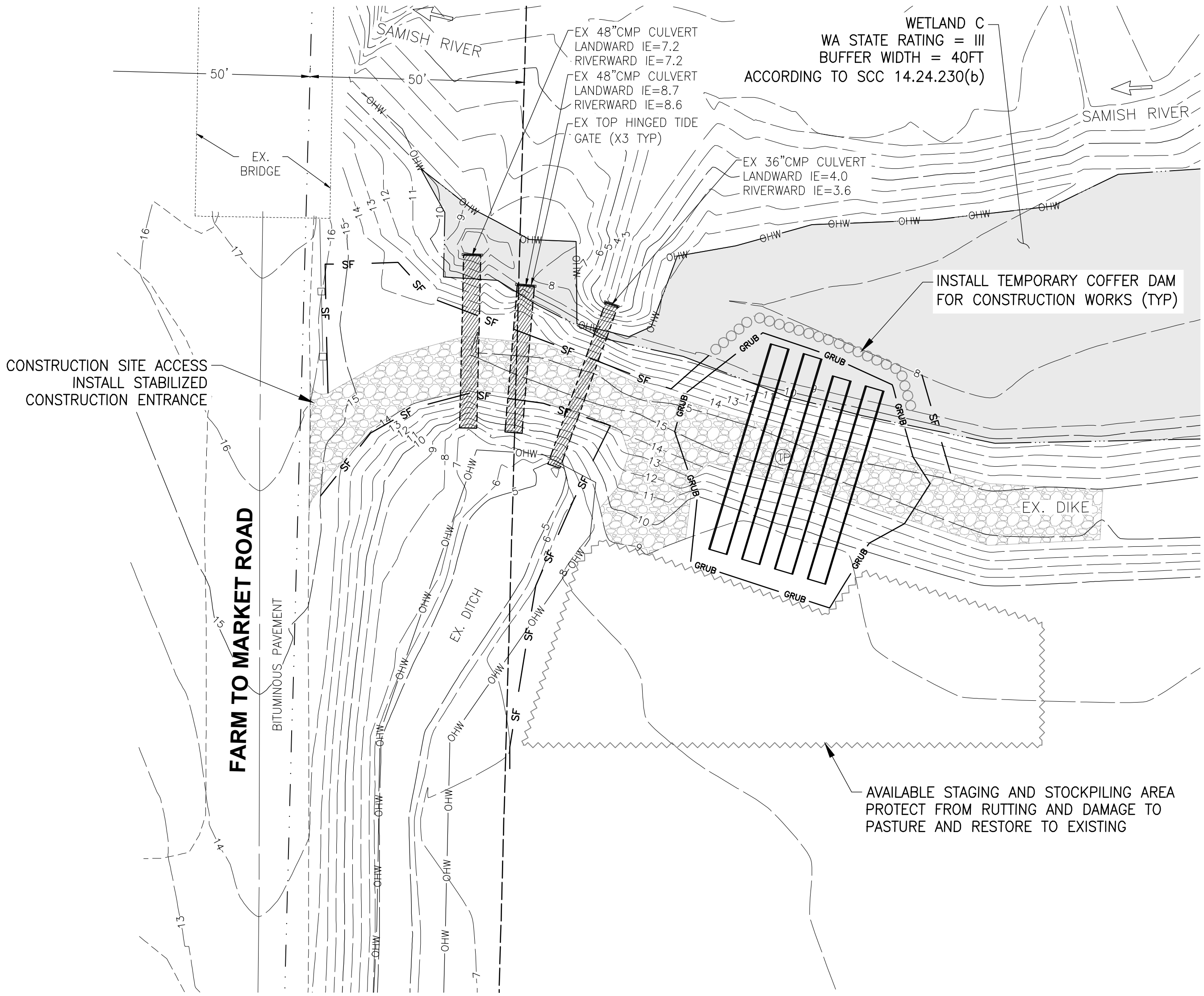
0.5 INCH SCALE BAR ADJUST SCALE ACCORDINGLY

SHEET 14 OF 17

VLAM - March 31, 2021 - 6:45 AM - B:\2002084_SKAGIT_RIVER_DELTA_FLOOD_DRAINAGE\96_CAD\DWG\SAMISH RIVER FD JARPA.DWG



LEGEND

EXISTING FEATURES:

- ROAD CENTERLINE
- ASPHALT EDGE
- GRAVEL EDGE
- BRIDGE
- MAJOR CONTOUR
- MINOR CONTOUR
- CULVERT
- FENCE

PROPOSED FEATURES

- ALIGNMENT LINE
- MAJOR CONTOUR
- MINOR CONTOUR
- CULVERT
- FENCE
- SILT FENCE
- CLEARING AND GRUBBING LIMIT
- TEMPORARY COFFER DAM
- CONSTRUCTION STAGING AREA
- GRAVEL ACCESS ROAD

SURVEY:

- PARCEL LINE
- RIGHT-OF-WAY LINE
- RIGHT-OF-WAY LINE CENTERLINE

HYDROLOGY:

- ORDINARY HIGH WATER
- WETLAND AREA

NOT FOR CONSTRUCTION

NOTE:

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   - DELINEATION BY GEOENGINEERS INC. USING RECENT LIDAR DATA COMBINED WITH FIELD OBSERVATIONS DATED JUNE 7, 2018.
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0' 20' 40'
SCALE 1"=40'

SKAGIT COUNTY PUBLIC WORKS

1800 CONTINENTAL PLACE
MOUNT VERNON, WA 98273-5625
(360) 336-9400 FAX (360) 336 9478

SKAGIT RIVER BRIDGE MODIFICATION AND INTERSTATE HIGHWAY PROTECTION PROJECT

SHEET NAME: SITE 3 - FARM TO MARKET ROAD TESC

PROJECT LOCATED NEAR: EDISON, WA (SKAGIT COUNTY)

NHC PROJECT NO.: 2002084
FED. AID NO.: HPP-2029(040)
LAT/LONG: 48.554, -122.455
WATERBODY: SAMISH RIVER
APPLICANT: SKAGIT COUNTY
REFERENCE #:

NO.	REVISIONS	DATE
1	JARPA APPLICATION	03/29/21

DATUM
NAVD 88

nhc northwest hydraulic consultants
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bellingham, washington 98225
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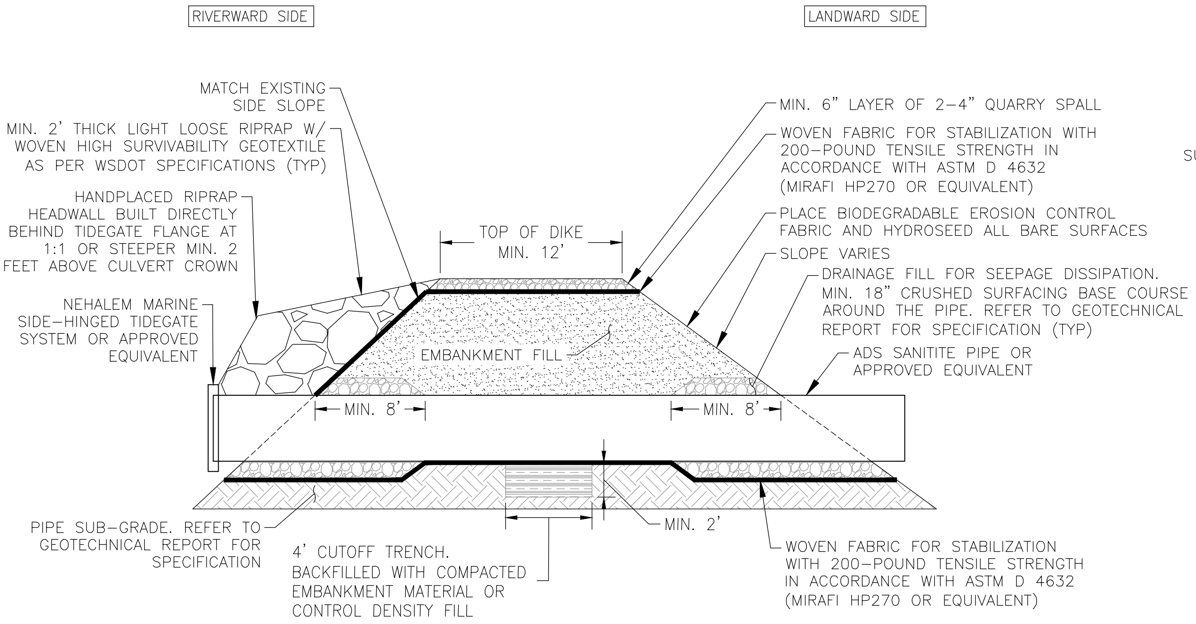
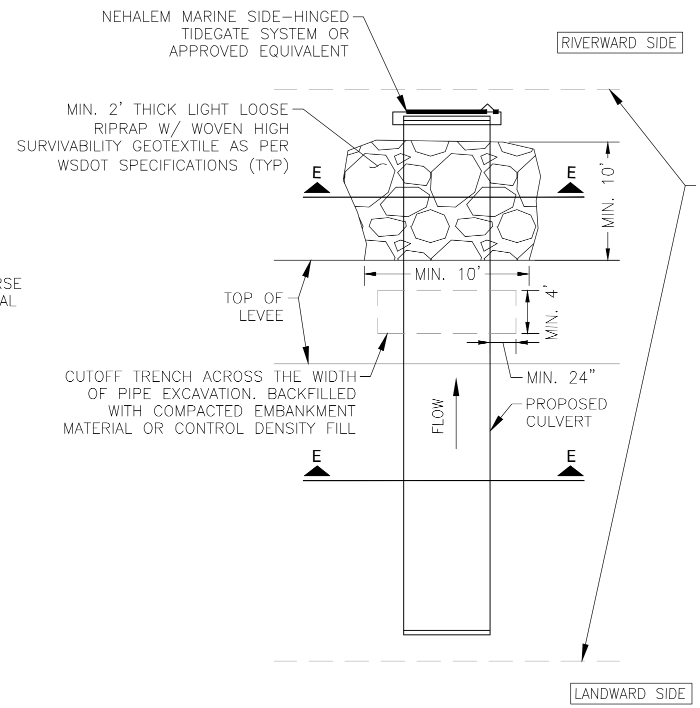
0.5 INCH SCALE BAR
ADJUST SCALE ACCORDINGLY

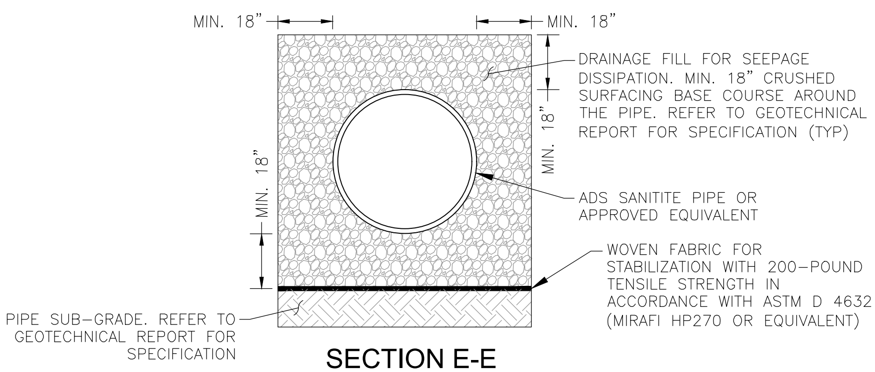
SHEET 15 OF 17



1 TYPICAL FLOOD/DRAINAGE CULVERT & DIKE SECTION
NOT TO SCALE



2 TYPICAL NEW FLOOD/DRAINAGE CULVERT PLAN VIEW
NOT TO SCALE



SECTION E-E
NOT TO SCALE

NOT FOR CONSTRUCTION

SKAGIT COUNTY PUBLIC WORKS
1800 CONTINENTAL PLACE
MOUNT VERNON, WA 98273-5625
(360) 336-9400 FAX (360) 336 9478

SKAGIT RIVER BRIDGE MODIFICATION AND INTERSTATE HIGHWAY PROTECTION PROJECT

SHEET NAME:	PROJECT LOCATED NEAR:
DETAILS	EDISON, WA (SKAGIT COUNTY)

NHC PROJECT NO.: 2002084
FED. AID NO.: HPP-2029(040)
LAT/LONG: 48.554, -122.455
WATERBODY: SAMISH RIVER
APPLICANT: SKAGIT COUNTY
REFERENCE #:

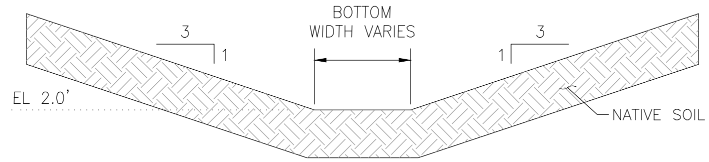
NO.	REVISIONS	DATE
1	JARPA APPLICATION	03/29/21

DATUM
NAVD 88

nhc
northwest hydraulic consultants
301 west holly street, suite u3
bellingham, washington 98225
phone: (206) 241-6000
www.nhcweb.com

0.5 INCH SCALE BAR
ADJUST SCALE ACCORDINGLY

SHEET
16 OF 17



3 SITE 1 - BAYVIEW EDISON NORTH TYPICAL DITCH SECTION

NOT TO SCALE

QUANTITY TABLE

QUANTITY	SITE 1 - BAYVIEW EDISON NORTH	SITE 2 - BAYVIEW EDISON SOUTH	SITE 3 - FARM TO MARKET ROAD
1. AREA OF EARTHWORKS OPERATION (EXCL. ROCK ACCESS ROAD)	7140 SF	6150 SF	3860 SF
2. CUT VOLUME	904 CY	1024 CY	338 CY
3. FILL VOLUME (INCL. RIP RAP & EXCL. ROCK ACCESS ROAD)	982 CY	1296 CY	430 CY
4. NET CUT/FILL	+ 78 CY	+ 272 CY	+ 92 CY

NOT FOR CONSTRUCTION

SKAGIT COUNTY PUBLIC WORKS
1800 CONTINENTAL PLACE
MOUNT VERNON, WA 98273-5625
(360) 336-9400 FAX (360) 336 9478

SKAGIT RIVER BRIDGE MODIFICATION AND INTERSTATE HIGHWAY PROTECTION PROJECT

SHEET NAME: DETAILS & QUANTITIES

PROJECT LOCATED NEAR: EDISON, WA (SKAGIT COUNTY)

NHC PROJECT NO.: 2002084
FED. AID NO.: HPP-2029(040)
LAT/LONG: 48.554, -122.455
WATERBODY: SAMISH RIVER
APPLICANT: SKAGIT COUNTY
REFERENCE #:

NO.	REVISIONS	DATE
1	JARPA APPLICATION	03/29/21

DATUM NAVD 88

nhc northwest hydraulic consultants
301 west holly street, suite u3
bellingham, washington 98225
phone: (206) 241-6000
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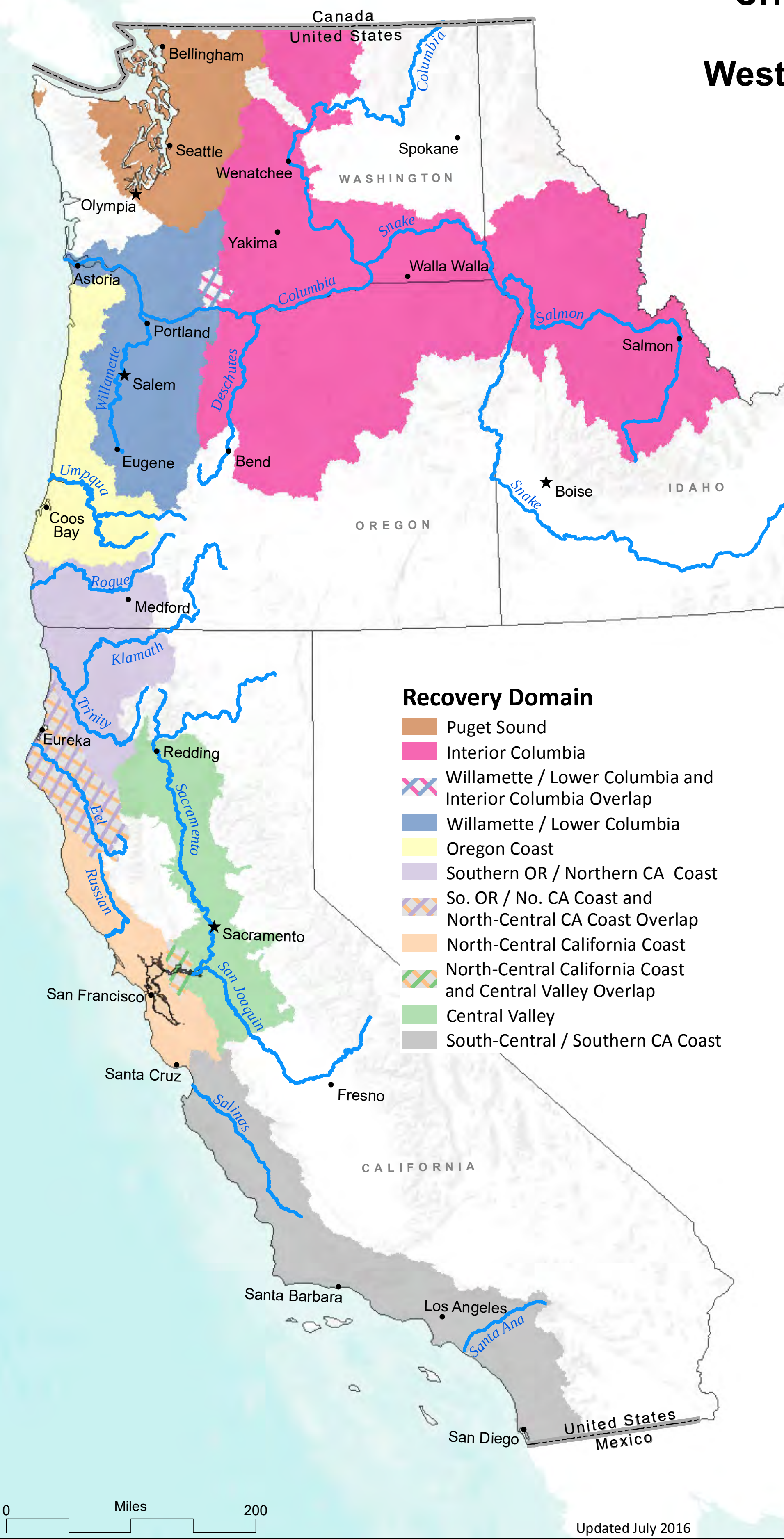
0.5 INCH SCALE BAR ADJUST SCALE ACCORDINGLY

APPENDIX C
Species Lists

Status of ESA Listings & Critical Habitat Designations for West Coast Salmon & Steelhead



Updated July 2016

Evolutionarily Significant Unit / Distinct Population Segment	ESA Status	Date of ESA Listing	Date of CH Designation
Puget Sound Recovery Domain			
Hood Canal Summer-run Chum Salmon	T	3/25/1999	9/2/2005
Ozette Lake Sockeye Salmon	T	3/25/1999	9/2/2005
Puget Sound Chinook Salmon	T	3/24/1999	9/2/2005
Puget Sound Steelhead	T	5/11/2007	2/24/2016
Interior Columbia Recovery Domain			
Middle Columbia River Steelhead	T	3/25/1999 1/5/2006	9/2/2005
Snake River Fall-run Chinook Salmon	T	4/22/1992	12/28/1993
Snake River Spring / Summer-run Chinook Salmon	T	4/22/1992	10/25/1999
Snake River Sockeye Salmon	E	11/20/1991	12/28/1993
Snake River Steelhead	T	8/18/1997 1/5/2006	9/2/2005
Upper Columbia River Spring-run Chinook Salmon	E	3/24/1999	9/2/2005
Upper Columbia River Steelhead	T	8/18/1997 1/5/2006	9/2/2005
Willamette / Lower Columbia Recovery Domain			
Columbia River Chum Salmon	T	3/25/1999	9/2/2005
Lower Columbia River Chinook Salmon	T	3/24/1999	9/2/2005
Lower Columbia River Coho Salmon	T	6/28/2005	2/24/2016
Lower Columbia River Steelhead	T	3/19/1998 1/5/2006	9/2/2005
Upper Willamette River Chinook Salmon	T	3/24/1999	9/2/2005
Upper Willamette River Steelhead	T	3/25/1999 1/5/2006	9/2/2005
Oregon Coast Recovery Domain			
Oregon Coast Coho Salmon	T	2/11/2008	2/11/2008
Southern Oregon / Northern California Coast Recovery Domain			
Southern OR / Northern CA Coasts Coho Salmon	T	5/6/1997	5/5/1999
North-Central California Coast Recovery Domain			
California Coastal Chinook Salmon	T	9/16/1999	9/2/2005
Central California Coast Coho Salmon	E	10/31/1996 (T) 6/28/2005 (E) 4/2/2012 (RE)	5/5/1999
Central California Coast Steelhead	T	8/18/1997 1/5/2006	9/2/2005
Northern California Steelhead	T	6/7/2000 1/5/2006	9/2/2005
Central Valley Recovery Domain			
California Central Valley Steelhead	T	3/19/1998 1/5/2006	9/2/2005
Central Valley Spring-run Chinook Salmon	T	9/16/1999	9/2/2005
Sacramento River Winter-run Chinook Salmon	E	11/5/1990 (T) 1/4/1994 (E)	6/16/1993
South-Central / Southern California Coast Recovery Domain			
South-Central California Coast Steelhead	T	8/18/1997 1/5/2006	9/2/2005
Southern California Steelhead	E	8/18/1997 5/1/2002 (RE) 1/5/2006	9/2/2005

ESA = Endangered Species Act, CH = Critical Habitat, RE = Range Extension
E = Endangered, T = Threatened,

Critical Habitat Rules Cited

- 2/24/2016 (81 FR 9252) Final Critical Habitat Designation for Puget Sound Steelhead and Lower Columbia River Coho Salmon
- 2/11/2008 (73 FR 7816) Final Critical Habitat Designation for Oregon Coast Coho Salmon
- 9/2/2005 (70 FR 52630) Final Critical Habitat Designation for 12 ESU's of Salmon and Steelhead in WA, OR, and ID
- 9/2/2005 (70 FR 52488) Final Critical Habitat Designation for 7 ESU's of Salmon and Steelhead in CA
- 10/25/1999 (64 FR 57399) Revised Critical Habitat Designation for Snake River Spring/Summer-run Chinook Salmon
- 5/5/1999 (64 FR 24049) Final Critical Habitat Designation for Central CA Coast and Southern OR/Northern CA Coast Coho Salmon
- 12/28/1993 (58 FR 68543) Final Critical Habitat Designation for Snake River Chinook and Sockeye Salmon
- 6/16/1993 (58 FR 33212) Final Critical Habitat Designation for Sacramento River Winter-run Chinook Salmon

ESA Listing Rules Cited

- 4/2/2012 (77 FR 19552) Final Range Extension for Endangered Central California Coast Coho Salmon
- 2/11/2008 (73 FR 7816) Final ESA Listing for Oregon Coast Coho Salmon
- 5/11/2007 (72 FR 26722) Final ESA Listing for Puget Sound Steelhead
- 1/5/2006 (71 FR 5248) Final Listing Determinations for 10 Distinct Population Segments of West Coast Steelhead
- 6/28/2005 (70 FR 37160) Final ESA Listing for 16 ESU's of West Coast Salmon
- 5/1/2002 (67 FR 21586) Range Extension for Endangered Steelhead in Southern California
- 6/7/2000 (65 FR 36074) Final ESA Listing for Northern California Steelhead
- 9/16/1999 (64 FR 50394) Final ESA Listing for Two Chinook Salmon ESUs in California
- 3/25/1999 (64 FR 14508) Final ESA Listing for Hood River Canal Summer-run and Columbia River Chum Salmon
- 3/25/1999 (64 FR 14517) Final ESA Listing for Middle Columbia River and Upper Willamette River Steelhead
- 3/25/1999 (64 FR 14528) Final ESA Listing for Ozette Lake Sockeye Salmon
- 3/24/1999 (64 FR 14308) Final ESA Listing for 4 ESU's of Chinook Salmon
- 3/19/1998 (63 FR 13347) Final ESA Listing for Lower Columbia River and Central Valley Steelhead
- 8/18/1997 (62 FR 43937) Final ESA Listing for 5 ESU's of Steelhead
- 5/6/1997 (62 FR 24588) Final ESA Listing for Southern Oregon / Northern California Coast Coho Salmon
- 10/31/1996 (61 FR 56138) Final ESA Listing for Central California Coast Coho Salmon
- 1/4/1994 (59 FR 222) Final ESA Listing for Sacramento River Winter-run Chinook Salmon
- 4/22/1992 (57 FR 14653) Final ESA Listing for Snake River Spring/summer-run and Snake River Fall Chinook Salmon
- 11/20/1991 (56 FR 58619) Final ESA Listing for Snake River Sockeye Salmon
- 11/5/1990 (55 FR 46515) Final ESA Listing for Sacramento River Winter-run Chinook Salmon

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Washington Fish And Wildlife Office
510 Desmond Drive Se, Suite 102
Lacey, WA 98503-1263
Phone: (360) 753-9440 Fax: (360) 753-9405
http://www.fws.gov/wafwo/

In Reply Refer To: April 14, 2021
Consultation Code: 01EWFW00-2021-SLI-0916
Event Code: 01EWFW00-2021-E-01787
Project Name: Samish Floodgates

Subject: List of threatened and endangered species that may occur in your proposed project location or may be affected by your proposed project

To Whom It May Concern:

The enclosed species list identifies threatened, endangered, and proposed species, designated and proposed critical habitat, and candidate species that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.).

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. The species list is currently compiled at the county level. Additional information is available from the Washington Department of Fish and Wildlife, Priority Habitats and Species website: http://wdfw.wa.gov/mapping/phs/ or at our office website: http://www.fws.gov/wafwo/species_new.html. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the ECOS-IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the ECOS-IPaC system by completing the same process used to receive the enclosed list.

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2) of the Act and its implementing regulations (50 CFR 402 et seq.), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species and to determine whether projects may affect threatened and endangered species and/or designated critical habitat.

A Biological Assessment is required for construction projects (or other undertakings having similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2)(c)). For projects other than major construction activities, the Service suggests that a biological evaluation similar to a Biological Assessment be prepared to determine whether or not the project may affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

If a Federal agency determines, based on the Biological Assessment or biological evaluation, that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Service recommends that candidate species, proposed species, and proposed critical habitat be addressed within the consultation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:
http://www.fws.gov/endangered/esa-library/pdf/TOC-GLOS.PDF

Please be aware that bald and golden eagles are protected under the Bald and Golden Eagle Protection Act (16 U.S.C. 668 et seq.). You may visit our website at http://www.fws.gov/pacific/eagle/for information on disturbance or take of the species and information on how to get a permit and what current guidelines and regulations are. Some projects affecting these species may require development of an eagle conservation plan: (http://www.fws.gov/windenergy/eagle_guidance.html). Additionally, wind energy projects should follow the wind energy guidelines (http://www.fws.gov/windenergy/) for minimizing impacts to migratory birds and bats.

Also be aware that all marine mammals are protected under the Marine Mammal Protection Act (MMPA). The MMPA prohibits, with certain exceptions, the "take" of marine mammals in U.S. waters and by U.S. citizens on the high seas. The importation of marine mammals and marine mammal products into the U.S. is also prohibited. More information can be found on the MMPA website: http://www.nmfs.noaa.gov/pr/laws/mmpa/.

We appreciate your concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Tracking Number in the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

Related website:
National Marine Fisheries Service: http://www.nwr.noaa.gov/protected_species/species_list/species_lists.html

Attachment(s):

- Official Species List

Official Species List

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

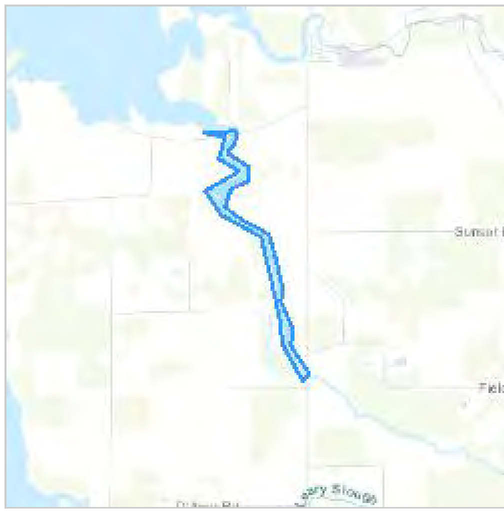
This species list is provided by:

Washington Fish And Wildlife Office
510 Desmond Drive Se, Suite 102
Lacey, WA 98503-1263
(360) 753-9440

Project Summary

Consultation Code: 01EWFW00-2021-SLI-0916
Event Code: 01EWFW00-2021-E-01787
Project Name: Samish Floodgates
Project Type: LAND - FLOODING
Project Description: tidegate structure installation at 3 sites along the Samish River/estuary
Project Location:

Approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/@48.54286295,-122.44938138882648,14z



Counties: Skagit County, Washington

Endangered Species Act Species

There is a total of 7 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries[1], as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

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1. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

Mammals

NAME	STATUS
Gray Wolf *Canis lupus* Population: Western Distinct Population Segment No critical habitat has been designated for this species.	Proposed Endangered

Birds

NAME	STATUS
Marbled Murrelet *Brachyramphus marmoratus* Population: U.S.A. (CA, OR, WA) There is **final** critical habitat for this species. The location of the critical habitat is not available. Species profile: https://ecos.fws.gov/ecp/species/4467	Threatened
Streaked Horned Lark *Eremophila alpestris strigata* There is **final** critical habitat for this species. The location of the critical habitat is not available. Species profile: https://ecos.fws.gov/ecp/species/7268	Threatened
Yellow-billed Cuckoo *Coccyzus americanus* Population: Western U.S. DPS There is **proposed** critical habitat for this species. The location of the critical habitat is not available. Species profile: https://ecos.fws.gov/ecp/species/3911	Threatened

Amphibians

NAME	STATUS
Oregon Spotted Frog *Rana pretiosa* There is **final** critical habitat for this species. The location of the critical habitat is not available. Species profile: https://ecos.fws.gov/ecp/species/6633	Threatened

Fishes

NAME	STATUS
Bull Trout *Salvelinus confluentus* Population: U.S.A., conterminous, lower 48 states There is **final** critical habitat for this species. Your location overlaps the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/8212	Threatened
Dolly Varden *Salvelinus malma* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/1008	Proposed Similarity of Appearance (Threatened)

Critical habitats

There is 1 critical habitat wholly or partially within your project area under this office's jurisdiction.

NAME	STATUS
Bull Trout *Salvelinus confluentus* https://ecos.fws.gov/ecp/species/8212#crithab	Final

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE
PRIORITY HABITATS AND SPECIES REPORT

SOURCE DATASET: PHSPlusPublic   Query ID: P190618110920
REPORT DATE: 06/18/2019 11.09

Common Name Scientific Name Notes	Site Name Source Dataset Source Record Source Date	Priority Area Occurrence Type More Information (URL) Mgmt Recommendations	Accuracy	Federal Status State Status PHS Listing Status	Sensitive Data Resolution	Source Entity Geometry Type
Chum Oncorhynchus keta	Samish River SASI 2044	Occurrence Occurrence http://wdfw.wa.gov/wlm/diversty/soc/soc.htm http://wdfw.wa.gov/publications/pub.php?	NA	Not Warranted N/A PHS Listed	N AS MAPPED	WDFW Fish Program Lines
Coho Oncorhynchus kisutch	SWIFD 45605	Occurrence/Migration Occurrence/migration http://wdfw.wa.gov/wlm/diversty/soc/soc.htm http://wdfw.wa.gov/publications/pub.php?	NA	N/A N/A PHS LISTED	N AS MAPPED	Lines
Coho Oncorhynchus kisutch	Samish River SWIFD 46098	Occurrence/Migration Occurrence/migration http://wdfw.wa.gov/wlm/diversty/soc/soc.htm http://wdfw.wa.gov/publications/pub.php?	NA	N/A N/A PHS LISTED	N AS MAPPED	Lines
Coho Oncorhynchus kisutch	Samish River SWIFD 46099	Breeding Area Breeding area http://wdfw.wa.gov/wlm/diversty/soc/soc.htm http://wdfw.wa.gov/publications/pub.php?	NA	N/A N/A PHS LISTED	N AS MAPPED	Lines
Coho Oncorhynchus kisutch	SASI 3030	Occurrence Occurrence http://wdfw.wa.gov/wlm/diversty/soc/soc.htm http://wdfw.wa.gov/publications/pub.php?	NA	Candidate N/A PHS Listed	N AS MAPPED	WDFW Fish Program Lines
Coho Oncorhynchus kisutch	Samish River SASI 3030	Occurrence Occurrence http://wdfw.wa.gov/wlm/diversty/soc/soc.htm http://wdfw.wa.gov/publications/pub.php?	NA	Candidate N/A PHS Listed	N AS MAPPED	WDFW Fish Program Lines
Cutthroat Oncorhynchus clarki	Samish River SASI 7300	Occurrence Occurrence http://wdfw.wa.gov/wlm/diversty/soc/soc.htm http://wdfw.wa.gov/publications/pub.php?	NA	Not Warranted N/A PHS Listed	N AS MAPPED	WDFW Fish Program Lines

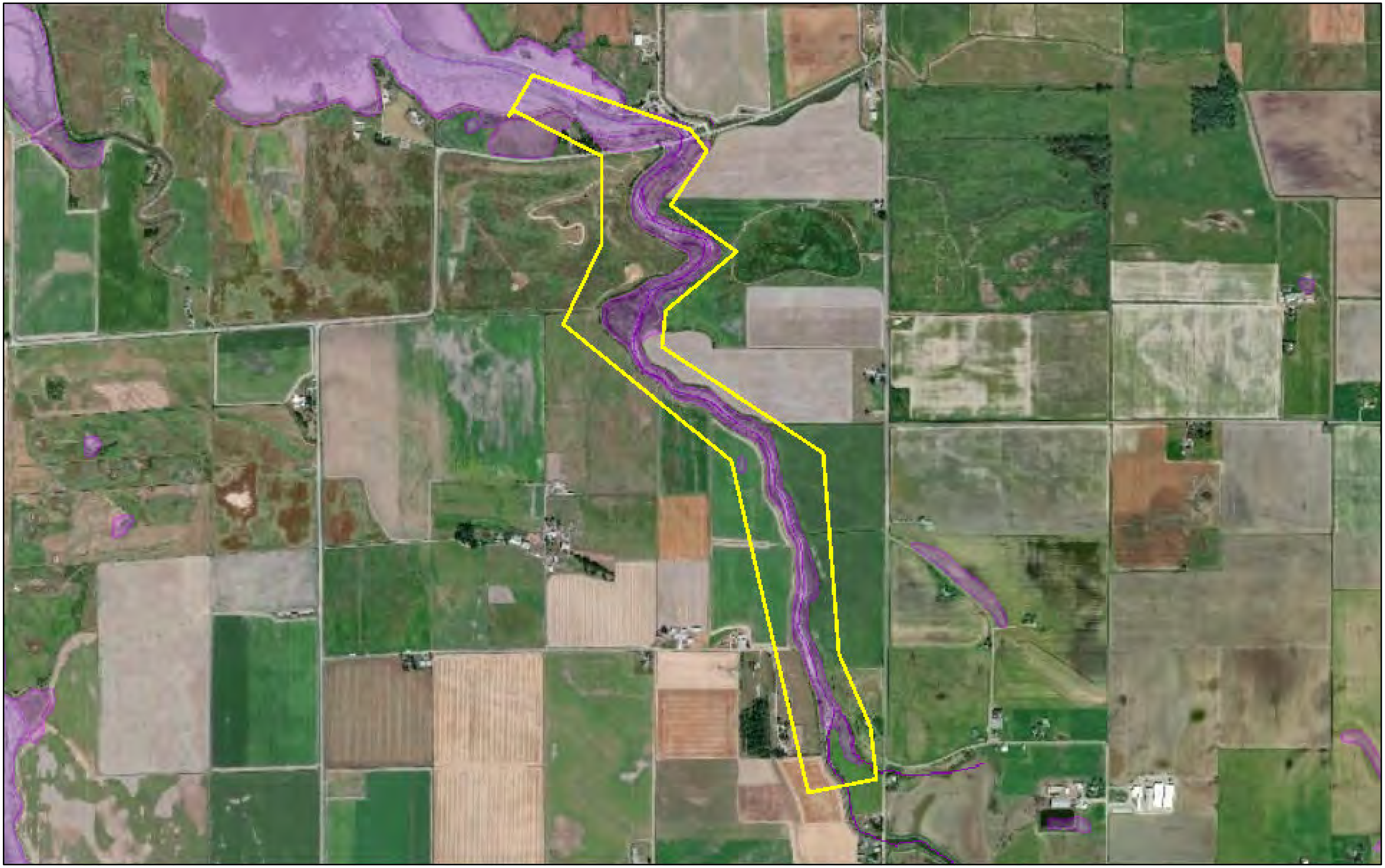
Common Name Scientific Name Notes	Site Name Source Dataset Source Record Source Date	Priority Area Occurrence Type More Information (URL) Mgmt Recommendations	Accuracy	Federal Status State Status PHS Listing Status	Sensitive Data Resolution	Source Entity Geometry Type
Dolly Varden/ Bull Trout Salvelinus malma	Samish River SWIFD 46101	Occurrence/Migration Occurrence/migration http://wdfw.wa.gov/wlm/diversty/soc/soc.htm http://wdfw.wa.gov/publications/pub.php?	NA	N/A N/A PHS LISTED	N AS MAPPED	 Lines
Estuarine and Marine	N/A NWIWetlands	Aquatic Habitat Aquatic habitat http://www.ecy.wa.	NA	N/A N/A PHS Listed	N AS MAPPED	US Fish and Wildlife Service Polygons
Estuarine and Marine	N/A NWIWetlands	Aquatic Habitat Aquatic habitat http://www.ecy.wa.	NA	N/A N/A PHS Listed	N AS MAPPED	US Fish and Wildlife Service Polygons
Estuarine and Marine	N/A NWIWetlands	Aquatic Habitat Aquatic habitat http://www.ecy.wa.	NA	N/A N/A PHS Listed	N AS MAPPED	US Fish and Wildlife Service Polygons
Estuarine and Marine	N/A NWIWetlands	Aquatic Habitat Aquatic habitat http://www.ecy.wa.	NA	N/A N/A PHS Listed	N AS MAPPED	US Fish and Wildlife Service Polygons
Estuarine and Marine	N/A NWIWetlands	Aquatic Habitat Aquatic habitat http://www.ecy.wa.	NA	N/A N/A PHS Listed	N AS MAPPED	US Fish and Wildlife Service Polygons
Estuarine and Marine	N/A NWIWetlands	Aquatic Habitat Aquatic habitat http://www.ecy.wa.	NA	N/A N/A PHS Listed	N AS MAPPED	US Fish and Wildlife Service Polygons
Estuarine and Marine	N/A NWIWetlands	Aquatic Habitat Aquatic habitat http://www.ecy.wa.	NA	N/A N/A PHS Listed	N AS MAPPED	US Fish and Wildlife Service Polygons

Common Name Scientific Name Notes	Site Name Source Dataset Source Record Source Date	Priority Area Occurrence Type More Information (URL) Mgmt Recommendations	Accuracy	Federal Status State Status PHS Listing Status	Sensitive Data Resolution	Source Entity Geometry Type
Fall Chinook Oncorhynchus tshawytscha	Samish River SWIFD 46091	Occurrence/Migration Occurrence/migration http://wdfw.wa.gov/wlm/diversty/soc/soc.htm http://wdfw.wa.gov/publications/pub.php?	NA	N/A N/A PHS LISTED	N AS MAPPED	 Lines
Fall Chum Oncorhynchus keta	Samish River SWIFD 46095	Occurrence/Migration Occurrence/migration http://wdfw.wa.gov/wlm/diversty/soc/soc.htm http://wdfw.wa.gov/publications/pub.php?	NA	N/A N/A PHS LISTED	N AS MAPPED	 Lines
Freshwater Emergent	N/A NWIWetlands	Aquatic Habitat Aquatic habitat http://www.ecy.wa.	NA	N/A N/A PHS Listed	N AS MAPPED	US Fish and Wildlife Service Polygons
Freshwater Emergent	N/A NWIWetlands	Aquatic Habitat Aquatic habitat http://www.ecy.wa.	NA	N/A N/A PHS Listed	N AS MAPPED	US Fish and Wildlife Service Polygons
Freshwater Forested/Shrub	N/A NWIWetlands	Aquatic Habitat Aquatic habitat http://www.ecy.wa.	NA	N/A N/A PHS Listed	N AS MAPPED	US Fish and Wildlife Service Polygons
Freshwater Forested/Shrub	N/A NWIWetlands	Aquatic Habitat Aquatic habitat http://www.ecy.wa.	NA	N/A N/A PHS Listed	N AS MAPPED	US Fish and Wildlife Service Polygons
Kokanee Oncorhynchus nerka	Samish River SWIFD 46104	Occurrence/Migration Occurrence/migration http://wdfw.wa.gov/wlm/diversty/soc/soc.htm http://wdfw.wa.gov/publications/pub.php?	NA	N/A N/A PHS LISTED	N AS MAPPED	 Lines
Pink Salmon Odd Year Oncorhynchus gorbuscha	Samish River SWIFD 46105	Occurrence/Migration Occurrence/migration http://wdfw.wa.gov/wlm/diversty/soc/soc.htm http://wdfw.wa.gov/publications/pub.php?	NA	N/A N/A PHS LISTED	N AS MAPPED	 Lines

Common Name Scientific Name Notes	Site Name Source Dataset Source Record Source Date	Priority Area Occurrence Type More Information (URL) Mgmt Recommendations	Accuracy	Federal Status State Status PHS Listing Status	Sensitive Data Resolution	Source Entity Geometry Type
Rainbow Trout Oncorhynchus mykiss	Samish River SWIFD 46107	Occurrence/Migration Occurrence/migration http://wdfw.wa.gov/wlm/diversty/soc/soc.htm http://wdfw.wa.gov/publications/pub.php?	NA	N/A N/A PHS LISTED	N AS MAPPED	Lines
Resident Coastal Cutthroat Oncorhynchus clarki	SWIFD 45602	Occurrence/Migration Occurrence/migration http://wdfw.wa.gov/wlm/diversty/soc/soc.htm http://wdfw.wa.gov/publications/pub.php?	NA	N/A N/A PHS LISTED	N AS MAPPED	Lines
Resident Coastal Cutthroat Oncorhynchus clarki	Samish River SWIFD 46089	Occurrence/Migration Occurrence/migration http://wdfw.wa.gov/wlm/diversty/soc/soc.htm http://wdfw.wa.gov/publications/pub.php?	NA	N/A N/A PHS LISTED	N AS MAPPED	Lines
Shorebird Concentrations	SAMISH BAY PHSREGION 920109	Regular Concentration Regular concentration http://wdfw.wa.gov/publications/pub.php?	1/4 mile (Quarter	N/A N/A PHS LISTED	N AS MAPPED	WA Dept. of Fish and Wildlife Polygons
Sockeye Oncorhynchus nerka	Samish River SWIFD 46109	Breeding Area Breeding area http://wdfw.wa.gov/wlm/diversty/soc/soc.htm http://wdfw.wa.gov/publications/pub.php?	NA	N/A N/A PHS LISTED	N AS MAPPED	Lines
Steelhead Oncorhynchus mykiss	Samish River SASI 6042	Occurrence Occurrence http://wdfw.wa.gov/wlm/diversty/soc/soc.htm http://wdfw.wa.gov/publications/pub.php?	NA	Threatened N/A PHS Listed	N AS MAPPED	WDFW Fish Program Lines
Waterfowl Concentrations	SAMISH BAY PHSREGION 902828	Regular Concentration Regular concentration http://wdfw.wa.gov/publications/pub.php?	1/4 mile (Quarter	N/A N/A PHS LISTED	N AS MAPPED	WA Dept. of Fish and Wildlife Polygons
Wetlands	REGION 4 SALTWATER PHSREGION 903606	Aquatic Habitat N/A http://www.ecy.wa.	1/4 mile (Quarter	N/A N/A PHS LISTED	N AS MAPPED	WA Dept. of Fish and Wildlife Polygons

Common Name Scientific Name Notes	Site Name Source Dataset Source Record Source Date	Priority Area Occurrence Type More Information (URL) Mgmt Recommendations	Accuracy	Federal Status State Status PHS Listing Status	Sensitive Data Resolution	Source Entity Geometry Type
Wetlands	SAMISH WETLANDS. PHSREGION 902762	Aquatic Habitat N/A http://www.ecy.wa.	1/4 mile (Quarter	N/A N/A PHS LISTED	N AS MAPPED	WA Dept. of Fish and Wildlife Polygons
Winter Steelhead Oncorhynchus mykiss	Samish River SWIFD 46110	Occurrence/Migration Occurrence/migration http://wdfw.wa.gov/wlm/diversty/soc/soc.htm http://wdfw.wa.gov/publications/pub.php?	NA	N/A N/A PHS LISTED	N AS MAPPED	 Lines

WDFW Test Map



June 18, 2019

PHS Report Clip Area	**POLY**	QTR-TWP
PT	AS MAPPED	TOWNSHIP
LN	SECTION	

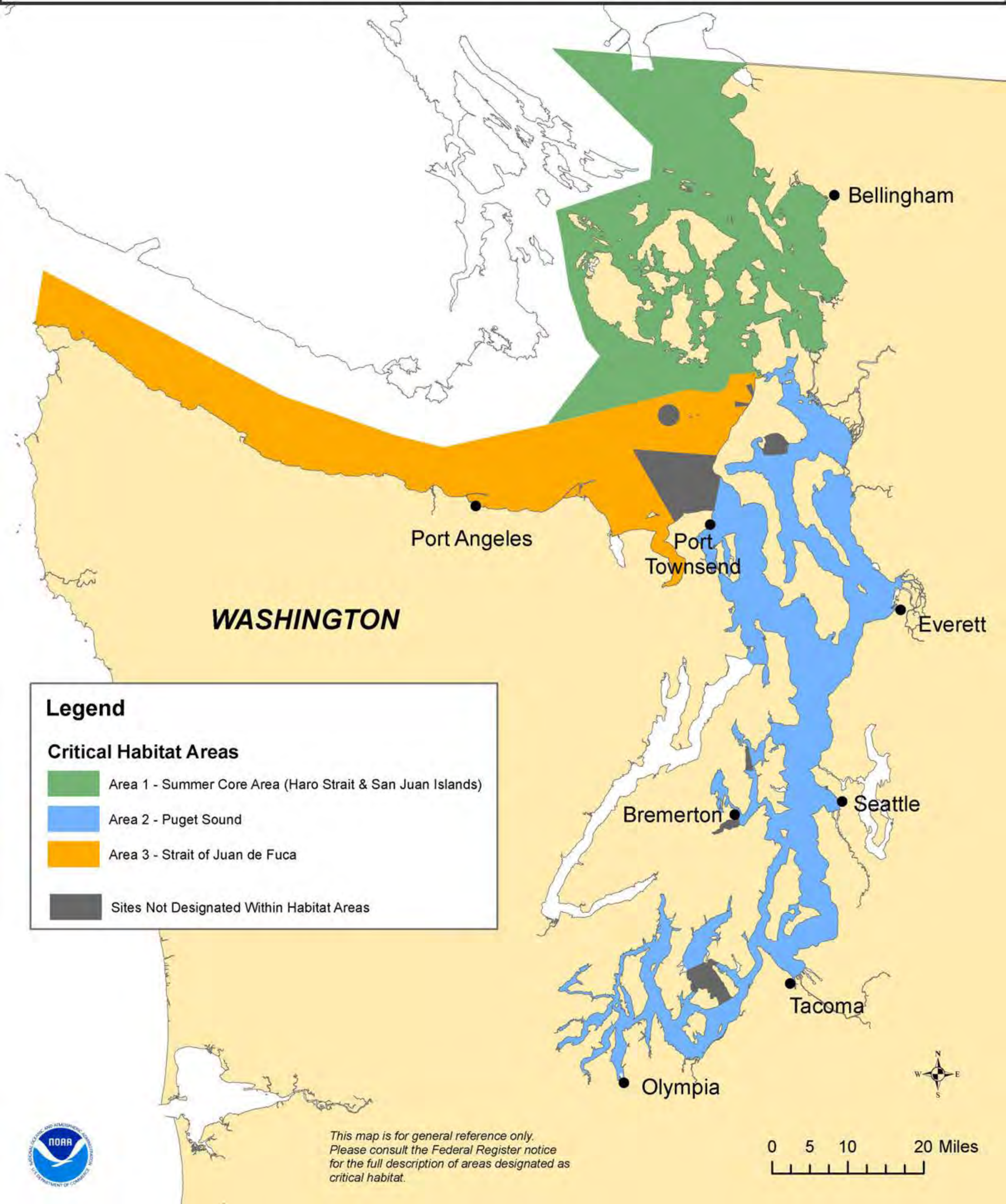
1:29,650

0 0.25 0.5 1 mi

0 0.4 0.8 1.6 km

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Designated Critical Habitat for Southern Resident Killer Whales
November 2006
NOAA Fisheries, Northwest Region



This map is for general reference only. Please consult the Federal Register notice for the full description of areas designated as critical habitat.

Appendix D
ESA Listing Status and Species Life Histories

APPENDIX D
ESA LISTING STATUS AND SPECIES LIFE HISTORIES

Marbled Murrelet (Brachyramphus marmoratus)

ESA Listing and Stock Status

The marbled murrelet was listed as threatened on October 1, 1992 (57 FR 45328). Critical habitat was designated on May 5, 1996 (61 FR 26255).

Marbled murrelet have a fairly large range (Alaska to northern California) but relatively little habitat is of high quality and the population trend is downward due to past and continuing habitat loss and/or fragmentation resulting from timber harvest. The total population of marbled murrelets is not known. Estimates range globally from 263,000 to 841,000. In Washington, the current estimated population is between 5,000 to 6,500 focused around the north Puget Sound area (NatureServe 2010). Beissinger (1995) predicts a 4 percent annual decline based on a demographic model. On the southern coast of Washington, north coast of Oregon and in California south of Humboldt County, murrelets are rare or uncommon where they once were common or abundant in the early 1900s (Ralph et al., 1995).

Life History

Marbled murrelets mainly inhabit coastal areas within 2 kilometers (km) from shore. This includes bays and sounds; occasionally they inhabit rivers and lakes within 20 km of the ocean usually during the breeding season. They roost during the night and typically hunt during the day; rare sightings have witnessed them feeding at night. Marbled murrelets diets range from fish (sandlance, capelin, herring, etc.), crustaceans (mysids, euphausiids) and mollusks (NatureServe 2010).

Marbled murrelets nest in mature/old growth coniferous forests near the coast. Marbled murrelets lay one single egg on an old growth tree branch covered in moss. The young marbled murrelets inhabit large stands of old growth forest until they are mature enough to fly to the ocean without parent assistance or escort. Females will occupy the same nesting tree in successive years, as long as habitat remains suitable.

Puget Sound Chinook Salmon (*Oncorhynchus tshawytscha*)

Endangered Species Act (ESA) Listing and Stock Status

As a result of the National Marine Fisheries Service's (NMFS') status review of Chinook salmon populations in Washington, Oregon, Idaho and California, five Evolutionary Significant Units (ESUs) were defined. The Puget Sound ESU, composed of all naturally spawning spring, summer and fall runs of Chinook salmon populations from the Elwha River to the Nooksack River, was listed as threatened under the ESA in March 1999 (64 FR 14308) and reaffirmed in 2005 (70 FR 37160). Critical habitat was designated for Puget Sound Chinook in 2000 but was vacated by court order in 2002. National Oceanic and Atmospheric Administration (NOAA) Fisheries reevaluated the critical habitat designations for Chinook in the Puget Sound and published the rules on this issue in 2005 (70 FR 52630).

Overall abundance of Chinook in the Puget Sound ESU has declined substantially from historic levels, and there has been concern over the effects of a high degree of hatchery supplementation on the genetic fitness of wild stocks. Additional factors leading to declines in the ESU include habitat degradation and high harvest rates, which in recent years have exceeded 90 percent (Myers et al. 1998).

Life History

Chinook salmon are anadromous. Adults migrate from marine environments and spawn in freshwater, while juveniles rear in freshwater for varying periods of time before migrating out to saltwater where they mature. Chinook use a wide variety of freshwater habitats from headwaters to the estuary but are typically found in low-gradient streams dominated by gravel and cobble (Scott and Crossman 1973). They require clean gravel for spawning. Juvenile Chinook are typically associated with low-gradient, meandering, unconstrained stream reaches (Lee et al. 1996) and require abundant habitat complexity such as that associated with accumulations of large woody debris and overhanging vegetation. Juvenile Chinook often move into side channels, beaver ponds and sloughs for over-wintering habitat.

Most juvenile Chinook salmon migrate to the marine environment as smolts during their first year although their early life history patterns vary. Some migrate downstream almost immediately after emerging from the gravel. Others migrate downstream and enter side-channels where they may rear for several weeks before migrating to marine waters. A third life history strategy involves a more extended rearing time (up to 2 years) in the river before migrating to saltwater.

Juvenile Chinook salmon reside for a period of time in shallow intertidal areas before migrating to the sea. The availability of rearing habitat that includes an abundance of food items and security from predation during this early marine phase is critical to their growth and survival.

As smolts mature into juveniles, they move into the North Pacific to feed and mature into adults. As juveniles, their diet consists usually of either small crustaceans or insects in fresh water and small crustaceans in the sea; as they mature their diet includes a greater proportion of small fish (Royce 1972). As juvenile salmon shift their prey preference to fish species such as juvenile herring and sandlance, they become dependent on these prey species as a forage base and are more likely to be found in shoreline zones containing eelgrass and other habitat features that support their prey.

Steelhead (*Oncorhynchus mykiss*)

ESA Listing and Stock Status

In 1996, the NOAA Fisheries conducted a comprehensive status review of coastal and inland steelhead stocks in California, Oregon, Washington and Idaho. This review identified a Puget Sound ESU of coastal steelhead. The conclusion of that review stated that the Puget Sound steelhead ESU was not in danger of becoming extinct and did not warrant listing under the ESA. Not listing the Puget Sound steelhead was largely based on large positive overall trends for the two largest area steelhead populations and the lack of strong upward or downward trends for the other winter-run steelhead populations in the Puget Sound. This review did express concern about the sustainability of summer steelhead populations and potential adverse impacts from hatchery practices in the Puget Sound (71 FR 15666).

On September 13, 2004, NOAA Fisheries received a petition to list Puget Sound steelhead as a threatened or endangered species. A status review was conducted and NOAA determined that naturally spawned summer- and winter-run steelhead populations and two hatchery steelhead stocks, below natural and manmade impassable barriers, in the river basins of the Strait of Juan de Fuca, Puget Sound and Hood Canal constitute a Distinct Population Segment (DPS) and are a “species” for listing under the ESA. The results of the status review were released on March 29, 2006 stating that NOAA has proposed to list Puget Sound steelhead as threatened based on widespread declines in abundance and productivity over the past nine years, particularly for the two populations identified as strongholds in the 1996 review. This proposed listing action includes only the anadromous form of *Oncorhynchus mykiss* (71 FR 15666). On May 11, 2007, the Final Rule was published to list Puget Sound steelhead as threatened under ESA (72 FR 26722). NMFS issued a final rule to designate critical habitat for Puget Sound steelhead (*O. mykiss*) in 2016 (81 FR 9252).

Life History

Steelhead is the name commonly applied to the anadromous (sea-going) form of the biological species *Oncorhynchus mykiss*. Steelhead exhibit perhaps the most complex suite of life-history traits of any species of Pacific salmonid. *Oncorhynchus mykiss* can be anadromous (''steelhead''), or freshwater residents (''rainbow" or "redband trout''), and under some circumstances yield offspring of the opposite life-history form. Those that are anadromous can spend up to 7 years in freshwater prior to smoltification (the physiological and behavioral changes required for the transition to saltwater), and then spend up to 3 years in saltwater prior to first spawning. Steelhead are also iteroparous (meaning individuals may spawn more than once), whereas the Pacific salmon species are principally semelparous (meaning individuals generally spawn once and die). Within the range of West Coast steelhead, spawning migrations occur throughout the year, with seasonal peaks of activity. In a given river basin there may be one or more peaks in migration activity; since these "runs" are usually named for the season in which the peak occurs, some rivers may have runs known as winter, spring, summer or fall steelhead (81 FR 9252).

Steelhead can be divided into two basic reproductive ecotypes, based on the state of sexual maturity at the time of river entry and duration of spawning migration. The summer or "stream-maturing" type enters fresh water in a sexually immature condition between May and October, and requires several months to mature and spawn. The winter or "ocean-maturing" type enters fresh water between November and April with well-developed gonads and spawns shortly thereafter. In basins with both summer and winter steelhead runs, the summer run generally occurs where habitat is not fully utilized by the winter run, or where an ephemeral hydrologic barrier separates them, such as a seasonal velocity barrier at a waterfall. Summer steelhead usually spawn farther upstream than winter steelhead (81 FR 9252).

Bull Trout (*Salvelinus confluentus*)

ESA Listing and Stock Status

United States Fish and Wildlife Service (USFWS) identified five DPS of bull trout in the western states and, in 1999, listed bull trout in the Coastal Puget Sound DPS as threatened. The coastal bull trout DPS is composed of 34 sub-populations, including the only anadromous bull trout runs within the contiguous United States (64 FR 58909). The more common life history forms presently recognized for bull trout are resident and fluvial, neither of which use marine waters. Critical habitat was designated on September 26, 2005 (70 FR 56212) and revised on October 18, 2010 (75 FR 63897).

Bull trout have a wide, but very patchy, distribution across their range (Reiman and McIntyre 1993). Bull trout have been extirpated from many of the large rivers within their historic range and exist primarily in isolated headwater populations. The decline of bull trout has been attributed to habitat degradation, blocking of migratory corridors, poor water quality, introduction of non-native species and the effects of past fisheries management practices. Critical habitat for bull trout was designated in 2005 (70 FR 56212).

Life History

The bull trout is a member of the *S. alpinus* complex. It was long confused with look-alike *S. malma* (Dolly Varden), especially where the ranges overlap on the Pacific slope (Lee et al. 1980). Cavender (1978) demonstrated the specific distinctiveness of *S. confluentus*, but hybridization and some introgression occur across a broad area of contact. Additionally, molecular data indicate that historical introgression of bull trout mitochondrial DNA (mtDNA) into Dolly Varden occurred sometime prior to the most recent glaciation (Redenbach and Taylor 2002).

Bull trout exhibit resident and migratory life-history strategies through much of the current range (Rieman and McIntyre 1993). Resident bull trout complete their entire life cycle in the tributary (or nearby) streams in which they spawn and rear. Migratory bull trout spawn in tributary streams where juvenile fish rear from one to 4 years before migrating to either a lake (adfluvial), river (fluvial) or in certain coastal areas, to saltwater (anadromous), where maturity is reached in one of the three habitats (Fraley and Shepard 1989). Resident and migratory forms may be found together and it is suspected that bull trout give rise to offspring exhibiting either resident or migratory behavior (Rieman and McIntyre 1993).

Bull trout are found primarily in colder streams, although individual fish are found in larger river systems throughout the Columbia River basin (Fraley and Shepard 1989; Rieman and McIntyre 1993). Water temperature above 15 degrees C (59 degrees F) is believed to limit bull trout distribution, which may partially explain the patchy distribution within a watershed (Fraley and Shepard 1989). Spawning areas are often associated with cold water springs, groundwater infiltration and the coldest streams in a given watershed (Pratt 1992; Rieman and McIntyre 1993). Preferred spawning habitat consists of low gradient streams with loose, clean gravel and water temperatures of 5 to 9 degrees C (41 to 48 degrees F) in late summer to early fall (Fraley and Shepard 1989).

Dolly Varden (*Salvelinus malma*)

ESA Listing and Stock Status

Currently the Dolly Varden is not regulated under the ESA. In 2001 USFWS proposed that this species be listed as threatened in Washington due to similarity of appearance to coexisting bull trout, currently listed as threatened (66 FR 1628).

Dolly Varden has a wide, but very patchy, distribution across their range (Reiman and McIntyre 1993). Dolly Varden has been extirpated from many of the large rivers within their historic range and exists primarily in isolated headwater populations. The decline of Dolly Varden has been attributed to habitat degradation, blocking of migratory corridors, poor water quality, introduction of non-native species and the effects of past fisheries management practices.

Life History

The Dolly Varden is a member of the *S. malma* complex. It was long confused with look-alike *S. alpinus* (bull trout), especially where the ranges overlap on the Pacific slope (Lee et al. 1980). Cavender (1978) demonstrated the specific distinctiveness of *S. confluentus*, but hybridization and some introgression occur across a broad area of contact. Additionally, molecular data indicate that historical introgression of bull trout mtDNA into Dolly Varden occurred sometime prior to the most recent glaciation (Redenbach and Taylor 2002).

Life history pattern varies with location and between anadromous and non-anadromous populations. Dolly Varden exhibit resident and migratory life-history strategies through much of the current range (Rieman and McIntyre 1993). Resident Dolly Varden completes their entire life cycle in the tributary (or nearby) streams in which they spawn and rear. Typically, Dolly Varden spawn from September to early November. Eggs hatch usually in the spring, approximately 4½ months after spawning. Migratory Dolly Varden spawn in tributary streams where juvenile fish rear from 1 to 4 years before migrating to either a lake (adfluvial), river (fluvial) or in certain coastal areas, to saltwater (anadromous), where maturity is reached in one of the three habitats (Fraley and Shepard 1989). Anadromous individuals occur in coastal seas 2 to 3 years before reaching sexual maturity. Resident and migratory forms may be found together, and it is suspected that Dolly Varden give rise to offspring exhibiting either resident or migratory behavior (Rieman and McIntyre 1993). Dolly Varden reach their sexual maturity within 3 to 6 years of being hatched.

Dolly Varden are found primarily in colder streams, although individual fish are found in larger river systems throughout the Columbia River basin (Fraley and Shepard 1989; Rieman and McIntyre 1993). Spawning areas are often associated with cold water springs, groundwater infiltration and the coldest streams in a given watershed (Pratt 1992; Rieman and McIntyre 1993).

Southern Resident Killer Whale (*Orcinus orca*)

ESA Listing and Stock Status

Killer whales first became protected under the Marine Mammal Protection Act (MMPA) in 1972 and were considered to be depleted by May 2003. Populations were drastically reduced from 1965 through 1975 due to captures of the animals for marine parks (NOAA 2005). Southern Resident killer whales (SRKWs) were determined to represent a single DPS of the killer whale species in August 2004 and were proposed for listing under the ESA in December 2004. In November of 2005 (70 FR 69903) the SRKW was listed as an endangered species (NOAA 2005). On November 29, 2006, killer whale critical habitat was designated for Puget Sound (71 FR 69054).

The SRKW population has fluctuated considerably over the past 30 years. In the early 1970s, the population consisted of 71 whales. It peaked in 1996 at 97 whales and declined to 79 in 2001. The population is currently estimated in the high 80s. There are several reasons why biologists think that the SRKW population is not thriving. There are limited numbers of reproductive-age males in the population. Several of the reproductive-age females are not having calves either. Their population has always been small, and this increases their susceptibility to catastrophic risks such as disease or oil spills. Some other potential causes of decline are the reduced quality and quantity of prey, excessive noise and disturbance from passing vessels. The factors causing the decline of SRKW are not well known, and are likely to continue until management agencies learn more about what needs to be done to reverse past trends (NOAA 2005).

In January 2008, the NMFS/NOAA Fisheries produced a Final Recovery Plan for the SRKW (NOAA Fisheries 2008). The recovery plan aims to address the known and potential causes of the species decline through direct research of the species and outreach programs. Specifically, the recovery efforts will include, but are not limited to, such activities as: supporting salmon restoration efforts to ensure prey availability; clean up and monitoring of polluted sites; examining the effects of vessel activity; implementation of outreach to increase public awareness and knowledge; improvement of responsiveness to injured, sick, or abandoned killer whales; and continued research and monitoring of the population and the ecosystem (NOAA Fisheries 2008).

Life History

SRKW occur in large, stable pods with memberships ranging from 10 to approximately 60 whales. The primary prey of these whales is fish and their distribution is closely tied with peak abundance of various species of salmon prey. The assemblage contains three distinct pods: J pod, K pod and L pod and is considered a stock under the MMPA. Their range during the spring, summer and fall includes the inland waterways of Puget Sound, Strait of Juan de Fuca and Southern Georgia Strait. Little is known about the winter movements and range of the Southern Resident stock. SRKWs have not been seen to associate with other resident whales. Mitochondrial and nuclear genetic data suggests that Southern Residents rarely interbreed with other killer whales if at all (NOAA 2005).

Both males and females reach sexual maturity at 15 years of age on average. Reported gestation periods, often established with captive animals, have ranged from 12 to 17 months. The interval between calving is usually about 5 years (ranging from 2 to 12 years). Length of calves at birth ranges from 7 to 9 feet. Calving occurs year round, but appears to peak between fall and spring. Mortality rates vary with age. Neonate mortality, from birth to 6 months of age, is high and has been known to reach 50 percent. From birth, the average life expectancy is about 29 years for females and 17 years for males (Species at Risk 2005).

The Southern Resident population is more subject to anthropogenic influences than any of the other populations. For example, levels of toxic chemicals in Southern Residents are three times higher than levels known to cause immunotoxicity in Harbor Seals (*Phoca vitulina*). Organochlorine concentrations are four times higher than reported for the Northern Resident population. It is also possible that the large and growing commercial and recreational whale watching industry on the west coast may be having an impact although specific impacts are unclear. The Southern Residents are also subject to significantly higher levels of vessel interactions due to the proximity of their summer range to large urban areas (Seattle, Victoria and Vancouver). Human interactions include live-capture fisheries, entanglement in fishing gear, collisions with vessels and exposure to oil spills (Species at Risk 2005).

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APPENDIX E
Site Photographs

Photograph 1. At the Bayview Edison North site, floodgates are proposed to the left and right of this access road.

Photograph 2. The Bayview Edison North levee is armored with rip rap and supports a timber pile pier structure.

Site Photographs

Skagit River Bridge Modification and Interstate Highway Protection Project
Skagit County, Washington

GeoEngineers | **Figure E-1**

Photograph 3. Wetland B has developed between the backside of the Bayview Edison North levee and a ditch.

Photograph 4. The Bayview Edison South levee floodgates outfall below ordinary high water mark (OHWM) to a vegetated/mudflat bench.

Site Photographs

Skagit River Bridge Modification and Interstate Highway Protection Project
Skagit County, Washington

GeoEngineers

Figure E-2

Photograph 5. Landward of the Bayview Edison South levee is a wide ditch running below the road and levee, surrounding what appears to be a relic agricultural field converted to a habitat restoration site.

Photograph 6. Two of three floodgates at the Farm to Market Road site discharge to a wide flat bench, Wetland C, while one outfalls directly to the river.

Site Photographs

Skagit River Bridge Modification and Interstate Highway Protection Project
Skagit County, Washington

GeoEngineers

Figure E-3

Photograph 7. Culvert under a driveway crossing and ditch viewed north towards the Farm to Market Road floodgates site.

Site Photographs

Skagit River Bridge Modification and Interstate Highway Protection Project
Skagit County, Washington

GEOENGINEERS

Figure E-4

APPENDIX F
Delineated Wetland Habitat

Legend

- Delineated Wetland Boundary Based on GPS
- Approximate Wetland Boundary Based on LiDAR
- Wetland
- Delineated OHWM Based on GPS
- Approximate OHWM Based on LiDAR

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: LiDAR downloaded from Puget Sound LiDAR Consortium, Aerial from GoogleEarthPro

Projection: NAD 1983 StatePlane Washington North FIPS 4601 Feet

Site Plan
Bayview Edison North

Skagit River Bridge Modification and Interstate Highway Protection Project
Skagit County, Washington

GEOENGINEERS

Figure 3

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Legend

- Delineated Wetland Boundary Based on GPS
- Approximate Wetland Boundary Based on LiDAR
- Wetland
- Delineated OHWM Based on GPS
- Approximate OHWM Based on LiDAR

N S W E

50 0 50

Feet

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: LiDAR downloaded from Puget Sound LiDAR Consortium, Aerial from GoogleEarthPro

Projection: NAD 1983 StatePlane Washington North FIPS 4601 Feet

Site Plan
Bayview Edison South

Skagit River Bridge Modification and Interstate Highway Protection Project
Skagit County, Washington

GEOENGINEERS

Figure 4

P:\0\0220097\GIS\MXD\022009700_CriticalAreas_F04_BayviewEdisonSouth.mxd Date Exported: 07/17/19 by ccabrera

Legend

- Delineated Wetland Boundary Based on GPS
- Approximate Wetland Boundary Based on LiDAR
- Wetland
- Delineated OHWM Based on GPS
- Approximate OHWM Based on LiDAR

N
W E
S

70 0 70

Feet

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: LiDAR downloaded from Puget Sound LiDAR Consortium, Aerial from GoogleEarthPro

Projection: NAD 1983 StatePlane Washington North FIPS 4601 Feet

Site Plan
Farm to Market Road

Skagit River Bridge Modification and Interstate Highway Protection Project
Skagit County, Washington

GEOENGINEERS

Figure 5

P:\0\0220097\GIS\MXD\022009700_CriticalAreas_F05_FarmtoMarketRoad.mxd Date Exported: 07/17/19 by ccabrera

ATTACHMENT G

Cost Estimate

Item No.	Work Area	Grouping Name for Summary Bid Tab	Item	WSDOT Specification & Name	Unit	Quantity	Unit Price	Total Amount
	Bayview Edison North							
1		1 Bayview Edison North	Clearing & Grubbing	0025	AC	0.15	$ 20,000.00	$3,000
2		1 Bayview Edison North	High visibility silt fence	6635	LF	336.00	$ 7.50	$2,520
3		1 Bayview Edison North	Stabilized construction entrance	6468	SY	81.10	$ 28.00	$2,271
4		1 Bayview Edison North	Roadway excavation incl. haul	0310	CY	640.20	$ 20.00	$12,804
5		1 Bayview Edison North	Controlled density fill	7015	CY	11.90	$ 300.00	$3,570
6		1 Bayview Edison North	Heavy loose riprap	1076	CY	30.70	$ 75.00	$2,303
7		1 Bayview Edison North	Crushed surfacing base course in stockpile	0640	CY	138.00	$ 93.00	$12,834
8		1 Bayview Edison North	Construction geotextile for underground drainage	7550	SY	277.40	$ 4.22	$1,171
9		1 Bayview Edison North	New 4 ft Dia HDPE pipe		LF	234.00	$ 243.40	$56,956
10		1 Bayview Edison North	New 4 ft Dia side hinge tidegate		EA	4.00	$ 13,860.00	$55,440
11		1 Bayview Edison North	Temporary coffer dam		SF	685.00	$ 34.00	$23,290
12		1 Bayview Edison North	Removing existing culvert and gate; dispose offsite	0049 Removing d	EA	1.00	$ 830.00	$830
13		1 Bayview Edison North	Embankment compaction	0470	CY	779.30	$ 10.00	$7,793
14		1 Bayview Edison North	Common borrow incl. haul	0405	CY	767.40	$ 30.00	$23,022
	Bayview Edison South							
15		2 Bayview Edison South	Clearing & Grubbing	0025	AC	0.14	$ 20,000.00	$2,800
16		2 Bayview Edison South	High visibility silt fence	6635	LF	232.00	$ 7.50	$1,740
17		2 Bayview Edison South	Stabilized construction entrance	6468	SY	73.30	$ 28.00	$2,052
18		2 Bayview Edison South	Roadway excavation incl. haul	0310	CY	901.50	$ 20.00	$18,030
19		2 Bayview Edison South	Controlled density fill	7015	CY	23.70	$ 300.00	$7,110
20		2 Bayview Edison South	Common borrow incl. haul	0405	CY	878.00	$ 30.00	$26,340
21		2 Bayview Edison South	Heavy loose riprap	1076	CY	122.30	$ 75.00	$9,173
22			Embankment compaction	0470	CY	901.70	$ 10.00	$9,017
23		2 Bayview Edison South	Crushed surfacing base course in stockpile	0640	CY	233.00	$ 93.00	$21,669
24		2 Bayview Edison South	Construction geotextile for underground drainage	7550	SY	519.50	$ 4.22	$2,192
25		2 Bayview Edison South	New 5 ft Dia HDPE pipe		LF	488.00	$ 317.46	$154,920
26		2 Bayview Edison South	New 5 ft Dia side hinge tidegate		EA	8.00	$ 15,960.00	$127,680
27		2 Bayview Edison South	Temporary coffer dam		SF	715.00	$ 34.00	$24,310
	Farm to Market Road							
28		3 Farm To Market Road	Clearing & Grubbing	0025	AC	0.09	$ 20,000.00	$1,800
29		3 Farm To Market Road	High visibility silt fence	6635	LF	346.00	$ 7.50	$2,595
30		3 Farm To Market Road	Stabilized construction entrance	6468	SY	84.50	$ 28.00	$2,366
31		3 Farm To Market Road	Roadway excavation incl. haul	0310	CY	543.00	$ 20.00	$10,860
32		3 Farm To Market Road	Controlled density fill	7015	CY	11.90	$ 300.00	$3,570
33		3 Farm To Market Road	Heavy loose riprap	1076	CY	43.10	$ 75.00	$3,233
34		3 Farm To Market Road	Crushed surfacing base course in stockpile	0640	CY	125.50	$ 93.00	$11,672
35		3 Farm To Market Road	Construction geotextile for underground drainage	7550	SY	232.10	$ 4.22	$979
36		3 Farm To Market Road	New 4 ft Dia HDPE pipe		LF	238.00	$ 243.40	$57,929
37		3 Farm To Market Road	New 4 ft Dia side hinge tidegate		EA	5.00	$ 13,860.00	$69,300
38		3 Farm To Market Road	Temporary coffer dam		SF	207.00	$ 34.00	$7,038
39		3 Farm To Market Road	Removing existing culvert and gate; dispose offsite	0049 Removing d	EA	1.00	$ 830.00	$830
40		3 Farm To Market Road	Embankment compaction	0470	CY	396.90	$ 10.00	$3,969
41		3 Farm To Market Road	Common borrow incl. haul	0405	CY	385.00	$ 30.00	$11,550
	Other	4 Other						
42		4 Other	Construction survey		LS	1.00	$ 10,000.00	$10,000
43	Subtotal							$812,527
44	Mobilization @ 9%						9%	$73,000
45	**Total Construction Costs**							**$886,000**
46	Contingency					1	30%	$265,800
47	Total Construction Costs w/ contingency							**$1,151,800**
48	Construction Management					1	$ -	$0
49	TOTAL							**$1,151,800**

APPENDIX F

ALICE BAY TIDE GATE BASIS OF DESIGN REPORT

Northwest Hydraulic Consultants Inc.
301 W Holly Street #U03
Bellingham, WA 98225
Tel: 206.241.6000
www.nhcweb.com

NHC Reference 2002084

May 11, 2023

Skagit County Public Works
1800 Continental Place
Mount Vernon, WA, 98273

Attention: CJ Jones, Water Resources Project Manager
Via email: cjjones@co.skagit.wa.us

Re: **Skagit River Delta Flood Drainage Project**
Alice Bay Control Structure Replacement Basis of Design

1 INTRODUCTION

This document presents Skagit County Public Works (SCPW) with the design basis to replace the existing flow control structure located at Alice Bay along the Siwash Slough, near Edison, WA.

SCPW is seeking to improve existing water crossings within the Skagit Delta Drainage District to reduce maintenance related issues and support estuarine restoration outlined within the Skagit Delta Tidegates and Fish Initiative Implementation Agreement (STFI) developed by the Western Washington Agricultural Association (WWAA) in 2010. The Alice Bay control structure (District 5, ID 37) is one of thirty-eight sites controlled with tide gates identified as a candidate for replacement under the STFI. The sections below provide details of the design developed by Northwest Hydraulic Consultants Inc. (NHC) to replace the four-barrel control structure with a new single-opening structure that conforms with guidelines outlined in the STFI.

1.1 Scope of Work

The following scope of work was developed to complete the control structure replacement design:

- Conduct a field review to assess the site conditions and install a level logger to record tidal water levels that influence the hydraulic performance at the structure.
- Complete a geotechnical investigation at the site, including borehole drilling.
- Render survey data collected by PSE in 2018 into a digital elevation model (DEM).
- Estimate the hydraulics of the existing control structure to establish the baseline conditions.
- Develop a geometric configuration for the replacement control structure and analyze the hydraulics to verify design criteria and performance objectives are achieved.
- Develop Plans, Specifications & Estimate (PSE) final design package, including:

  - *Construction* drawings.
  - Summary of Quantities.
  - Planning Level cost estimate (+/- 25%).
  - Construction Specifications.
- Provide reference information for construction, including guidance on access, timing, reclamation and other recommendations.

1.2 Project Team

The project was initiated by the SCPW. NHC was the prime consultant and provided hydraulic design and project coordination to a multi-disciplined project team that included Dibble Engineers Inc. (Dibble), Geoengineers Inc. (Geoengineers), and Nehalem Marine (Nehalem). Dibble supported the project with structural design. Geoengineers provided geotechnical expertise completing ground investigations and geotechnical designs for the proposed structure and temporary cofferdam. Nehalem provided information for the side-mounted tide gate.

Table 1-1. Alice Bay Project Team

Organization	Name	Role
SCPW	CJ Jones	Water Resources Project Manager
	Michael See	Water Resources Section Manager
SCDIC	Jenna Friebel	Executive Director
NHC	Derek Stuart	Principal
	Aaron Blezy	Project Manager
	Vaughn Collins	Sr. Design Lead
	Evan Heitman	Hydraulic Modeler
Dibble	Beth Jensen	Structural Engineer
Geoengineers	Aaron Hartvigsen	Geotechnical Engineer
PSE	Adam Morrow	Geomatics Survey
Nehalem Marine	Leo Kuntz	Tide Gate Design and Supplier

1.3 Design Timeline

Key events occurring in the development of the design included:

- March 2021: 2018 base survey map issued by PSE.
- April 2021: Geotechnical Report (Draft) issued by Geoengineers.
- July 2021: NHC installs a hydrometric gauge to record tidal water levels downstream of the control structure.
- December 2021: Structural design drawings produced by Dibble are issued.
- December 2021: Coffer dam design drawings produced by Geoengineers are issued.
- July 2022: At the request of the SCPW, finalization of the design (opening size, bank armoring, tide gate) and development of the specification tender package were placed on hold to await a decision on if the culvert replacement would follow the clauses established in the STFI.

2 Site Description and Existing Conditions

Siwash Slough, also known as Connors Slough, is a tidally influenced channel on the Skagit Delta that drains agricultural farmland north into Alice Bay, a nested bay within the larger Samish Bay (Figure 2-1). The watercourse is without headwaters and has been significantly channelized, ditched and constrained by dikes. The mouth of the slough is located approximately 1.8 miles west of town of Edison, WA, and roughly 1.4 miles west of the mouth of Samish River. The flow control structure is located at the mouth and crosses the sea dike network on the delta immediately to the east of the Samish Sports Club (48°33'33.9"N 122°29'10.7"W).

The control structure drains approximately 1,549 acres[1] of the diked land through four 48-inch tide gates mounted to the downstream outlet of four corrugated fibreglass culverts projecting from the dike embankments downstream slope. The four tide gates are top-hinged and designed to open when the upstream water level is greater than the downstream water level. Dimensions of the culverts are provided in Table 2-1; photographs of the control structure are included in **Attachment A.**

The dike embankment crest at the control structure is roughly 20’ wide near elevation El. 12’ and is vegetated with grass. Concrete wingwalls at the outlet flank the outer culverts (#1 and #4) and extend 21’ downstream retaining earth along the lateral banks. On the bed, a concrete apron with unknown length provides scour protection at the outlet. The top elevation of the apron is near elevation El. -0.3’.

[1] WWAA, 2010 Table 4-2

Table 2-1. Alice Bay crossing culvert data

Culvert	Length (feet)	Diameter (inches)	Inlet Invert El. (feet)	Outlet Invert El. (feet)
#1	40.6’	40”	0.4’	0.9’
#2	40.7’	40”	0.9’	1.1’
#3	40.7’	36”	0.9’	1.8’
#4	41.7’	48”	0.8’	0.9’

1. Elevations are NAVD88.
2. Diameters as per PSE.
3. Culvert number increases from left bank to right bank (west to east).

The downstream dike embankment slope above the culvert outlets is slumping and has been surface-treated with loosely placed concrete rubble. On the left side of the channel above the west wingwall a single layer of 3’ (b-axis) riprap has been placed on the slope and extents approximately 38’ downstream of the culvert #1 outlet. The riprap is loosely placed, overly steepened (estimated at 1.2H:1V) perched up the slope near the embankment crest, and not keyed-in to the bank toe.

The channel downstream of the apron is generally 6’ deep with a flat, silty mud bottom that varies in width between 30’ and 50’ with invert near elevation El. 1.1’. The silts overlie a firm base that is resistant to penetration with a probe at El. -1.3’. This corresponds with a gray fine to medium sand with trace silt loose to medium dense alluvium documented in Geoengineers borehole log (Geoengineers, 2021). The left and right banks are vertically incised in the soft marsh silts and vegetated with marine grass.

Upstream of the control structure the slough channel has been straightened for roughly 1,750’ and parallels the sea dike/access road north to the Samish Sports Club. The straightened channel has flat silty bottom that is 30’ to 35’ wide. Banks are generally 12’ above the bed and slope at 1.4H:1V. Both banks are lightly vegetated with grass, brush and small deciduous tree stands; the top of the leftbank forms the access road prism that is topped with road mulch.

Capacity of the existing control structure was estimated using the FHWA’s HY-8 v7.5 software program. Analysis indicates that during low tide (El. 1.7’)[2] the soffits of the control structure culvert inlets surcharge at approximately 100 ft^3/s.

[2] Estimated based on unverified water level recordings collected by NHC with level logger between August 7 and September 25, 2021.

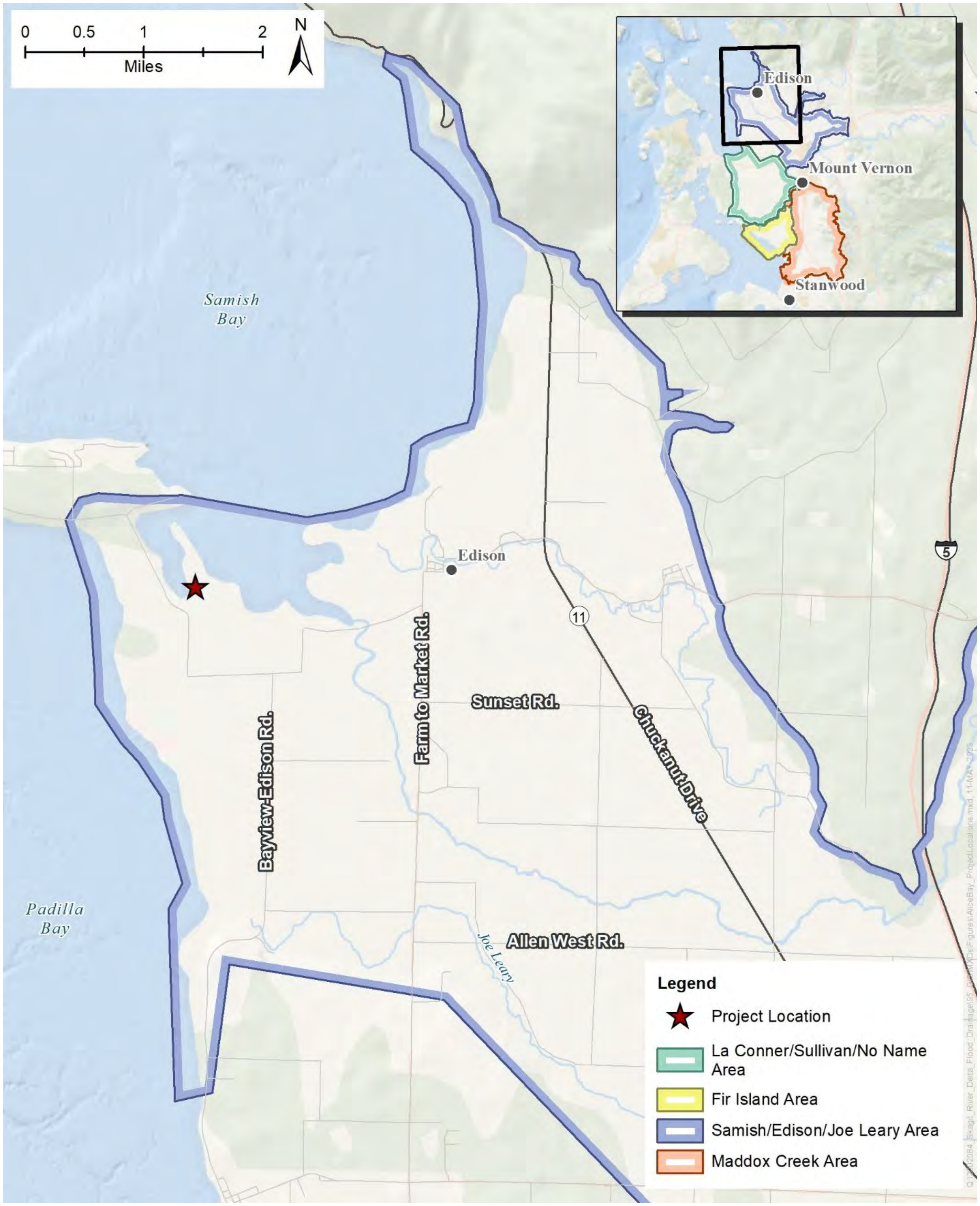

Figure 2-1 Samish Slough Catchment and Alice Bay Control Structure Location

3 DESIGN

The design objective is to replace the four existing culverts with a one single-opening control structure that adheres to the guidelines in the STFI. Specifically, the STFI outlines:

- the amount of new material required in the channel is less than 50 cubic yards.
- the overall footprint and function of the tide gate or floodgate structure will remain the same as the original.

Details of the design development for the control structure are provided in the sections below.

3.1 Guides, Standards and Codes

Design guides, standard methods, and codes used include:

- USACE Design and Construction of Levees Manual No. 1110-2-1913
- Channel bed and bank material specifications, thickness, and placement:
    - Aguirre-Pe et al.'s (2003) particle densimetric Froude Number method.
    - Blenches (1970) Flow Regime Equations for scour.
    - The United States Army Corps of Engineers' (USACE) methods presented by Maynord (1995).

3.2 Reference Materials

Previous studies, documentation, drawings and communications referenced as part of the design include:

- PSE Survey (2018075_Samish_Sports_Club_WC.dwg). Received by NHC on 05 March 2021 (**Attachment B**).
- Geoengineers Proposed Alice Bay Tidegate Replacement Geotechnical Report File No. 0220-106-00 - Draft (**Attachment C**).
- NHC 'Skagit River Delta Flood Drainage Project Flood Modeling, Mapping, and Mitigation Analysis' Report and associated hydraulic model. Dated May 10, 2023.

3.3 Criteria and Considerations

Criteria developed and adopted for the design include:

- The new structure shall have the same footprint and 37 ft^2 opening (equivalent to the combined area of the existing flow control structure)[3].
- Placement of new fill[3] below high tide in the channel is limited to 50 cubic yards.
- Minimum Gross Vehicle Weight Limit rating of 55,000 lbs.
- The crest width shall be a minimum 15.0' wide.
- Crest elevation established at El. 14.0' to allow for future dike raising to adapt to increase in sea level.
- the water surface profile in the upstream channel should not be adversely affected.

The design and lay-out must also consider construction equipment weights and operational limitations during construction.

A specific design discharge was not applied as part of the design for the replacement control structure. This was based on preserving the combined cross-sectional area of the existing control structure making design tied to a specific return period event not necessary.

3.4 Hydraulics

The design approach adopted the following procedure:

1. Model the existing conditions to determine the baseline hydraulic performance.
2. Develop a geometric configuration for the control structure in AutoCAD Civil3D©
3. Verify the hydraulic performance of the proposed configuration by:
    a. analyzing the geometry in HY-8.
    b. grafting the geometry into the HECRAS model mesh and simulate various 100-year Skagit River Dike Breach scenarios (located at Sterling, West Mt Vernon and the North Fork).

3.4.1 Analysis

Hydraulics analysis of the proposed configuration using HY-8 indicates at low tide, water levels in the upstream slough will surcharge the culvert inlet soffit (El. 4.5') when the flow is approximately 200 ft^3/s.

The US Army Corps of Engineers (USACE) HEC-RAS numerical modeling software program (v5.2) was also used to model the 100-year dike breach scenarios and evaluate the design geometry. Full details of the model development including assumptions, limitations, results, and inundation duration difference maps are provided in NHC (2023). A summary of the inundation durations at various locations within the drainage area for a dike breach considered likely during a 100-year Skagit River flood are summarized in

[3] stipulated in the initiative (WWAA, 2008)

Table 3-1. Generally, results indicate a moderate decrease in the inundation-duration throughout the drainage area.

Table 3-1. Summary of Mitigation Measure Performance (100-year breach scenario) for Samish/Edison/Joe Leary Area. Values in parenthesis show percentage difference in inundation duration.

Roadway Location	Average inundation duration (days)		Average difference in inundation duration
	Base (existing condition)	Proposed Geometry	
Bayview Edison Road (From Samish Island Road intersection, south to Leary)	7.1	6.8	-0.3 (-3.6%)
Bayview Edison Road (From Samish Island Road, east to Farm to Market Road	6.3	6.1	-0.2 (-2.4%)
Farm to Market Road (From Edison, south to high ground south of Allen West Road)	2.5	2.5	0.0 (0.0%)
Chuckanut Drive (From Bow Hill Road, south to Interstate-5	1.3	1.3	> -0.05 (-0.3%)
Allen West Road (From Farm to Market Road to Chuckanut Drive)	1.5	1.5	0.0 (0.0%)
Sunset Road (From Farm to Market Road to Chuckanut Drive)	0.7	0.7	< +0.05 (0.2%)

3.5 Geometric Configuration

General arrangement plans, profiles and sections of the proposed control structure are included in **Attachment D**. The geometry is highlighted by the following:

- The structure is a 17’ long cast-in-place box culvert with 8’ x 4.5’ inlet and outlet openings
- Inlet and outlet inverts at El. 0.0’
- Top of structure elevation at El. 14.0’
- 1.0’ x 1.0’ high curbs at the upstream and downstream headwall.
- 15.0’ wide driving surface on top of the structure.
- 18’.0 long tapered inlet and outlet wingwalls splayed at 45˚ for lateral earth retention.
- The outlet headwall is tapered at a 0.033H:1V vertical slope for tidal gate operation.
- A 20’ long pad at El. -1.6’ for scour protection.
- Banks re-graded at a 2H:1V slopes.

The proposed configuration allows the control structure opening to be expanded should increasing the capacity be desired. This would be completed by cutting the inlet and outlet soffits to a higher elevation or incorporating removable metal plates at the soffits.

4 CONSTRUCTION

4.1 Materials

Material types, including cofferdam, fills, and concrete, are provided in Geoengineers geotechnical document (**Attachment C**), cofferdam design drawings (**Attachment E**) and structural design drawings prepared by Dibble (**Attachment F**).

Nehalem Marine makes custom-order gates to suit each individual structure and has suggested a NSRG4.5x8oc tide gate as a suitable assembly at Alice Bay. This should be confirmed prior to procurement.

4.2 Quantities

Quantity estimates of excavations and fill placements have been generated using Civil3D® 2023. Dike material extracted during the culvert removal may be re-used if deemed suitable by a geotechnical professional reviewing the material; augmenting this material may be necessary depending on the volume determined during construction. Overall, an estimated 1,000 cubic yards are anticipated to be excavated to facilitate removal of the existing structure, install the cofferdam, and construct the new control structure.

Estimated quantities for key design elements are summarized in Table 4-1. Detailed quantities and cost estimate are included as **Attachment G**.

Table 4-1. Summary of Quantities for key design elements

Parameter	Quantity
Excavation	1,400 cubic yards
Cast-in-place Concrete	145 cubic yards
NSRG4.5x8oc Tide Gate	1 Unit
Base material	40 cubic yards
Supplemental Dike Fill	Dependent on contractor approach and re-use of existing materials on-site

1. Should be confirmed prior to purchase.

4.3 Logistics and Construction Considerations

General site access to the work area is proposed via the unnamed road to the Samish Sports Club. The area to the east of the site provides space for equipment and material laydown, temporary stockpiling, and office and trailer staging.

Clearing and hazard tree removal are not anticipated with this work. Some stripping of organics, road mulch and riprap will be needed. These should be salvaged and temporarily stockpiled for re-use during reclamation. Concrete rubble identified on the downstream embankment slope should be removed from site and disposed of at a suitable location. The riprap on the downstream left bank can be salvaged for other uses.

Construction activities that include excavation activities or equipment operation below high-water line are anticipated to be limited by permitting agencies from August 1 through October 15 (WWAA, 2008). The temporary cofferdam shall be installed prior to initiating any excavation activity below the high-water line to isolate the project site from the watercourse.

Areas that are disturbed by the work should be reclaimed as per District operational and maintenance requirements and protocols.

4.4 Cost Estimate

An estimated construction cost based on estimated quantities is included in **Attachment G**. The estimate is limited to probable construction costs and does not include expenses such as reporting, engineering inspection or contract administration. The estimate is limited to materials and construction costs and does not include miscellaneous expenses such surveys, mobilization, reporting, engineering inspection or contract administration. The cost estimate does not include the costs to transport and place excess soils generated from the excavations off-site. As part of the estimate, the follow assumptions have been made:

- Construction would be performed over a 6-week period.
- Labor, equipment and materials would be tendered to local contractors and suppliers, limiting time of travel to approximately 1 hour.
- Salvage and disposal prices of waste material are not included.
- The estimates assume that material quantities derived are within ±25%.

4.5 Recommendations

The slough soils are soft and susceptible to erosion. Armoring the upstream and downstream slough banks with riprap is recommended to protect the soils as part of the implementation of the project. Armoring should be keyed-in at the toe of slope and upstream and downstream terminals of the armour in a layer thickness and gradation determined by a hydrotechnical professional. This detail was not finalized due to the limitation of placing new fill below high tide, limited to 50 cubic yards of new fill. Once the SDIDC has a decision if the culvert replacement will follow STFI, this detail along with the size of the opening can be finalized.

5 CLOSURE

We hope this report meets your requirements. Please feel free to contact me to discuss further for additional detail or information.

Report prepared by:

Aaron Blezy, PEng (BC)
Associate | Hydrotechnical Engineer

Under the direct supervision of:

5/10/2023

Vaughn Collins, PE (WA)
Principal

Enclosure:

- ATTACHMENT A, Photographs
- ATTACHMENT B, PSE Base Survey
- ATTACHMENT C, Geotechnical Report
- ATTACHMENT D, General Arrangement Drawings
- ATTACHMENT E, Cofferdam Design Drawings
- ATTACHMENT F, Stuctural Design Drawings
- ATTACHMENT G, Cost Estimate

DISCLAIMER

This report has been prepared by **Northwest Hydraulic Consultants Inc.** for the benefit of **Skagit County Public Works** for specific application to the **Skagit River Delta Flood Drainage Project.** The information and data contained herein represent **Northwest Hydraulic Consultants Inc.** best professional judgment in light of the knowledge and information available to **Northwest Hydraulic Consultants Inc.** at the time of preparation and was prepared in accordance with generally accepted engineering and geoscience practices.

Except as required by law, this report and the information and data contained herein are to be treated as confidential and may be used and relied upon only by **Skagit County Public Works**, its officers and employees. **Northwest Hydraulic Consultants Inc.** denies any liability whatsoever to other parties who may obtain access to this report for any injury, loss or damage suffered by such parties arising from their use of, or reliance upon, this report or any of its contents.

6 REFERENCES

Aguirre-Pe, et J. Olivero, M.L. and Moncada, A.T. 2003. Particle Densimetric Froude Number for Estimating Sediment Transport. Journal of Hydraulic Engineering, 126 (6), 428-437.

Geoengineers. 2021. Proposed Alice Bay Tidegate Replacement Geotechnical Report – Draft (File No. 0220-106-00).

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Flood Modeling, Mapping, and Mitigation Analysis. Prepared for Skagit County Public Works.

Skagit River System Cooperative. 2020. Skagit Basin Barrier Culvert Analysis: Public and Private Stream Crossings.

Skagit River System Cooperative and Washington Department of Fish and Wildlife. 2005. Skagit Chinook Recovery Plan. La Conner, Washington.

Western Washington Agricultural Association. 2010. Skagit Delta Tidegates and Fish Initiative Implementation Agreement.

ATTACHMENT A

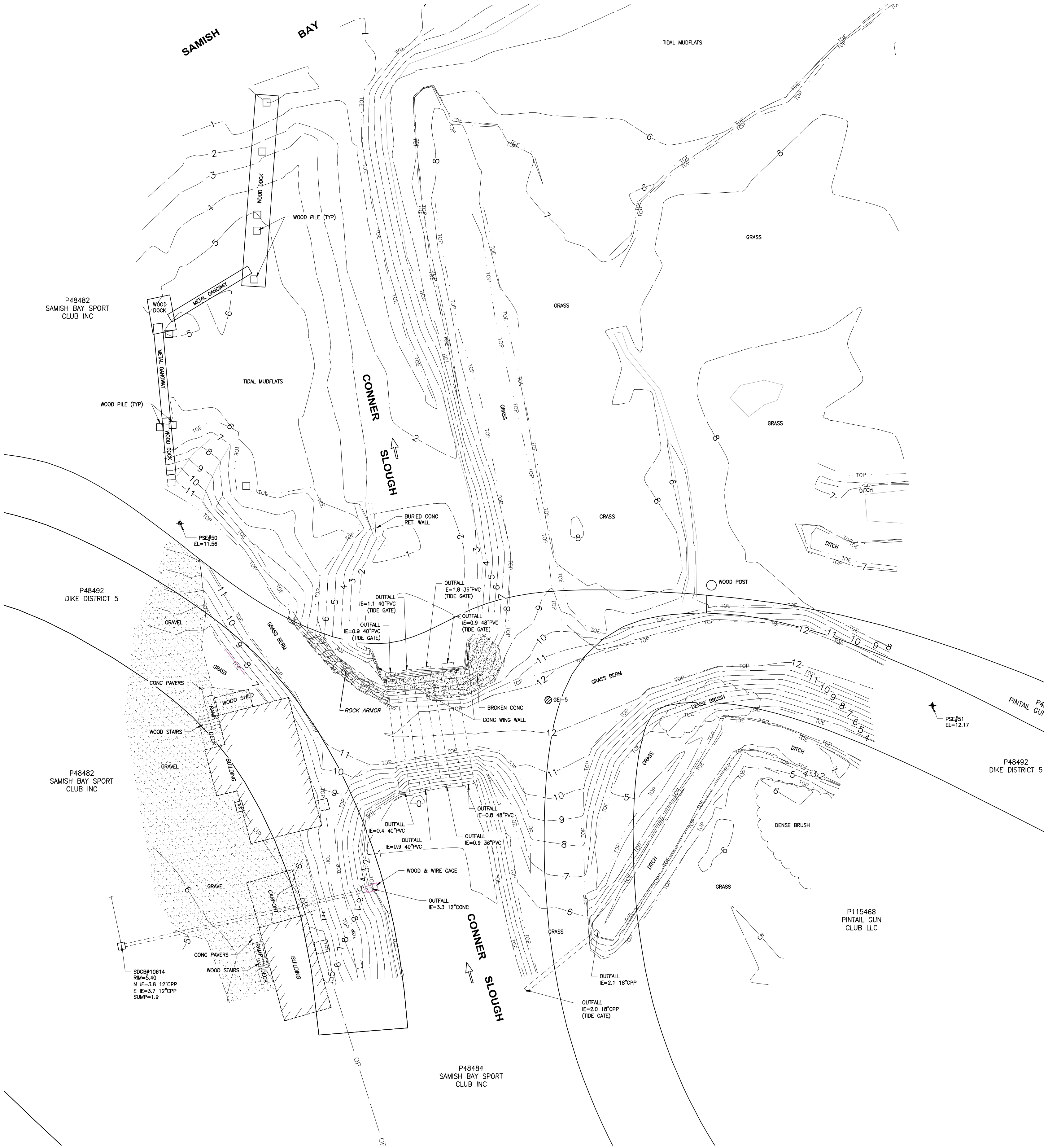
Photographs

Photo 1. Alice Bay Control Structure Outlet (viewing from the leftbank towards the right bank)

Photo 2. Alice Bay downstream of the control structure outlet

ATTACHMENT B

PSE Base Survey



SURVEYOR'S NOTES:

1. DATA FOR THIS SURVEY WAS GATHERED BY FIELD TRAVERSE UTILIZING ELECTRONIC DATA COLLECTION IN AUGUST 2018.
2. EQUIPMENT USED: THEOMAT 00'01.5" +/- 1 PPM, +/- 2 MM
   TOPCON GR3 GPS RECEIVERS
3. HORIZONTAL DATUM: NAD 83/91 WASHINGTON STATE PLANE NORTH ZONE
4. VERTICAL DATUM: NAVD 88
   BENCHMARK: NGS BENCHMARK "R455 RESET" ELEV=35.65'
5. CONTOURS ARE DEPICTED AT 1-FOOT INTERVALS AND ARE DERIVED FROM GROUND SURVEY DATAPOINTS GATHERED BY PSE FIELD CREWS IN 2018. LOCATION OF AND SURVEY INFORMATION FOR UTILITIES AND OTHER STRUCTURES SHOULD BE FIELD VERIFIED PRIOR TO CONSTRUCTION.
6. NO UNDERGROUND UTILITY LOCATIONS WERE REQUESTED. PSE DOES NOT ACCEPT RESPONSIBILITY FOR THE LOCATION OF UTILITIES THAT WERE NEITHER VISIBLE NOR PAINTED ON THE GROUND AT THE TIME OF THE SURVEY. CONTRACTOR SHOULD VERIFY LOCATION OF UTILITIES PRIOR TO ANY SITE DISTURBANCE.
7. PARCEL AND RIGHT OF WAY LINES ARE SHOWN PER AVAILABLE SKAGIT COUNTY G.I.S. RECORDS. PARCEL OWNERSHIP INFORMATION SHOWN PER SKAGIT COUNTY ASSESSOR RECORDS AS OF AUGUST 22, 2018. NO BOUNDARY SURVEY WAS PERFORMED FOR THIS PROJECT AND NO TITLE REPORTS WERE PROVIDED.

PRIMARY SURVEY CONTROL TABLE

POINT NO.	NORTHING	EASTING	ELEVATION	DESCRIPTION
50	573189.4289	1240082.2968	11.56	SET #4 REBAR W/ ORANGE PLASTIC CAP
51	573128.1249	1240335.4650	12.17	SET #4 REBAR W/ ORANGE PLASTIC CAP

SYMBOLS:

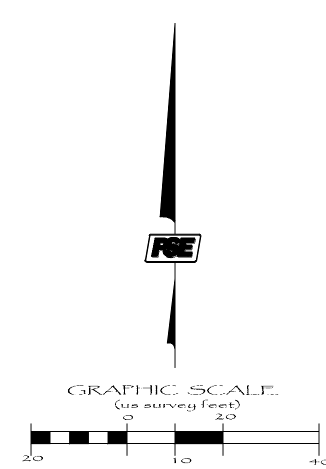
- CONTROL POINT
- BORE HOLE
- POST
- POWER POLE
- POWER METER
- CATCH BASIN

LINETYPES:

- CONCRETE EDGE
- GRAVEL EDGE
- DITCH CENTERLINE
- DITCH TOP/TOE
- BUILDING FOOT
- MAJOR CONTOUR
- MINOR CONTOUR
- CULVERT
- BLOCK/CONCRETE WALL
- OVERHEAD POWER
- DRAIN

ABBREVIATIONS:

CONC	CONCRETE SURFACE
CPP	CORRUGATED POLYETHYLENE PIPE
IE	INVERT ELEVATION
NTS	NOT TO SCALE
OHW	ORDINARY HIGH WATER MARK
PSE#	PACIFIC SURVEYING & ENGINEERING CONTROL POINT NUMBER
PVC	POLYVINYL CHLORIDE PIPE
RET.	RETAINING
SDCB	STORM DRAIN CATCH BASIN
SF	SQUARE FOOT
TOE	TOE OF SLOPE
TOP	TOP OF SLOPE
TYP	TYPICAL



3-5-2021

ADAM SCOTT MORROW
STATE OF WASHINGTON
40565
REGISTERED PROFESSIONAL LAND SURVEYOR

SKAGIT COUNTY
PUBLIC WORKS
1800 CONTINENTAL PLACE
MOUNT VERNON, WA 98273-5625
(360) 336-9400 FAX (360) 336 9478

NO.	REVISIONS	DATE

DESIGN ENGINEER

ENGINEER OF RECORD

PROJECT NO.: ####
FED. AID NO.: ####
DESIGNED BY: ####
DRAWN BY: JAM
CHECKED BY: ASM
APPROVED BY:

PROJECT LOCATED NEAR:
SIWASH SLOUGH
31-36-4E

SAMISH SPORTS CLUB
FOR NORTHWEST
HYDRAULIC CONSULTANTS

EXISTING CONDITIONS

1 INCH SCALE BAR
ADJUST SCALE ACCORDINGLY

SHEET
1 OF 1

AMORROW - March 5, 2021 - 4:06 PM - P:\PSE PROJECT\2018075\DWGS\2018075_SAMISH_SPORTS_CLUB_WC.DWG

ATTACHMENT C

Geotechnical Report

Geotechnical Engineering Services

Proposed Alice Bay Tidegate Replacement
Skagit County, Washington

for
Northwest Hydraulic Consultants, Inc.

December 30, 2022

GeoEngineers
Earth Science + Technology

Geotechnical Engineering Services

Proposed Alice Bay Tidegate Replacement
Skagit County, Washington

for
Northwest Hydraulic Consultants, Inc.

December 30, 2022

GeoEngineers

554 West Bakerview Road
Bellingham, Washington 98226
360.647.1510

Geotechnical Engineering Services

Proposed Alice Bay Tidegate Replacement
Skagit County, Washington

File No. 0220-106-00

December 30, 2022

Prepared for:

Northwest Hydraulic Consultants, Inc.
12787 Gateway Drive South
Seattle, Washington 98168

Attention: Derek Stuart, PE

Prepared by:

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554 West Bakerview Road
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Aaron Hartvigsen, PE
Geotechnical Engineer

Sean Cool, PE
Principal

AARON J HARTVIGSEN
STATE OF WASHINGTON
46948
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12/30/2022

MWR:AJH:JRG:SWC:leh

GeoEngineers

Table of Contents

1.0 INTRODUCTION AND BACKGROUND

This report presents the results of GeoEngineers, Inc.'s (GeoEngineers') geotechnical engineering services for the proposed Alice Bay Tidegate Replacement project in Skagit County, Washington. This submittal is based on experience working on similar projects, discussion with Northwest Hydraulic Consults, Inc. (NHC), information provided by the Skagit Drainage and Irrigation District Consortium, and our knowledge of the area. The general location of the site is shown in the Vicinity Map (Figure 1). The proposed tidegate location and existing site conditions are shown in the Site and Exploration Plan (Figure 2).

The site is located in the lowland area where Skagit Valley meets the Salish Sea. The tidegate prevents tidal waters from entering the Siwash Slough, which discharges between Alice Bay and Samish Bay approximately 1,500 feet east of Samish Island Road. The soils consist of levee fill over a significant depth of alluvium, which includes loose sand. The surficial conditions consist of a gravel access road/trail constructed on a dike running east-west crossing the outlet of an irrigation canal with the Sammish Bay Sports Club to the west of the dike and fields to the east. Based on survey information available (Figure 2), the existing earthen dike is approximately 15 feet wide with a crest elevation of approximately 12 feet (NAVD88). Existing structures include four culverts ranging from 36-inch to 48-inch diameter and the north face of the dike is protected by a concrete bulkhead, wingwalls, and a portion of the slope along the upper north west edge is lined with rock armor.

We understand that the existing culverts will be replaced by a new cast-in-place (CIP) concrete tidegate structure. The tidegate is a structural box with a closing door or hatch. CIP concrete wingwalls are located at each end to restrain the dike embankment soils. We assume that the invert elevation of the structure will be constructed at about Elevation 0 to -2 feet (NAVD88) to allow drainage of the slough at low tide. The top elevation of the tidegate structure is undetermined at this time. The typical construction practice is to install temporary sheet pile shoring, with any necessary dewatering during construction. We anticipate that the preferred method for addressing pass-through seepage concerns is to backfill around the structure with on-site or imported impermeable backfill materials as much as practical.

The critical geotechnical considerations for the proposed site development include settlement and bearing support for the tidegate structure, seepage around the structure, and temporary shoring and dewatering for the project construction. The purpose of our geotechnical engineering services is to explore subsurface conditions at the site as a basis for developing geotechnical conclusions and recommendations for the proposed tidegate installation based on the understanding provided above. The scope included drilling two geotechnical borings and reviewing a previous nearby boring, completing laboratory testing on samples obtained from the recent explorations, performing engineering analyses, and preparing this report. The original scope of work is described in our proposal for the project dated January 12, 2021 and authorized Derek Stuart of NHC on January 12, 2021.

2.0 SITE CONDITIONS

2.1. Surface Conditions

The site is located in the lowland of western Skagit County where the Siwash Slough discharges to Alice Bay and Samish Bay. The overall topography is relatively level and topographic features are related to the slough and dike embankment. The site is vegetated with grass, brush and gravel surfaced trail. The dike geometry is described previously in the Introduction section above. We did not observe any indications of slope instability or seepage along the dike while we were on-site. The site is bordered by farmland to the east and a few single-story structures as part of the sports club to the west.

2.2. Geology

We reviewed a United State Geological Survey map for the project area, "Geologic map of the Bow and Alger 7.5 Minute Quadrangle Western Skagit County, Washington" by Dragovich et al. (1998). Soil deposits in the site area are mapped as Quaternary Alluvium. Quaternary Alluvium consist of water driven sedimentary deposits and are typically a mix of silt and sand with varying gravel and clay. Organic material is also common in the alluvial deposits.

2.3. Subsurface Explorations

Subsurface soil and groundwater conditions were evaluated by advancing two geotechnical borings (GEI-1 and GEI-2) at the site using a track-mounted drill rig subcontracted to GeoEngineers on February 12, 2021. The borings were completed to depths between 41½ to 51½ feet below the existing ground surface (bgs). The approximate locations of the borings are shown in Figure 2. Details of the field exploration program, laboratory testing, and the boring logs are presented in Appendix A.

2.4. Previous Studies

As part of this evaluation, GeoEngineers' reviewed available geotechnical information completed for other nearby projects. The following reports and plans containing geotechnical information, logs of explorations, were reviewed as part of this study:

- GeoEngineers, Inc. "Geotechnical Engineering Services, Samish River Floodgates, Skagit County, Washington." August 1, 2018.

The location of pertinent exploration (B-4) is shown in Figure 2 and the boring log is presented in Appendix B.

2.5. Subsurface Conditions

The borings were advanced from the top of the levee. Subsurface soil conditions generally consisted of fill from the existing levee embankment overlying fine to medium sand with silt alluvium deposits to the full depth explored.

The fill for the existing levee embankments consisted of very soft to medium stiff silt with sand and organic matter. Fill typically extended to a depth of approximately 12½ to 13½ feet bgs. The fill has low to moderate strength and high compressibility characteristics.

Alluvium deposits were encountered below the fill soils. In general, the alluvium deposits consisted of loose to medium dense poorly sorted sands with trace silt. Alluvium deposits continued to the full depth explored of 41½ to 51½ feet bgs. The alluvium has moderate strength and compressibility characteristics and is also highly susceptible to liquefaction.

2.5.1. Groundwater Conditions

Groundwater monitoring wells/piezometers were not installed. During drilling, groundwater was encountered at approximately 12 to 13 feet bgs, which is at the dike embankment fill/native near-shore deposit interface. Groundwater conditions should be expected to vary as a function of season, precipitation, slough level, tides, and other factors.

3.0 CONCLUSIONS AND RECOMMENDATIONS

We conclude that the proposed tidegate structure may be supported by a mat foundation over a layer of geogrid reinforced foundation material. A summary of the primary site preparation, design, and construction considerations for the proposed project is provided below. The summary is presented for introductory purposes only and should be used in conjunction with the complete recommendations presented in this report.

- We anticipate that the excavation for foundation support of the tidegate will remove the existing levee fill and expose the saturated sandy alluvial soils. It should be noted that this soil will be easily disturbed by equipment and may experience heave upon removal of overburden without appropriate dewatering. Settlement is anticipated to occur quickly as loading occurs.
- A Site Class E in accordance with the 2018 International Building Code (IBC) is appropriate for design due to the soft/loose soils encountered underlying the site.
- The site soils have a high potential for liquefaction during the design earthquake. No mitigation is recommended because of the regional extent of liquefaction potential and the expense of such mitigation is typically not considered feasible for these types of projects.
- The proposed tidegate structure is designed with what serves as a mat foundation. We recommend a minimum 2 feet of foundation material to support the tidegate structure. The foundation material should consist of crushed rock with a layer of geogrid. This will also facilitate pumping of surface water and shallow groundwater out of the excavation.
- The construction for tidegates in this environment has typically occurred within an enclosed cofferdam of continuous sheet piles. A design will be prepared under separate submittal by GeoEngineers. Because no aquitard was encountered at the site, dewatering will be necessary to lower the water table and stabilize the base of the excavation.
- The sides of the tidegate structure should be backfilled with imported low permeability dike embankment material that is properly moisture conditioned and compacted.
- We recommend that anti-seepage barriers be implemented in the design to reduce seepage around and beneath the tidegate structure. We anticipate this will consist of a combination of sheet piles and controlled density fill (CDF).
- The embankment soils encountered at the site have an elevated fines content and the native soils expected at the foundation level are loose to medium dense sands that will be easily disturbed. Wet weather trafficability will be very poor. We recommend that earthwork occur during dry summer months to reduce earthwork and dewatering costs.

3.1. Seismic Considerations

3.1.1. Seismic Hazards

We evaluated the site for seismic hazards including liquefaction, lateral spreading and fault rupture. Our evaluation indicates the saturated alluvial deposits are highly susceptibility to liquefaction as discussed in detail below. The foundation soils have a low risk of lateral spreading since the intertidal area is relatively level. The proposed project will result in an improved localized stability at the tidegate location. The levee embankment itself, similar to most of the historical levees in this area, is oversteepened and at risk of instability during an earthquake; however, assessment and mitigation for this potential risk is not within the scope of this project and generally not considered feasible in these situations. Based on United States Geological Survey (USGS) maps of active faults in the Puget Sound region, there are mapped faults within 2 miles of the Project area. Since there are no mapped faults in the immediate vicinity of the project area, it is our opinion that there is a low risk of fault displacement resulting in ground rupture at the surface.

3.1.2. 2015 IBC Seismic Design Information

We expect that the project will use the 2018 IBC. The 2018 IBC references the 2016 Minimum Design Loads for Buildings and Other Structures (ASCE 7-16). Per American Society of Civil Engineers (ASCE) 7-16 Section 11.4.8, a ground motion hazard analysis or site-specific response analysis is required to determine the design ground motions for structures on Site Class E sites with S1 greater than or equal to 0.2g. For this project, the site is classified as Site Class E with an S_1 value of 0.353g; therefore, this provision applies. Alternatively, the parameters listed in Table 1 below may be used to determine the design ground motions if Exceptions 1 or 3 of Section 11.4.8 of ASCE 7-16 are used. T represents the fundamental period of the structure and T_S=0.74 sec. Exception should be determined by the structural engineer.

TABLE 1. MAPPED 2018 IBC SEISMIC DESIGN PARAMETERS

Seismic Design Parameters	Recommended Value [1]
Site Class	E
Mapped Spectral Response Acceleration at Short Period (S_S)	1.055g
Mapped Spectral Response Acceleration at 1 Second Period (S_1)	0.373g
Site Modified Peak Ground Acceleration (PGA_M)	0.585g
Site Amplification Factor at 0.2 second period (F_a)[2]	1.2
Site Amplification Factor at 1.0 second period (F_v)[2]	2.508
Design Spectral Acceleration at 0.2 second period (S_{DS})[2]	0.844
Design Spectral Acceleration at 1.0 second period (S_{D1})[2]	0.623

Notes: [1] Parameters developed based on Latitude 48.559° and Longitude -122.486° using the ATC Hazards online tool.
[2] See ASCE 7-16 Section 11.4.8, applicable for Exception 1. If exception 3 is used the equivalent static force procedure should be used to develop seismic parameters.

3.1.3. Liquefaction Potential

Liquefaction is a phenomenon where soils experience a rapid loss of internal strength as a consequence of strong ground shaking. Ground settlement, lateral spreading, and/or sand boils may result from liquefaction. Structures supported on liquefied soils could suffer foundation settlement or lateral movement that could be severely damaging to the structures. Conditions favorable to liquefaction occur in loose to medium dense, clean to moderately silty sand that is below the groundwater level. Dense soils/bedrock or soils that exhibit cohesion are generally considered not to be susceptible to liquefaction.

The evaluation of liquefaction potential is complex and is dependent on numerous site parameters, including soil grain size, soil density, site geometry, static stresses, and the magnitude and ground acceleration of the design-level earthquake. Typically, the liquefaction potential of a site is evaluated by comparing the cyclic shear stress ratio (the ratio of the cyclic shear stress to the initial effective overburden stress) induced by an earthquake to the cyclic shear stress ratio required to cause liquefaction.

Our analysis indicates that the saturated granular near-shore deposits have a high potential for liquefaction during the design earthquake. The liquefaction will occur over a broad area beyond the project limits. The anticipated settlement (greater than 1 foot) is not tolerable for structures on conventional isolated spread footings. Use of a monolithic structural mat foundation will bridge isolated areas of settlement and is considered sufficient mitigation for this type of structure. These structural mats are typically 12 to 18 inches thick with top and bottom steel reinforcement layers.

Sand boils and localized loss of ground support can also occur in the saturated sand. However, the recommended structural fill zone with geogrid reinforcement and the monolithic structural mat will bridge any ground loss and provide adequate foundation support. As previously mentioned, ground subsidence of the site and surrounding area will occur as a result of a large design earthquake. The settlement to the actual tidegate structure could be fully mitigated by either (a) pile supporting the structure or (b) performing ground improvements such as vibroreplacement (stone columns); however, this would result in differential movement between the tidegate structure and the levee that likely would result in a more damage to its functionality than “floating” the structure on the reinforced structural fill mat. Therefore, we conclude that no additional mitigation is warranted.

3.2. Tidegate Structure Foundation and Seepage Controls

We expect that the base of the tidegate structure will be founded at approximately Elevation 0 to -2 feet. The result of our subsurface exploration indicates that the foundation excavation will expose loose to medium dense sand with trace silt. Stabilization of the base will be required to facilitate construction, which we recommend be accomplished by placing 2 feet of a rock foundation material as described below. Adequate seepage control around the structure is critical.

3.2.1. Seepage Considerations

The anti-seepage barriers increase the potential flow path for water to travel around the structure thereby reducing the risk of piping. Based on experience, the preferred method to address seepage concerns around the sides of the tidegate structure is to backfill around the structure with low permeability embankment material. We recommend a minimum 4-foot thickness (perpendicular to the levee) of low permeability soil against the tidegate structure extending into the existing dike embankment to serve as a seepage barrier along the length of the structure. If only 4 feet of low permeability material will be used, we recommend it be located near the middle of the tidegate structure and extend at least 2 feet into the existing levee material. The results of our laboratory testing of the levee soils indicates that the existing levee material has a moisture content significantly greater than the optimum moisture content to achieve adequate compaction; therefore, we conclude that the existing levee material will be unsuitable and recommend importing a low permeability soil as described in Embankment Fill in Section 3.6.1. Alternatively, 4 feet of CDF could be used. We recommend that a sheet pile cutoff wall be installed that connects to the poured footing. We recommend that a 10 foot long sheet pile wall extend below the middle of the proposed tide gate.

3.2.2. Foundation Support

The base of the foundation excavation to construct the reinforced structural fill section excavation will expose saturated loose sand. Dewatering will be required at the base of the excavation to prevent basal heave and provide subgrade stability as discussed in a subsequent section of this report. We recommend that the foundation support consist of the following:

- Woven fabric for stabilization with a minimum 200-pound tensile strength in accordance with ASTM International (ASTM) D 4632 (Mirafi HP270 or equivalent) placed over the native sand subgrade.
- A foundation layer consisting of at least 24 inches of a rock product such as: crushed surfacing base course (CSBC) per Washington State Department of Transportation (WSDOT) Standard Specification 9-03.9(3); quarry spalls per WSDOT Standard Specification 9-13.1(5) or permeable ballast per WSDOT Standard Specification 9-03.9(2).
- Placement of a layer of geogrid at the middle of the crushed rock layer.
    - The geogrid should be a biaxial geogrid such as Tensar BX 1200 or equivalent.

We recommend that the foundation material be compacted to a firm condition with a backhoe-mounted vibratory plate, a moderate sized drum roller, or uniformly tamped with the bottom of the excavator bucket. We recommend that we observe the foundation soils prior to placing the foundation material. Although not observed in available subsurface information, if organic or very soft conditions are encountered, overexcavation and replacement with additional foundation material may be appropriate.

For a mat foundation founded as described above, we recommend a maximum allowable pressure of 2,500 pounds per square foot (psf) for the base of the structure. This value may be increased up to ⅓ for wind or seismic loads without inducing significant additional settlement. A modulus of subgrade reaction of 50 pounds per cubic inch (pci) can be used for design of reinforcement.

3.2.3. Settlement Considerations

We expect that the load across the mat foundation will not exceed the weight of the fill embankment material that will be removed to construct the tidegate. We estimate that less than 1 inch of settlement will occur. Differential settlement across the width of the mat foundation is estimated to be less than ½ inch. Settlement will occur quickly (as loading occurs) due to the granular foundation soils.

3.2.4. Lateral Earth Pressures

The side walls of the tidegate structure will act as retaining walls and should be designed for at-rest earth pressures using an equivalent fluid density of 95 pounds per cubic foot (pcf) calculated from the top of the levee. This value is based on the assumptions that: (1) the walls will be restrained against rotation when the backfill is placed; (2) the backfill surface is level behind the wall; and (3) the wall backfill may become saturated. If the walls are free to rotate and backfilled prior to placement of the lid, then it may be appropriate to design the walls with the active earth pressure presented below.

We recommend that a uniform traffic surcharge of 75 psf be included in the design for limited traffic loading. We recommend a uniform lateral seismic load of 8H be included in design. Additional surcharge loads should be considered as appropriate. These lateral loads will be resisted by the structural strength of the concrete.

Additional construction surcharge loads should also be considered based on the temporary usage of the adjacent levees as working pads for heavy equipment such as cranes.

3.2.5. Wing Walls

We anticipate that some of the wingwalls of tidegate structure will be unrestrained and should be designed for active earth pressures using an equivalent fluid density of 85 pounds pcf calculated from the top of the roadway. This value is based on the assumptions that: (1) the walls will be unrestrained against rotation when the backfill is placed; (2) the backfill surface is level behind the wall; and (3) the wall backfill may become saturated.

3.2.6. Scour Protection

Scour protection should be in accordance with any recommendations provided by the project hydraulic engineer, if appropriate.

3.3. Excavations

All excavations and other construction activities must be completed in accordance with applicable city, county, state and federal safety standards. The on-site soils can be excavated using conventional earthmoving equipment. The subgrade will be susceptible to disturbance which could be reduced by use of smaller or low ground pressure equipment. The deep excavation is subject to Washington State Administrative Code (WAC) 296-155, Part N. In this case, temporary shoring will be accomplished with contiguous sheet piles as discussed in Section 3.4.

3.4. Temporary Shoring

Construction of the tidegate structure will require the excavation to be shored because of the depth of the excavation and the presence of saturated sand. We anticipate the use of sheet piles for temporary shoring of the excavation. The subsurface profile lacks a low permeability hydraulic cutoff layer to embed sheet piles and effectively cut off groundwater flow into the excavation. Temporary shoring using internal bracing can be designed using active soil and hydrostatic pressures as provided in Figure 3.

GeoEngineers will provide cofferdam/sheet pile design for the project when adequate tidegate design information is available. The design drawings will be submitted under separate cover for permitting and bidding purposes.

3.5. Basal Heave and Construction Dewatering

3.5.1. Basal Heave

The shoring system should consider basal heave with regard to the required depth of sheet piling and dewatering method and execution. If soil and water pressures inside and outside of the shored excavation are imbalanced, it may result in instability of the base of the excavation, and which would be manifest as fissures or silt/sand boils with flowing water.

We plan to complete a limited basal heave and seepage analysis concurrently with the cofferdam design, when the tidegate design is further developed.

3.5.2. Construction Dewatering

We recommend a target dewatered elevation of approximately -6 feet, which is 2 feet below the recommended excavation depth for foundation material of -4 feet. The base of the excavation for installation of the tidegate is below the static groundwater level and groundwater will need to be lowered several feet to facilitate construction activities. Based on our analyses and experience on similar projects with similar soil conditions, we anticipate that pumped wells implemented within the excavation area after sheet pile installation will likely be the dewatering method that produces satisfactory results.

A single-tier wellpoint system installed ahead of excavation would not have sufficient suction lift to fully dewater the excavation in advance, and we conclude that a staged dewatering/excavation plan would be necessary to dewater to stabilize against basal heave. Open pumping will not provide sufficient dewatering to limit risk of basal heave based on the fines content of the sandy soils encountered but could control shallow water in the excavation. Some localized pumping of surface water/sheet pile seepage could occur using shallow sumps and pumps if necessary. Specific dewatering recommendations/preliminary design will be provided after cofferdam design and dewatering analysis have been completed.

3.6. Earthwork

Temporary erosion control measures should be used during construction depending on the water in the slough, location, soil type, and other factors. Temporary erosion protection (e.g., straw, plastic, or rolled erosion control products) may be necessary to reduce sediment transport until vegetation is established or permanent surfacing applied for the excavation into the dike embankment. Appropriate best management practices should be incorporated into the temporary erosion and sediment control plan developed by the civil engineer. We are available to provide input if desirable.

3.6.1. Structural Fill

General. All new fill placed under the tidegate structure should be placed and compacted as structural fill. In general, backfill should be placed in horizontal lifts not exceeding 10 inches in loose thickness or that necessary to obtain the specified compaction with the equipment used. Each lift must be thoroughly and uniformly compacted. All structural fill material should be free of organic matter, debris, and other deleterious material. The maximum particle size diameter should be the lesser of either 5 inches or one half of the loose lift thickness.

- Compaction for the tidegate foundation material was provided previously.
- Backfill immediately adjacent to retaining walls and above the tidegate structure should be compacted to 90 to 92 percent of the maximum dry density (MDD) in accordance with ASTM D 1557.
- Gravel base and crushed surfacing materials for the dike roadway surface reconstruction should be compacted to at least 95 percent of the MDD.

As the amount of fines (material passing the U.S. No. 200 sieve) increases in a soil, it becomes more sensitive to small changes in moisture content and during wet conditions, adequate compaction becomes more difficult to achieve. Generally, soils containing more than about 5 percent fines by weight cannot be properly compacted when the moisture content is more than a few percent from optimum.

Sufficient earthwork monitoring and a sufficient number of in-place density tests should be performed to evaluate fill placement and compaction operations and to confirm that the required compaction is being achieved.

Embankment/Levee Fill. We conclude that the existing levee material has a moisture content so high above the optimum moisture content so that it is not feasible/cost effective to try to moisture condition (dry out) this soil so that it could be properly compacted. Therefore, we recommend importing a low permeability soil consistent with the *Western Washington Stormwater Management Manual*. The berm embankment should be constructed of soils with roughly the following characteristics per the United States Department of Agriculture's Textural Triangle (i.e., the portion of the sample passing the U.S. No. 10 sieve): a minimum of

20 percent silt and clay, a maximum of 60 percent sand, a maximum of 60 percent silt, with nominal gravel and cobble content.

Select Import Fill. Imported soil should conform to the recommendations provided in the "General" section above. We anticipate that imported soil will be limited to crushed rock for the foundation material and for the driveway section or embankment fill if needed. Imported fill materials should meet the requirements presented in this report. Other import soils may be submitted and approved by the geotechnical engineer.

3.7. Recommended Additional Geotechnical Services

GeoEngineers should be retained to review the project plans and specifications when complete to confirm that our design recommendations have been implemented as intended.

We recommend part-time construction observation during the installation to document construction activities and advise the project team of areas of concern and recommended actions to promote the successful installation of the proposed tidegate structure.

4.0 LIMITATIONS

We have prepared this report for use by Northwest Hydraulic Consultants, Inc., Skagit County, and other members of the design team for use in design of the proposed Alice Bay Tidegate project in Skagit County, Washington.

Within the limitation of scope, schedule and budget, our services have been executed in accordance with generally accepted geotechnical practices in the area at the time the report was prepared. No warranty or other conditions, express or implied, should be understood.

Any electronic form, facsimile or hard copy of the original document (email, text, table, and/or figure), if provided, and any attachments are only a copy of the original document. The original document is stored by GeoEngineers, Inc. and will serve as the official document of record.

Please refer to the Appendix C, "Report Limitations and Guidelines for Use," for additional information pertaining to use of this report.

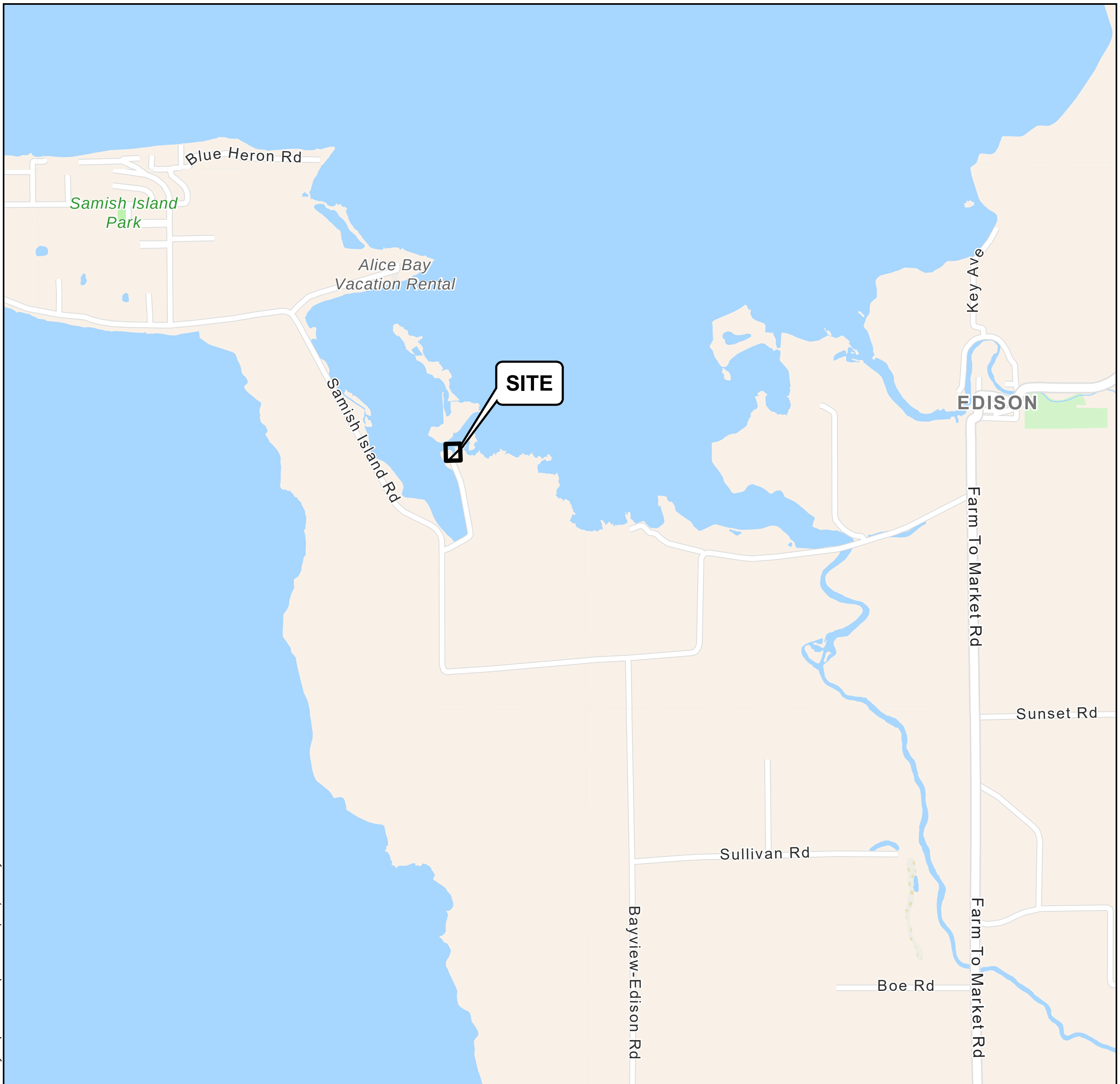
5.0 REFERENCES

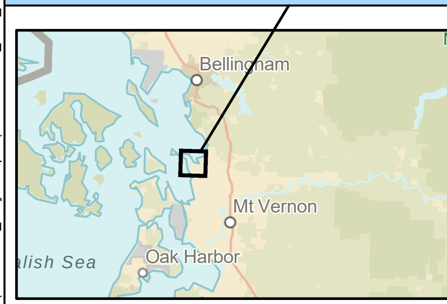
International Code Council. 2018. "International Building Code."

Dragovich, et al. 1998. "Geologic map of the Bow and Alger 7.5-minute quadrangles, Western Skagit County, Washington." Washington Division of Geology and Earth Resources, Open File Report 98-5, scale 1:24,000.

Washington State Department of Transportation. 2018. "Standard Specifications for Road, Bridge and Municipal Construction," M 41-10, 2018.

FIGURES





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Feet

Vicinity Map

Alice Bay Tidegate R
Skagit County, Washington

GEOENGINEERS

Figure 1

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: ESRI. World Navigation Map.

Projection: NAD 1983 UTM Zone 10N

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GEI-1 –

B-4 –

Notes:

1. The locations
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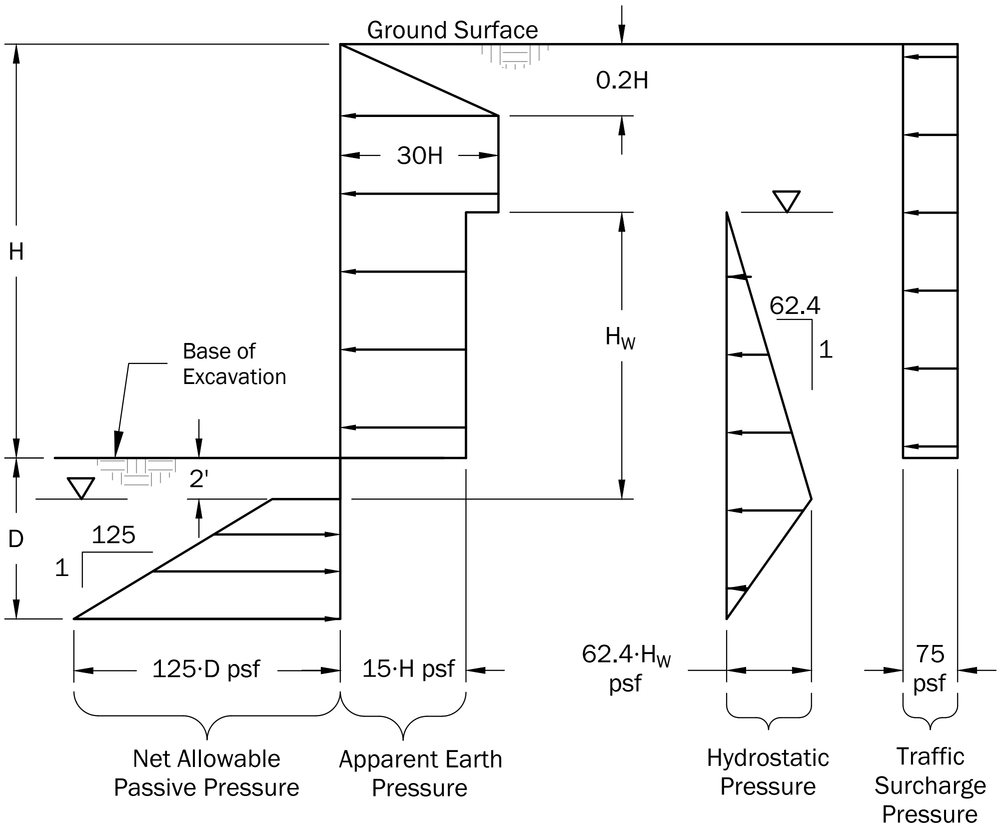
GEO

P:\0\0220106\CAD\00\Geotech\022010600_F02_Site Plan.dwg TAB:F02 Date Exported: 04/08/21 - 8:11 by gregister

TEMPORARY SHORING WALL WITH BRACING



NOT TO SCALE

Legend

H = Height of Excavation, Feet

D = Diaphragm Wall Embedment Depth, Feet

▽ Design Groundwater Elevation for Undrained Walls/ Passive Resistance Design

H_W= Design Height of Excavation Located Below Design Ground Water Table, feet

Notes:

1. Apparent earth pressure and surcharge act over the exposed face of wall.
2. Passive earth pressure acts over the embedded portion of the wall excluding the upper 2'.
3. Passive pressure includes a factor of safety of 1.5
4. This pressure diagram is appropriate for temporary diaphragm walls. If additional surcharge loading (such as from soil stockpiles, excavators, dumptrucks, cranes, or concrete trucks) is anticipated, GeoEngineers should be consulted to provide revised surcharge pressures.

Earth Pressure Diagram - Impermeable Walls
Temporary Walls with Bracing

Alice Bay Tidegate
Skagit County, Washington

GEOENGINEERS

Figure 3

APPENDICES

GeoEngineers

APPENDIX A
Field Exploration and Laboratory Testing

APPENDIX A
FIELD EXPLORATION AND LABORATORY TESTING

Field Explorations

Subsurface soil and groundwater conditions were evaluated by drilling two geotechnical borings. The borings were completed to depths of 31½ and 41½ feet below the existing ground surface (bgs) on January 21, 2019 using a track-mounted drill rig subcontracted to GeoEngineers. The approximate locations of the explorations are shown in Figure 2. The locations of the borings were determined by pacing and taping from existing site features and by recreational grade global positioning system (GPS); therefore, the locations shown in Figure 2 should be considered approximate. The elevations shown on the logs are based on interpolation of the elevation information on the survey provided as shown in Figure 2.

Disturbed soil samples were obtained using Standard Penetration Test (SPT) methodology with the standard split spoon sampler in the borings with a rope and cathead driven 140-pound hammer with 30-inch drop. The samples were placed in plastic bags to maintain the moisture content and transported back to our laboratory for analysis and testing.

The explorations were continuously monitored by a geotechnical engineer from our firm who examined and classified the soils/rock encountered, obtained representative soil/rock samples, observed groundwater conditions and prepared a detailed log of each exploration. Soils were visually classified in general accordance with ASTM International (ASTM) D 2488-90, which is described in Figure A-1. An explanation of our boring log symbols is also shown on Figure A-1.

The logs of the borings are presented in Figures A-2 through A-4. The exploration logs are based on our interpretation of the field and laboratory data and indicate the various types of soils encountered. It also indicates the depths at which these soils or their characteristics change, although the change might actually be gradual. If the change occurred between samples in the boring, it was interpreted.

Observations of groundwater conditions were made during exploration. The groundwater conditions observed are presented on the logs. Groundwater conditions observed during exploration represent a short-term condition and may or may not be representative of the long-term groundwater conditions at the site.

Laboratory Testing

Soil samples obtained from the explorations were transported to our laboratory and examined to confirm or modify field classifications, as well as to evaluate index properties of the soil samples. Representative samples were selected for laboratory testing consisting of the determination of the moisture content, grain size distribution, and percent fines determinations. The tests were performed in general accordance with test methods of ASTM or other applicable procedures.

Moisture Content

Moisture content tests of selected samples were completed in general accordance with ASTM D 2216. The results of these tests are presented on the exploration logs in Appendix A at the depths at which the samples were obtained.

Percent Passing U.S. No 200 Sieve

Selected samples were "washed" through the U.S. No. 200 mesh sieve to determine the relative percentages of coarse- and fine-grained particles in the soil. The percent passing values represent the percentage by weight of the sample finer than the U.S. No. 200 sieve. These tests were conducted to verify field descriptions and to determine the fines content for analysis purposes. The tests were conducted in general accordance with ASTM D 1140, and the results are shown on the exploration logs in Appendix A at the representative sample depths.

Sieve Analyses

Sieve analyses were performed on selected samples in general accordance with ASTM D 422 to determine the sample grain size distribution. The wet sieve analysis method was used to determine the percentage of soil greater than the U.S. No. 200 mesh sieve. The results of the sieve analyses were plotted, classified in general accordance with the Unified Soil Classification System (USCS), and are presented in Figures A-4 through A-5.

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% RETAINED ON NO. 200 SIEVE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS
				SP	POORLY-GRADED SANDS, GRAVELLY SAND
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% PASSING NO. 200 SIEVE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS, ROCK FLOUR, CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS AND SILTS OF MEDIUM TO HIGH PLASTICITY
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: Multiple symbols are used to indicate borderline or dual soil classifications

Sampler Symbol Descriptions

- 2.4-inch I.D. split barrel
- Standard Penetration Test (SPT)
- Shelby tube
- Piston
- Direct-Push
- Bulk or grab
- Continuous Coring

Blowcount is recorded for driven samplers as the number of blows required to advance sampler 12 inches (or distance noted). See exploration log for hammer weight and drop.

"P" indicates sampler pushed using the weight of the drill rig.

"WOH" indicates sampler pushed using the weight of the hammer.

ADDITIONAL MATERIAL SYMBOLS

SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
	AC	Asphalt Concrete
	CC	Cement Concrete
	CR	Crushed Rock/ Quarry Spalls
	SOD	Sod/Forest Duff
	TS	Topsoil

Groundwater Contact

Measured groundwater level in exploration, well, or piezometer

Measured free product in well or piezometer

Graphic Log Contact

Distinct contact between soil strata

Approximate contact between soil strata

Material Description Contact

Contact between geologic units

Contact between soil of the same geologic unit

Laboratory / Field Tests

%F	Percent fines
%G	Percent gravel
AL	Atterberg limits
CA	Chemical analysis
CP	Laboratory compaction test
CS	Consolidation test
DD	Dry density
DS	Direct shear
HA	Hydrometer analysis
MC	Moisture content
MD	Moisture content and dry density
Mohs	Mohs hardness scale
OC	Organic content
PM	Permeability or hydraulic conductivity
PI	Plasticity index
PL	Point load test
PP	Pocket penetrometer
SA	Sieve analysis
TX	Triaxial compression
UC	Unconfined compression
VS	Vane shear

Sheen Classification

NS	No Visible Sheen
SS	Slight Sheen
MS	Moderate Sheen
HS	Heavy Sheen

NOTE: The reader must refer to the discussion in the report text and the logs of explorations for a proper understanding of subsurface conditions. Descriptions on the logs apply only at the specific exploration locations and at the time the explorations were made; they are not warranted to be representative of subsurface conditions at other locations or times.

Key to Exploration Logs

GeoEngineers

Figure A-1

Drilled	Start 2/12/2021	End 2/12/2021	Total Depth (ft) 51.5	Logged By AWS Checked By AJH	Driller Boretec1, Inc.	Drilling Method Hollow-stem Auger with Mud

Surface Elevation (ft) Vertical Datum	12.11 NAVD88	Hammer Data	Rope & Cathead 130 (lbs) / 30 (in) Drop	Drilling Equipment	EC-95 Track
Easting (X) Northing (Y)	1240165 573119	System Datum	WA State Plane North NAD83 (feet)	See "Remarks" section for groundwater observed	

Notes:

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0							SOD	Approximate 6-inch sod layer			
10						S-1		ML	Brown silt with sand, roots and organic matter (medium stiff, moist) (fill)			
			16	4		S-2 / MC			Becomes soft	39		
	5		18	3		S-3 / MC				44		
5												
	10		18	4		S-4 / MC			Becomes moist to wet	55		
0												Groundwater observed at approximately 12 feet below ground surface during drilling Organic odor
			18	11		S-5 / MC		SP	Gray fine to medium sand with trace silt (loose to medium dense, wet) (2-inch-thick silt lens) (alluvium)	26		
	15		18	11		S-6 / SA				24	4	
-5			0	12		S-7						Heave noted, mud added at 17½ feet
	20		18	8		S-8						
-10												
	25		18	9		S-9 / SA				22	5	
-15												
	30		18	14		S-10						
-20												
	35											

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Aerial Imagery. Vertical approximated based on Topographic Survey.

Log of Boring GEI-1

GeoEngineers

Project: Alice Bay Tidegate
Project Location: Skagit County, Washington
Project Number: 0220-106-00

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35		18	11		S-11 / SA				21	4	
-25												
	40		18	6		S-12						
-30												
	45		18	10		S-13 / SA		SP	Gray fine to medium poorly-graded sand (medium dense, wet)	24	5	
-35												
	50		18	11		S-14						

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Log of Boring GEI-1 (continued)

GeoEngineers

Project: Alice Bay Tidegate
Project Location: Skagit County, Washington
Project Number: 0220-106-00

Figure A-2
Sheet 2 of 2

Drilled	Start 2/12/2021	End 2/12/2021	Total Depth (ft)	41.5	Logged By AWS / Checked By AJH	Driller	Boretec1, Inc.	Drilling Method	Hollow-stem Auger with Mud

Surface Elevation (ft) / Vertical Datum	11.68 / NAVD88	Hammer Data	Rope & Cathead 130 (lbs) / 30 (in) Drop	Drilling Equipment	EC-95 Track
Easting (X) / Northing (Y)	1240143 / 573117	System Datum	WA State Plane North NAD83 (feet)	See "Remarks" section for groundwater observed	

Notes:

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0							ML	Brown silt with sand and organic matter (roots) (soft, moist) (fill)			
10						S-1 / MC				43		
			18	3		S-2 / MC				45		
	5		18	3		S-3 / MC			Becomes brown to gray	56		
5												
	10		18	2		S-4 / MC			Becomes very soft	54		
0												
			18	6		S-5A / MC / S-5B				42		
								SP	Gray fine to medium sand with trace silt (loose to medium dense, wet) (alluvium)			Groundwater observed at approximately 13 feet below ground surface during drilling
	15		18	15		S-6 / SA				14	5	
-5												
			18	6		S-7						
	20		18	15		S-8						
-10												
	25		18	6		S-9 / SA				14	5	
-15												
	30		18	13		S-10						
-20												
	35											

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Aerial Imagery. Vertical approximated based on Topographic Survey.

Log of Boring GEI-2

GeoEngineers

Project: Alice Bay Tidegate
Project Location: Skagit County, Washington
Project Number: 0220-106-00

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
-25	35	X	18	7		S-11 / SA				20	5	
	40	X	18	7		S-12						

Date:4/7/21 Path:W:\PROJECTS\0\0220106\GINT\022010600.GPJ DBLibrary/Library:GEOENGINEERS_DF_STD_US_JUNE_2017.GLB/GEI8_GEOTECH_STANDARD_%F_NO_GW

Log of Boring GEI-2 (continued)

GeoEngineers

Project: Alice Bay Tidegate
Project Location: Skagit County, Washington
Project Number: 0220-106-00

Figure A-3
Sheet 2 of 2

APPENDIX B
Logs of Borings from Previous Studies

APPENDIX B
PREVIOUS STUDIES

GeoEngineers reviewed logs of previous explorations completed in the general vicinity of the currently planned project. The locations of previous explorations are shown on the Site Plan, Figure 2. The log of the previous exploration is presented in this appendix and include:

- The logs of one boring (B-4) completed in 2018 by GeoEngineers in the report entitled “Geotechnical Engineering Services, Samish River Floodgates, Skagit County, Washington.” August 1, 2018.

Drilled	Start: 5/16/2018	End: 5/16/2018	Total Depth (ft): 26.5	Logged By: BWS Checked By: MWR	Driller: Boretec1, Inc.
Drilling Method	Hollow-stem Auger				
Surface Elevation (ft) Vertical Datum	7 NAVD88	Hammer Data	Rope & Cathead 140 (lbs) / 30 (in) Drop	Drilling Equipment	EC 95 Track
Easting (X) Northing (Y)	1240249 573170	System Datum	WA State Plane North NAD83 (feet)	See "Remarks" section for groundwater observed	

Notes:

Elevation (feet)	Depth (feet)	FIELD DATA: Interval	FIELD DATA: Recovered (in)	FIELD DATA: Blows/foot	FIELD DATA: Collected Sample	FIELD DATA: Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0							MH	Gray-brown silt with occasional sand and organic matter (rootlets, wood fibers) (stiff, moist) (fill)			
5		X	18	10		1 / MC				38		
	5	X	18	4		2 / MC			Becomes soft to medium stiff	47		
0		X	18	3		3 / MC		MH	Gray-brown silt with organic matter (fibers) (soft, moist) (alluvium)	66		
	10	X	18	2		4 / MC				50		
-5								SP	Gray fine to medium sand with trace silt (medium dense, wet)			Groundwater observed at approximately 13½ feet at time of drilling
	15	X	15	12		5						
-10												
	20	X	18	13		6						
-15												
	25	X	18	12		7						

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on USGS Topo. Vertical approximated based on USGS Topo.

Log of Boring B-4

GEOENGINEERS

Project: Samish River Floodgates
Project Location: Bow, Washington
Project Number: 0220-097-00

Figure A-5
Sheet 1 of 1

Date:8/1/18 Path:P:\0\0220097\GINT\022009700.GPJ DBLibrary/Library:GEOENGINEERS_DF_STD_US_JUNE_2017.GLB/GEI8_GEOTECH_STANDARD_%F_NO_GW

APPENDIX C
Report Limitations and Guidelines for Use

APPENDIX C
REPORT LIMITATIONS AND GUIDELINES FOR USE[1]

This appendix provides information to help you manage your risks with respect to the use of this report.

Read These Provisions Closely

It is important to recognize that the geoscience practices (geotechnical engineering, geology and environmental science) rely on professional judgment and opinion to a greater extent than other engineering and natural science disciplines, where more precise and/or readily observable data may exist. To help clients better understand how this difference pertains to our services, GeoEngineers includes the following explanatory "limitations" provisions in its reports. Please confer with GeoEngineers if you need to know more how these "Report Limitations and Guidelines for Use" apply to your project or site.

Geotechnical Services Are Performed for Specific Purposes, Persons and Projects

This report has been prepared for Northwest Hydraulic Consultants, Inc., Skagit County and for the Project(s) specifically identified in the report. The information contained herein is not applicable to other sites or projects.

GeoEngineers structures its services to meet the specific needs of its clients. No party other than the party to whom this report is addressed may rely on the product of our services unless we agree to such reliance in advance and in writing. Within the limitations of the agreed scope of services for the Project, and its schedule and budget, our services have been executed in accordance with our Agreement with Northwest Hydraulic Consultants, Inc. dated January 12, 2021 authorized the same day and generally accepted geotechnical practices in this area at the time this report was prepared. We do not authorize, and will not be responsible for, the use of this report for any purposes or projects other than those identified in the report.

A Geotechnical Engineering or Geologic Report is Based on a Unique Set of Project-Specific Factors

This report has been prepared for the proposed Alice Bay Tidegate project in Skagit County, Washington. GeoEngineers considered a number of unique, project-specific factors when establishing the scope of services for this project and report. Unless GeoEngineers specifically indicates otherwise, it is important not to rely on this report if it was:

- Not prepared for you,
- Not prepared for your project,
- Not prepared for the specific site explored, or
- Completed before important project changes were made.

[1] Developed based on material provided by ASFE, Professional Firms Practicing in the Geosciences; www.asfe.org.

For example, changes that can affect the applicability of this report include those that affect:

- The function of the proposed structure;
- Elevation, configuration, location, orientation or weight of the proposed structure;
- Composition of the design team; or
- Project ownership.

If changes occur after the date of this report, GeoEngineers cannot be responsible for any consequences of such changes in relation to this report unless we have been given the opportunity to review our interpretations and recommendations. Based on that review, we can provide written modifications or confirmation, as appropriate.

Subsurface Conditions Can Change

This geotechnical or geologic report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by man-made events such as construction on or adjacent to the site, new information or technology that becomes available subsequent to the report date, or by natural events such as floods, earthquakes, slope instability or groundwater fluctuations. If more than a few months have passed since issuance of our report or work product, or if any of the described events may have occurred, please contact GeoEngineers before applying this report for its intended purpose so that we may evaluate whether changed conditions affect the continued reliability or applicability of our conclusions and recommendations.

Geotechnical and Geologic Findings Are Professional Opinions

Our interpretations of subsurface conditions are based on field observations from widely spaced sampling locations at the site. Site exploration identifies the specific subsurface conditions only at those points where subsurface tests are conducted or samples are taken. GeoEngineers reviewed field and laboratory data and then applied its professional judgment to render an informed opinion about subsurface conditions at other locations. Actual subsurface conditions may differ, sometimes significantly, from the opinions presented in this report. Our report, conclusions and interpretations are not a warranty of the actual subsurface conditions.

Geotechnical Engineering Report Recommendations Are Not Final

The recommendations included in this report are preliminary and should not be considered final. GeoEngineers' recommendations can be finalized only by observing actual subsurface conditions revealed during construction. GeoEngineers cannot assume responsibility or liability for the recommendations in this report if we do not perform construction observation.

We recommend that you allow sufficient monitoring, testing and consultation during construction by GeoEngineers to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes if the conditions revealed during the work differ from those anticipated, and to evaluate whether earthwork activities are completed in accordance with our recommendations. Retaining GeoEngineers for construction observation for this project is the most effective means of managing the risks associated with unanticipated conditions.

A Geotechnical Engineering or Geologic Report Could Be Subject to Misinterpretation

Misinterpretation of this report by members of the design team or by contractors can result in costly problems. GeoEngineers can help reduce the risks of misinterpretation by conferring with appropriate members of the design team after submitting the report, reviewing pertinent elements of the design team's plans and specifications, participating in pre-bid and preconstruction conferences, and providing construction observation.

Do Not Redraw the Exploration Logs

Geotechnical engineers and geologists prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. The logs included in a geotechnical engineering or geologic report should never be redrawn for inclusion in architectural or other design drawings. Photographic or electronic reproduction is acceptable, but separating logs from the report can create a risk of misinterpretation.

Give Contractors a Complete Report and Guidance

To help reduce the risk of problems associated with unanticipated subsurface conditions, GeoEngineers recommends giving contractors the complete geotechnical engineering or geologic report, including these "Report Limitations and Guidelines for Use." When providing the report, you should preface it with a clearly written letter of transmittal that:

- Advises contractors that the report was not prepared for purposes of bid development and that its accuracy is limited; and
- Encourages contractors to confer with GeoEngineers and/or to conduct additional study to obtain the specific types of information they need or prefer.

Contractors Are Responsible for Site Safety on Their Own Construction Projects

Our geotechnical recommendations are not intended to direct the contractor's procedures, methods, schedule or management of the work site. The contractor is solely responsible for job site safety and for managing construction operations to minimize risks to on-site personnel and adjacent properties.

Biological Pollutants

GeoEngineers' Scope of Work specifically excludes the investigation, detection, prevention or assessment of the presence of Biological Pollutants. Accordingly, this report does not include any interpretations, recommendations, findings or conclusions regarding the detecting, assessing, preventing or abating of Biological Pollutants, and no conclusions or inferences should be drawn regarding Biological Pollutants as they may relate to this project. The term "Biological Pollutants" includes, but is not limited to, molds, fungi, spores, bacteria and viruses, and/or any of their byproducts.

A Client that desires these specialized services is advised to obtain them from a consultant who offers services in this specialized field.

GeoEngineers

ATTACHMENT D

General Arrangement Drawings

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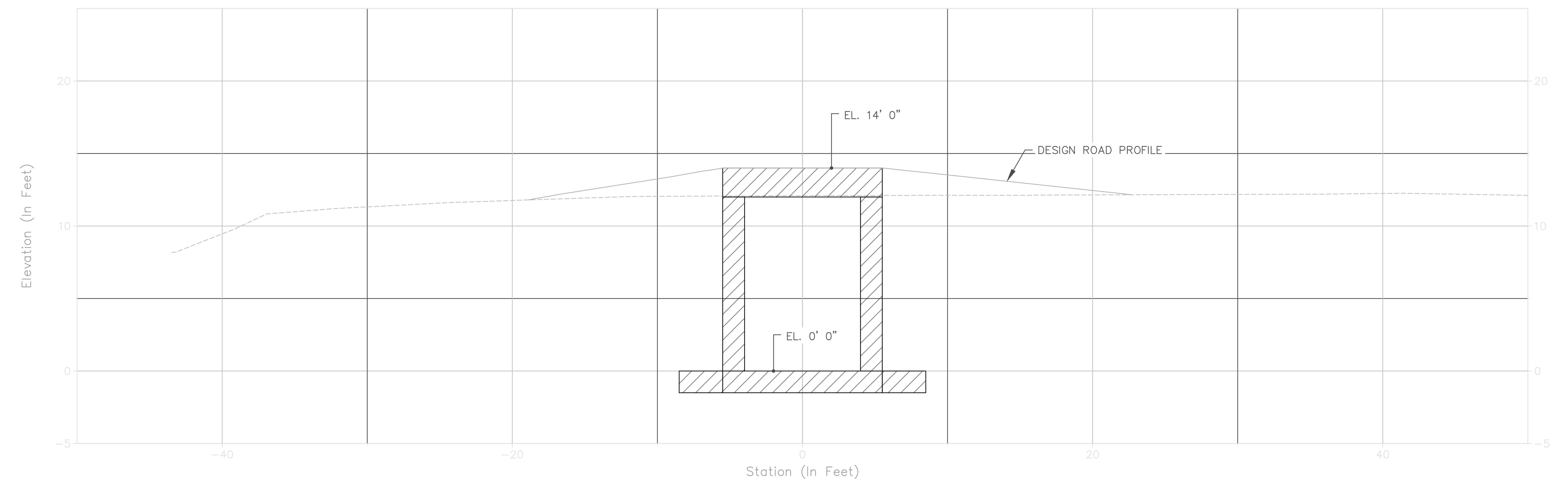

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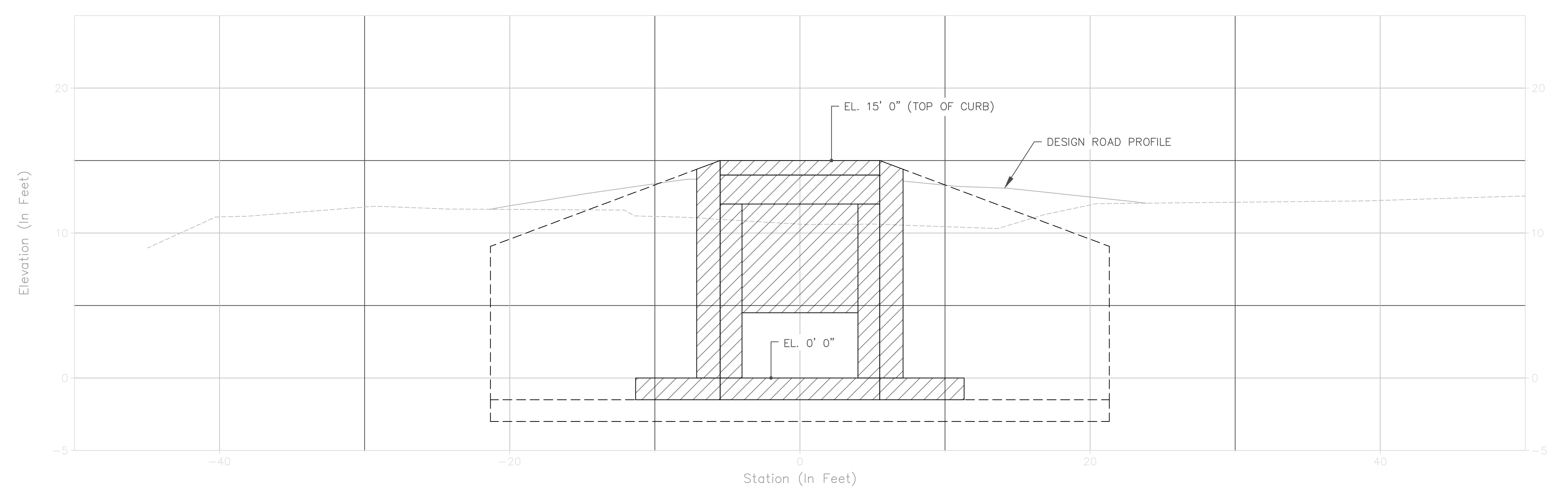

0' 5' 10' 15' 20'
SCALE 1"=5'

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PRELIMINARY
NOT FOR CONSTRUCTION

Revisions		
No.	Date	Description

Drawing Information	
Date	21 November 2022 (19:03)
Status	ISSUED FOR REVIEW
Designer	A. Blezy
Drafter	K. Hooper
Checked	D. Stuart
File Name	2002084-230-IFP-SET-ALICE-GA-_INV0FT_R2B
Plotted Scale	

Skagit Delta Drainage

Alice Bay Culvert Replacement Sections

Invert at elevation 0

Job Number 2002084
Sheet Number 310
Sheet 3 of 3

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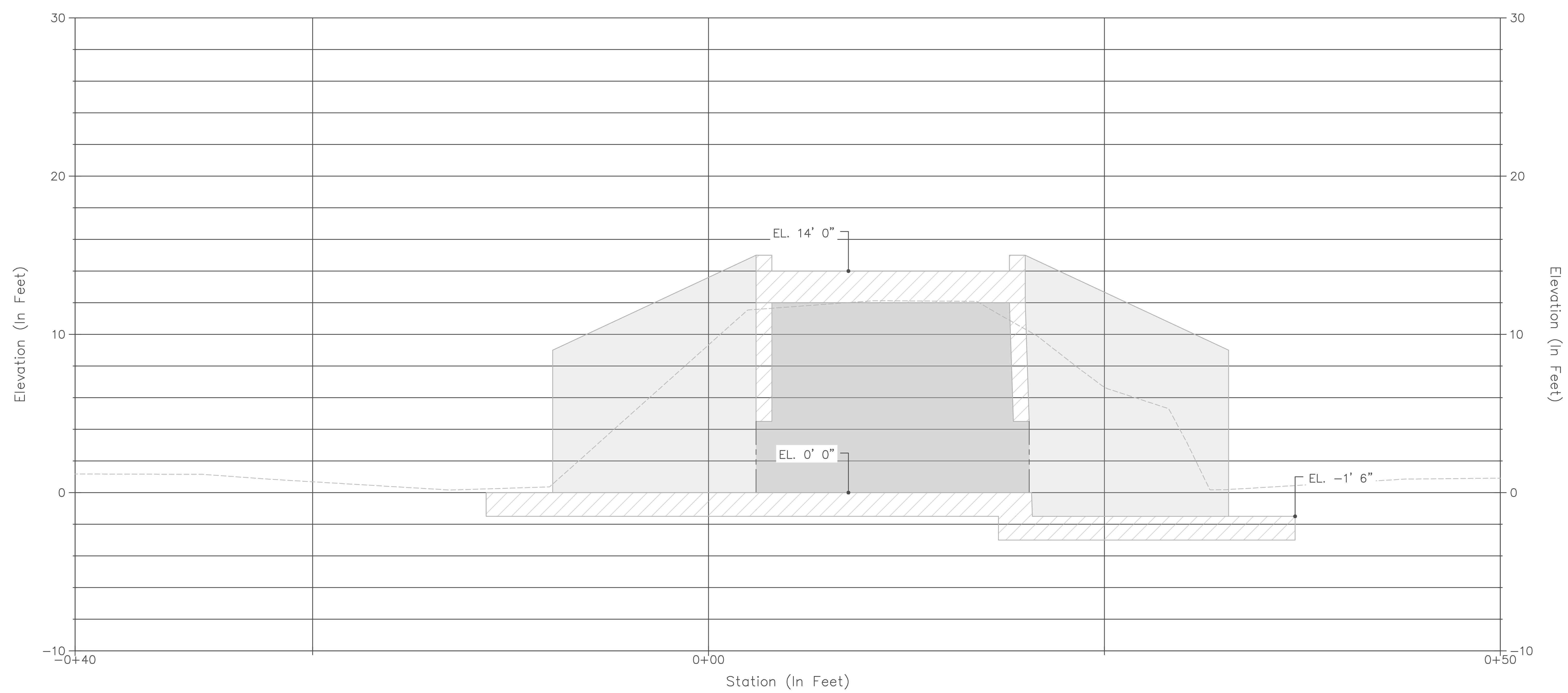
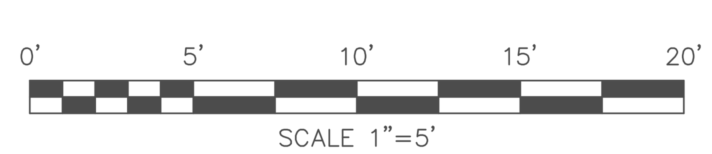
2002084-230-IFP-ALGN-THALWEG-R0A PROFILE





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Revisions		
No.	Date	Description

Drawing Information	
Date	21 November 2022 (19:03)
Status	ISSUED FOR REVIEW
Designer	A. Blezy
Drafter	K. Hooper
Checked	D. Stuart
File Name	2002084-230-IFP-SET-ALICE-GA-_INV0FT_R2B
Plotted Scale	0 1/2 1 18:06:48

Skagit Delta Drainage

Alice Bay Culvert Replacement
Profile

Invert at elevation 0

Job Number
2002084

Sheet Number
210

Sheet 2 of 3

LAST SAVED BY: ablezy LAST DATE SAVED: 11/21/2022 18:06
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BOTTOM OF FOOTING WORKPOINT TABLE			
Point #	Northing	Easting	Elevation
1	573163.70	1240190.38	−3.00
2	573166.39	1240217.93	−3.00
3	573159.79	1240226.09	−3.00
4u	573145.56	1240214.59	−1.50
4l	573145.56	1240214.59	−3.00
5	573135.34	1240215.59	−1.50
6	573123.60	1240229.62	−1.50
7	573115.54	1240222.88	−1.50
8	573112.87	1240195.30	−1.50
9	573119.48	1240187.14	−1.50
10	573133.74	1240198.71	−1.50
11u	573143.86	1240197.73	−1.50
11l	573143.86	1240197.73	−3.00
12	573155.65	1240183.64	−3.00

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Checked	D. Stuart
File Name	2002084-230-IFP-SET-ALICE-GA-_INV0FT_R2B
Plotted Scale	

Skagit Delta Drainage

Alice Bay Culvert Replacement
Site Arrangement Plan

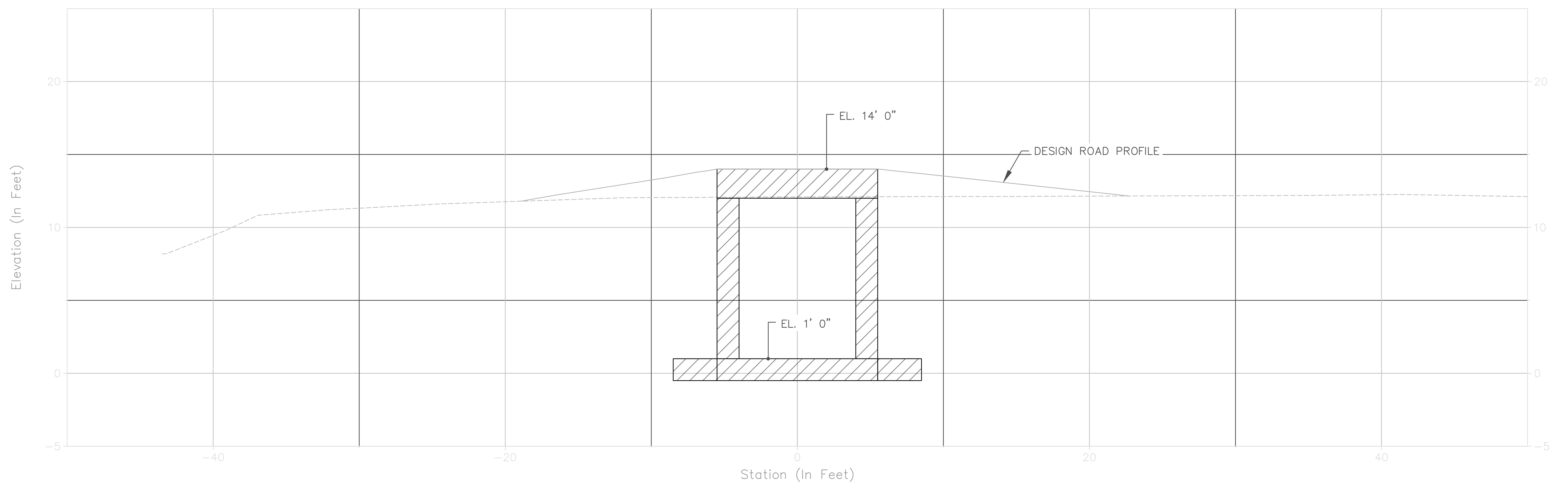
Invert at elevation 0

Job Number 2002084

Sheet Number 110

Sheet 1 of 3

STA 0+10.00



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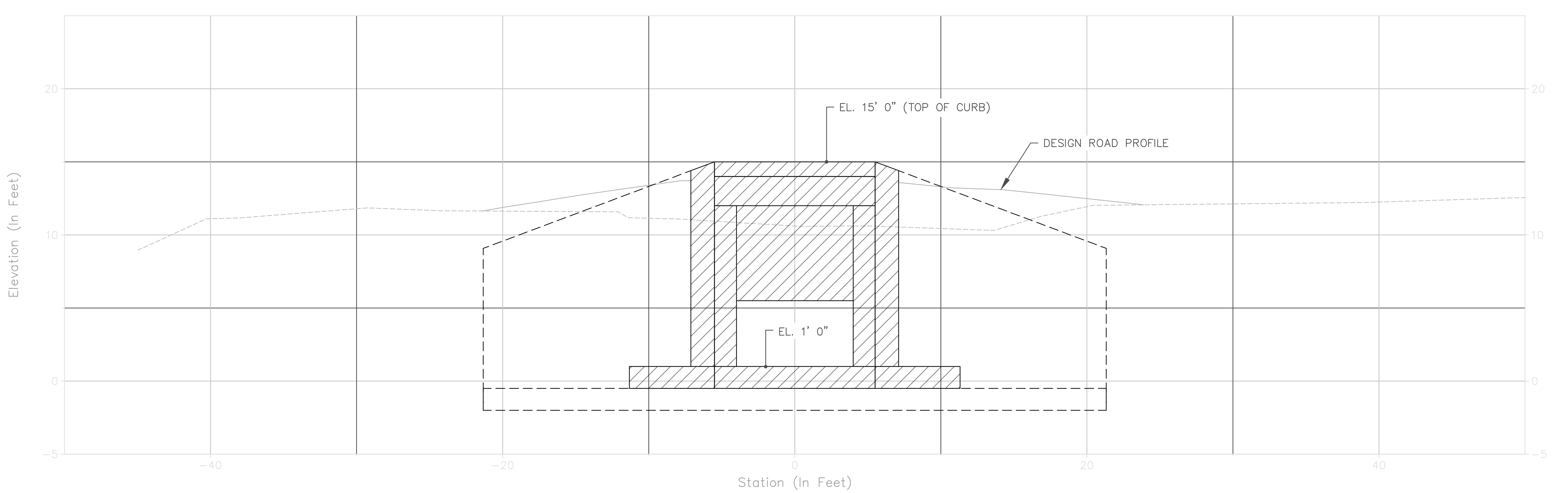


0' 5' 10' 15' 20'
SCALE 1"=5'

Skagit County
1800 Continental Place
Mount Vernon, WA 98273
Phone: (360) 416-1400
Fax: (360) 416-1405
www.skagitcounty.net

nhc
northwest hydraulic consultants
214 west holly street, suite U3
bellingham, washington 98225
phone: (206) 241-6000
www.nhcweb.com

PRELIMINARY
NOT FOR CONSTRUCTION

Revisions		
No.	Date	Description

Drawing Information	
Date	21 November 2022 (18:56)
Status	ISSUED FOR REVIEW
Designer	A. Blezy
Drafter	K. Hooper
Checked	D. Stuart
File Name	2002084-230-IFP-SET-ALICE-GA-_INV1FT_R2B
Plotted Scale	

Skagit Delta Drainage

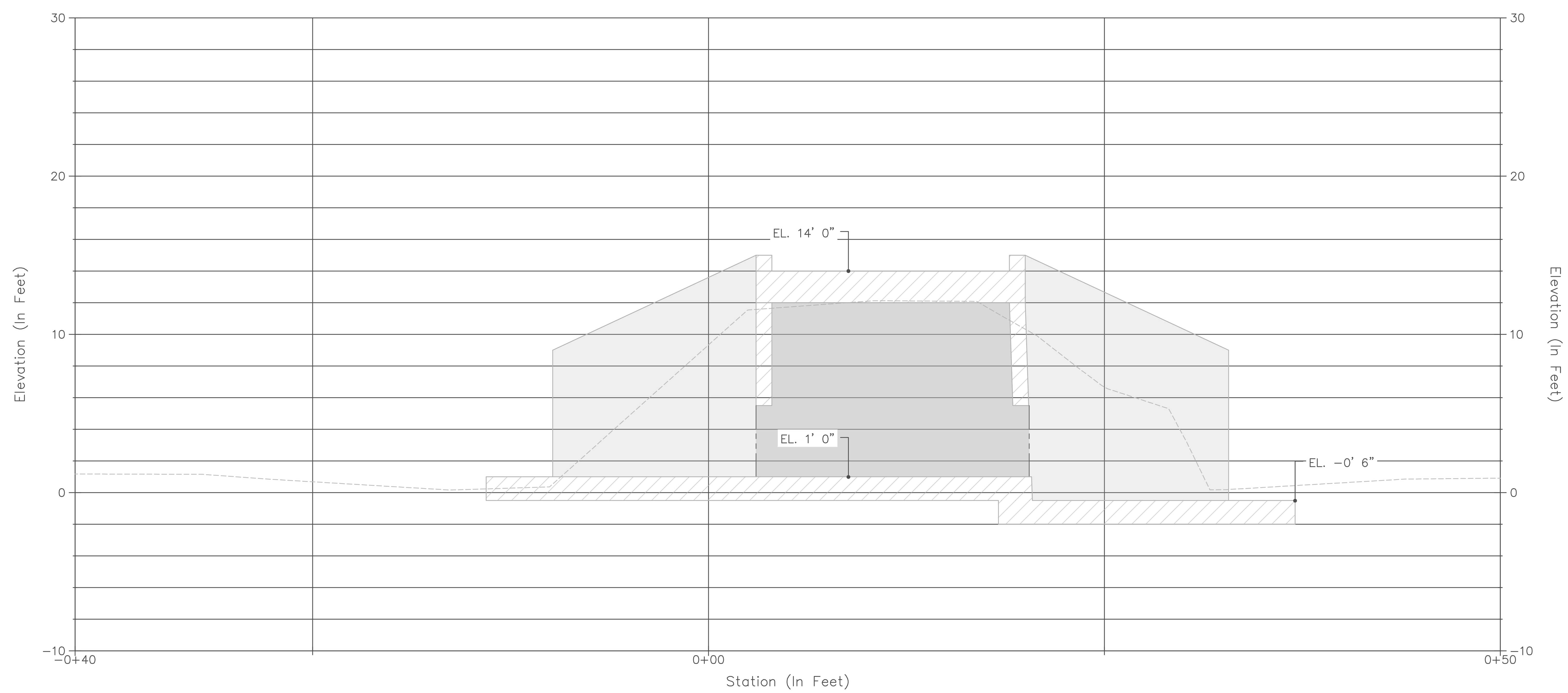
Alice Bay Culvert Replacement Sections

Invert at elevation 1

Job Number 2002084
Sheet Number 310
Sheet 3 of 3

LAST SAVED BY: ablezy LAST DATE SAVED: 11/21/2022 18:03
FILE LOCATION: \\MAINFILE-BELL\PROJECTS\2002084_SKAGIT_RIVER_DELTA_FLOOD_DRAINAGE\96_CAD\ALICEBAY\02 DESIGNPRODUCTION\0100_CURRENT\2002084-230-IFP-SET-ALICE-GA-_INV1FT_R2B.DWG

2002084-230-IFP-ALGN-THALWEG-R0A PROFILE



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Plotted Scale	

Skagit Delta Drainage

Alice Bay Culvert Replacement Profile

Invert at elevation 1

Job Number
2002084
Sheet Number
210
Sheet 2 of 3

BOTTOM OF FOOTING WORKPOINT TABLE

Point #	Northing	Easting	Elevation
1	573163.70	1240190.38	−2.00
2	573166.39	1240217.93	−2.00
3	573159.79	1240226.09	−2.00
4u	573145.56	1240214.59	−0.50
4l	573145.56	1240214.59	−2.00
5	573135.34	1240215.59	−0.50
6	573123.60	1240229.62	−0.50
7	573115.54	1240222.88	−0.50
8	573112.87	1240195.30	−0.50
9	573119.48	1240187.14	−0.50
10	573133.74	1240198.71	−0.50
11u	573143.86	1240197.73	−0.50
11l	573143.86	1240197.73	−2.00
12	573155.65	1240183.64	−2.00

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File Name	2002084-230-IFP-SET-ALICE-GA-_INV1FT_R2B
Plotted Scale	

Skagit Delta Drainage

Alice Bay Culvert Replacement
Site Arrangement Plan

Invert at elevation 1

Job Number 2002084
Sheet Number 110
Sheet 1 of 3

ATTACHMENT E

Cofferdam Design Drawings

Temporary Support of Excavation

Proposed Alice Bay Tidegate Replacement
Skagit County, Washington

for
Northwest Hydraulic Consultants, Inc.

December 30, 2022

GeoEngineers

554 West Bakerview Road
Bellingham, Washington 98226
360.647.1510

GeoEngineers

554 West Bakerview Road
Bellingham, Washington 98226
360.647.1510

December 30, 2022

Northwest Hydraulic Consultants, Inc.
12787 Gateway Drive South
Seattle, Washington 98168

Attention: Derek Stuart, PE

Subject: Temporary Support of Excavation
Proposed Alice Bay Tidegate Replacement
Skagit County, Washington
File No. 0220-106-00

Pursuant to your request, GeoEngineers, Inc. (GeoEngineers) has prepared the attached design calculations and drawings for the temporary support of excavation as part of the above referenced project located in Idaho.

The enclosed drawings provide typical plans and calculations for the proposed internally braced cofferdam to support the Tidegate replacement project. The subsurface characterization used to design the cofferdam is based on the geotechnical report prepared by the GeoEngineers dated December 30, 2022. The cofferedam is designed to support a tide elevation of 10 ft or less (NAVD 88 vertical datum). The design tide elevation is based on historical data from NOAA for Cherry Point, WA and included in the wall analysis summary.

We trust this satisfies the project needs at this time. Please contact Steve Spencer at 425.444.3495 with any questions or comments.

Sincerely,
GeoEngineers, Inc.

STEPHEN W. SPENCER
STATE OF WASHINGTON
33616
REGISTERED
PROFESSIONAL ENGINEER
12/30/22

Arash Pirouzi, PhD
Geotechnical Engineer

Stephen W. Spencer, PE
Principal Geo-structural Engineer

TABLE OF CONTENTS

Temporary Support of Excavation
Proposed Alice Bay Tidegate Replacement
Skagit County, Washington

SHEET INDEX

SHEET NUMBER	SHEET TITLE
0.0	GENERAL NOTES
1.0	SITE PLAN
2.0	SECTION VIEWS
3.0	DETAILS

ALICE BAY, SKAGIT COUNTY, WASHINGTON
SUPPORT OF EXCAVATION PLANS

GENERAL NOTES

GENERAL NOTES:

1. DESIGN HEREIN IS BASED ON INFORMATION PROVIDED BASED ON INFORMATION PROVIDED BY NORTHWEST HYDRAULIC CONSULTANTS, INC AND INFORMATION PROVIDED BY THE SKAGIT DRAINAGE AND IRRIGATION DISTRICT CONSORTIUM.. FOR STRUCTURE AND CONTRACT DESIGN ELEMENTS SEE APPLICABLE CONTRACT DOCUMENTS.
2. ALL WORK TO BE PERFORMED IN ACCORDANCE WITH ALL LOCAL, STATE AND FEDERAL CODES.
3. REPORT ANY CHANGES IN CONTRACT DOCUMENTS AND CHANGED SUBSURFACE CONDITIONS (BASED ON BORING LOGS) TO GEOENGINEERS, INC (GEOENGINEERS) SO THAT THE EFFECT ON THE DESIGN CAN BE EVALUATED AND THE DESIGN MODIFIED IF REQUIRED.
4. THE CONTRACTOR SHALL BE RESPONSIBLE FOR COMPLIANCE WITH THESE DRAWINGS IN ACCORDANCE WITH ALL PROJECT REQUIREMENTS.
5. CONTRACTOR IS RESPONSIBLE TO FIELD VERIFY LOCATIONS OF ALL EXISTING AND PROPOSED CONSTRUCTION. REFER TO CONTRACT DRAWINGS FOR EXISTING AND PROPOSED LOCATIONS.
6. IN PREPARATION OF THESE DRAWINGS, GEOENGINEERS HAS NOT BEEN CONTRACTED NOR IS GEOENGINEERS RESPONSIBLE TO PROVIDE FIELD OBSERVATION OR VERIFICATION OF THE CONSTRUCTION. ON SITE INSPECTION TO VERIFY COMPLIANCE WITH THESE DRAWINGS SHALL BE PERFORMED BY THE CONTRACTOR IN ACCORDANCE WITH ALL PROJECT REQUIREMENTS.
7. ALL EXCAVATIONS AND WORK SHALL CONFORM TO THE REQUIREMENTS OF THE FEDERAL REGISTER BY THE DEPARTMENT OF LABOR, OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION, 29 CFR PART 1926, FOR EXCAVATIONS. ALL ANCILLARY ITEMS SUCH AS HANDRAILS WHICH ARE REQUIRED BY OSHA, BUT NOT SHOWN ON THE DRAWINGS, SHALL BE INSTALLED PER OSHA STANDARDS.
8. ALL EXCAVATION, DEWATERING/WATER CONTROL, BACKFILLING, COMPACTION, AND GRADING SHALL BE IN ACCORDANCE WITH CONTRACT DOCUMENTS AND PROJECT SPECIFICATIONS. THE GROUNDWATER LEVEL SHALL BE MAINTAINED 2-FT (MIN.) BELOW THE BOTTOM OF EXCAVATION (BOE) DURING ALL STAGES OF CONSTRUCTION. REFER TO "DEWATERING CONSIDERATIONS REPORT BY GEOENGINEERS" FOR ADDITIONAL DEWATERING REQUIREMENTS AND ESTIMATE OF PUMPING REQUIREMENTS. ALL SHEET PILES AND CORNERS SHALL BE INTERLOCKING FULL DEPTH.
9. THE FOLLOWING SURCHARGES HAVE BEEN CONSIDERED IN THE DESIGN OF THE TEMPORARY SOE WALLS SHOWN ON THESE DRAWINGS:

   CONSTRUCTION EQUIPMENT

   500 PSF X 20-FT WIDE STRIP LOAD ALONG EAST AND WEST SHORING WALLS

   (LOCATED 2-FT FROM REAR FACE OF SOE)

   PROPOSED SURCHARGE LOADING OTHER THAN ABOVE MUST BE SUBMITTED TO GEOENGINEERS FOR EVALUATION AND WRITTEN APPROVAL PRIOR TO APPLICATION OF LOAD.
10. HORIZONTAL DATUM: NAD 83/91 WASHINGTON STATE PLANE NORTH ZONE
11. VERTICAL DATUM: NAVD 88
12. TIDE ELEVATION INFORMATION IS BASED ON HIGHEST RECORDED NOAA DATA FOR CHERRY POINT IN JULY, 9.5' (NAVD88, DATA TO 1976). 10' USED FOR DESIGN.
13. A SURVEY MONITORING PROGRAM SHOULD BE ESTABLISHED TO MONITOR THE PERFORMANCE OF THE SHEET PILES. A VISUAL INSPECTION OF CONNECTIONS IS REQUIRED TO MONITOR THE PERFORMANCE OF THE CONNECTIONS. THE MONITORING PROGRAM SHOULD BE PERFORMED ON A WEEKLY BASIS DURING THE EXCAVATION PERIOD UNTIL THE EXCAVATION IS BACKFILLED.

MATERIAL NOTES:

1. ALL STRUCTURAL SHEET PILES, H-PILES AND WIDE FLANGE SECTIONS SHALL BE SIZED AS NOTED AND CONFORM TO ASTM A992 OR ASTM A572 (GRADE 50).
2. ALL MISCELLANEOUS STRUCTURAL STEEL ANGLES, PLATES (E.G. SHIMS, STIFFENERS) SHALL CONFORM TO ASTM A36, GRADE 36 MIN., UNLESS OTHERWISE NOTED.
3. ALL SHOP & FIELD WELDING SHALL BE PERFORMED IN ACCORDANCE WITH THE REQUIREMENTS OF THE LATEST EDITION OF THE AMERICAN SOCIETY FOR WELDING IN BUILDINGS AND CONSTRUCTION AWS D1.1. WELDING ELECTRODES SHALL BE E70XX.
4. UNLESS OTHERWISE NOTED, ANY SUBSTITUTION OF STRUCTURAL SHAPES OR DETAILS SHALL BE APPROVED BY GEOENGINEERS IN WRITING PRIOR TO USE.

CONSTRUCTION SEQUENCE:

1. FIELD LOCATE ALL UTILITIES AND EXISTING STRUCTURES WHICH MAY INTERFERE WITH THE PROPOSED CONSTRUCTION AND RELOCATE AS REQUIRED. NOTIFY GEOENGINEERS SO THAT ANY EFFECTS ON THE DESIGN MAY BE EVALUATED AND THE DESIGN MODIFIED AS REQUIRED. CONTACT GEOENGINEERS IF ADDITIONAL TEMPORARY UTILITY/STRUCTURE SUPPORT IS REQUIRED.
2. LAYOUT AND INSTALL SHEET PILES AT THE LOCATIONS AND TO THE MINIMUM DEPTHS SHOWN HEREIN.
3. BEGIN EXCAVATION TO WITHIN 2-FT BELOW BRACING ELEVATION. INSTALL BRACING AT THE ELEVATION SHOWN HEREIN.
4. PERFORM GENERAL EXCAVATION TO THE BOTTOM OF EXCAVATION AS NOTED HEREIN. MAINTAIN GROUNDWATER BELOW BOE.
5. LAYOUT AND INSTALL CUT-OFF SHEET PILES AT THE LOCATIONS AND TO THE MINIMUM DEPTHS SHOWN HEREIN. EXPEDITE PLACEMENT OF BASECOURSE MATERIAL FOLLOWING SUBGRADE APPROVAL. PLACE SHEET PILE CAP WHILE POURING THE TIDE GATE STRUCTURAL SLAB. CONCRETE SPECIFICATIONS TO MATCH STRUCTURAL SLAB CONCRETE.
6. PLACE STRUCTURES, UTILITIES AND BACKFILL UP TO WITHIN 2-FT BELOW THE BRACING THROUGHOUT THE SITE. REMOVE BRACING.
7. PLACE STRUCTURES, BACKFILL AND RESTORE AREA AS REQUIRED PER CONTRACT DOCUMENTS, SPECIFICATIONS, AND PROJECT REQUIREMENTS.

NO.	DATE	BY	ISSUE / DESCRIPTION

DESIGNED BY: TAB, AP
DRAWN BY: EHA
APPROVED BY: SWS
REVISION NO.: —
DATE: 12/30/2022

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PREPARED FOR:
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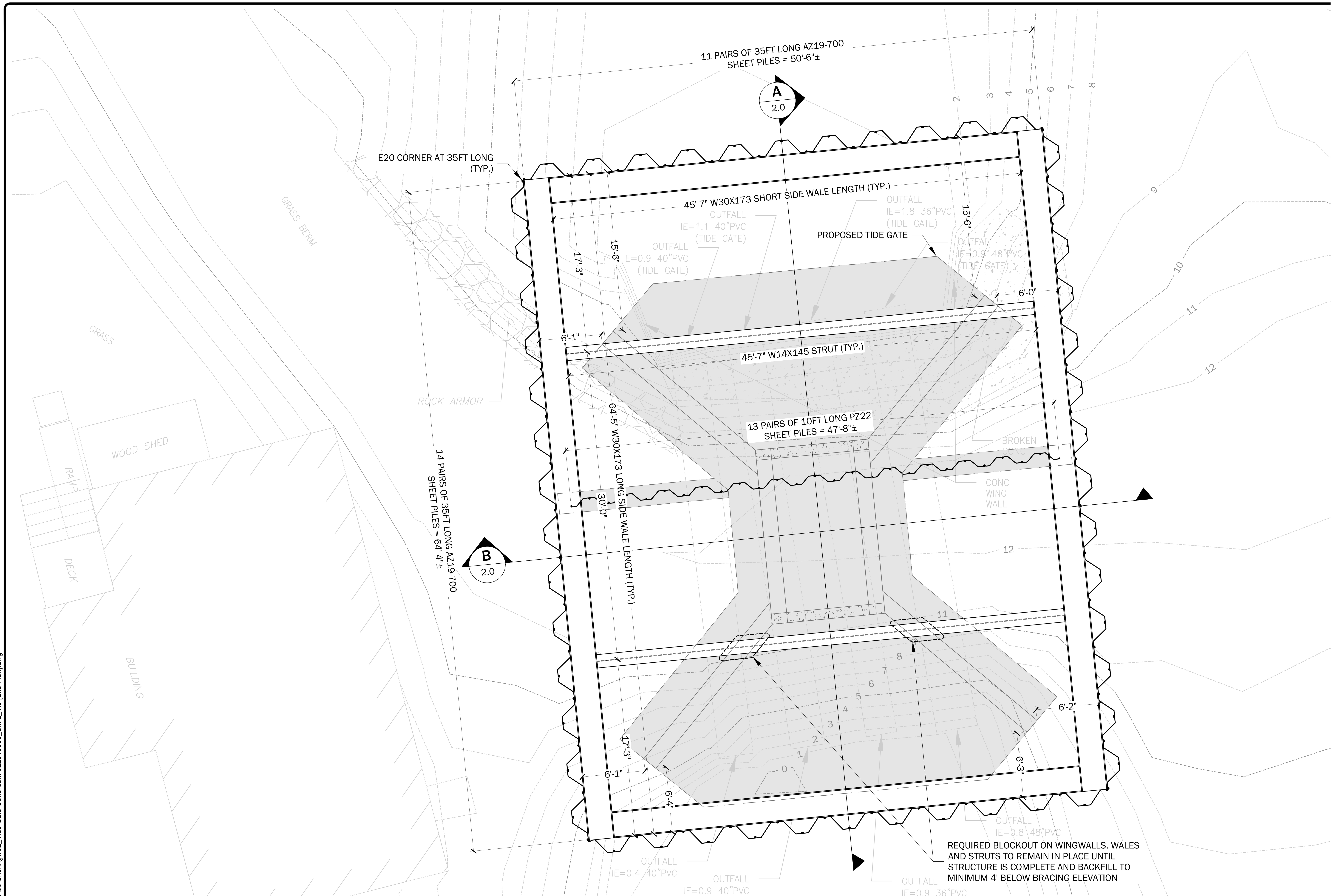
ALICE BAY, SKAGIT COUNT
SUPPORT OF EXC

GENERAL N



SITE PLAN -

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DATE: 12/30/2022

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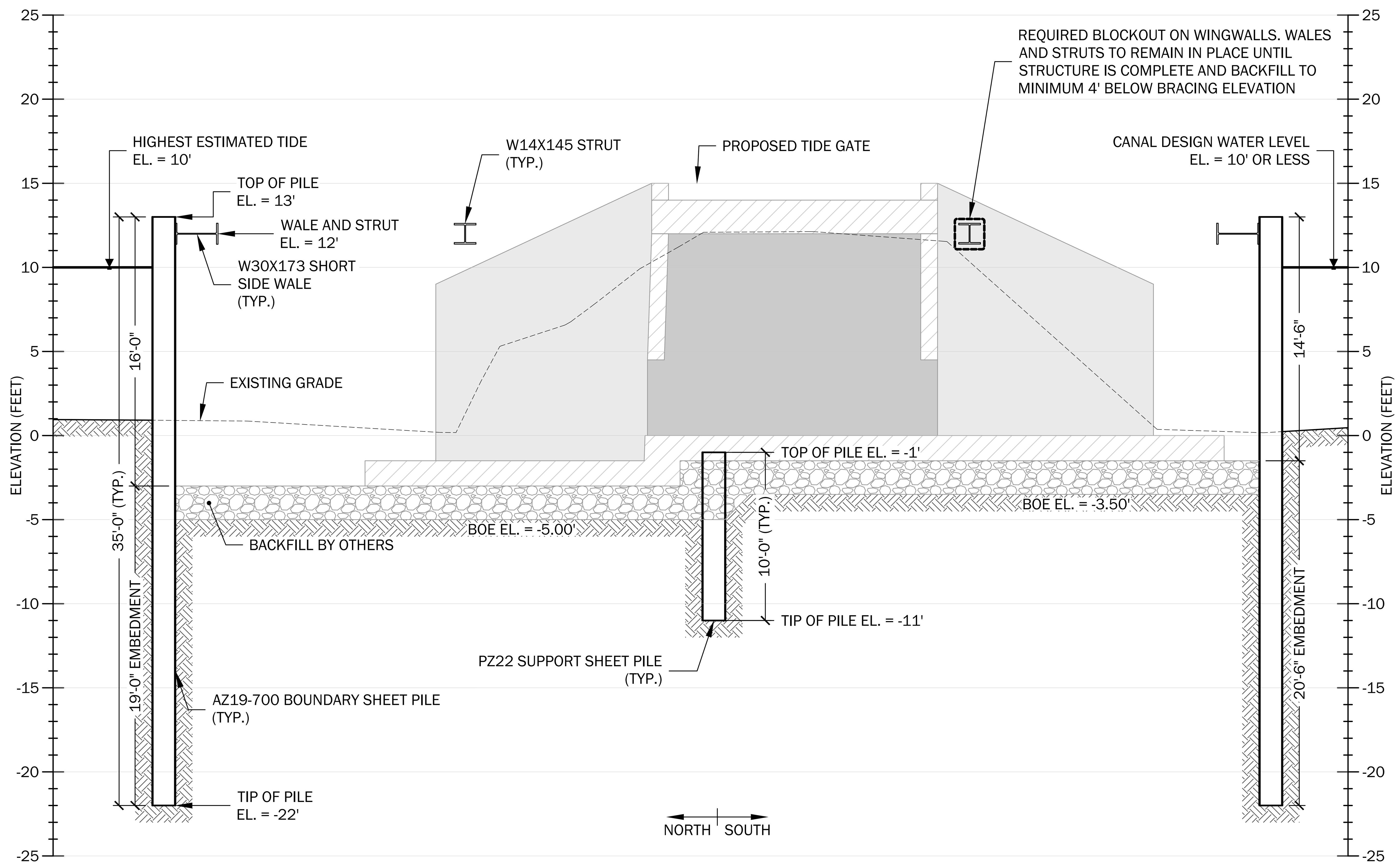
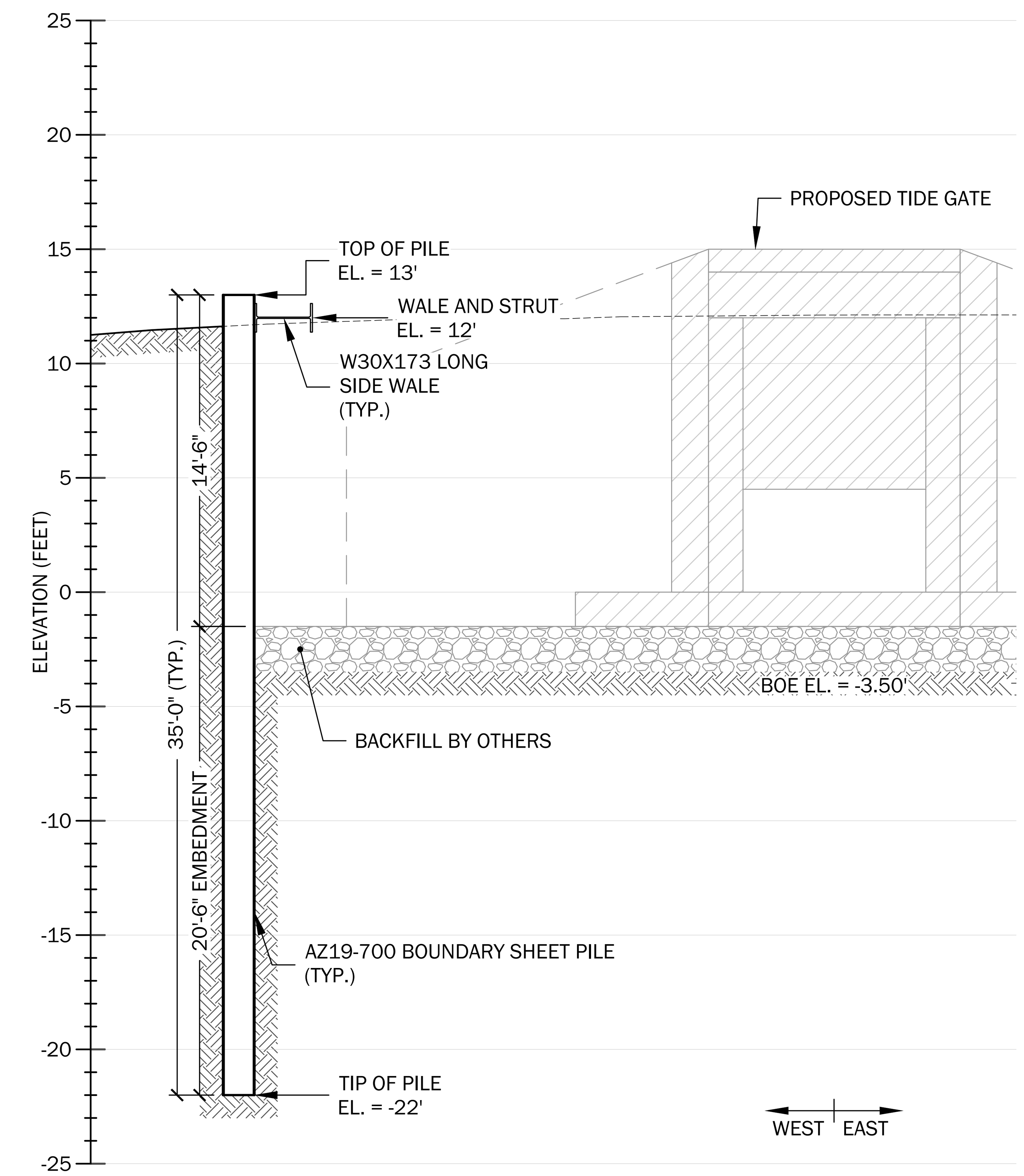
ALICE BAY, SKAGIT COUNT
SUPPORT OF EXC

SITE PLA



SECTION VIEW A
SCALE: 1:5



SECTION VIEW B
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NO.	DATE	BY	ISSUE / DESCRIPTION

DESIGNED BY: TAB, AP
DRAWN BY: EHA
APPROVED BY: SWS
REVISION NO.: —
DATE: 12/30/2022

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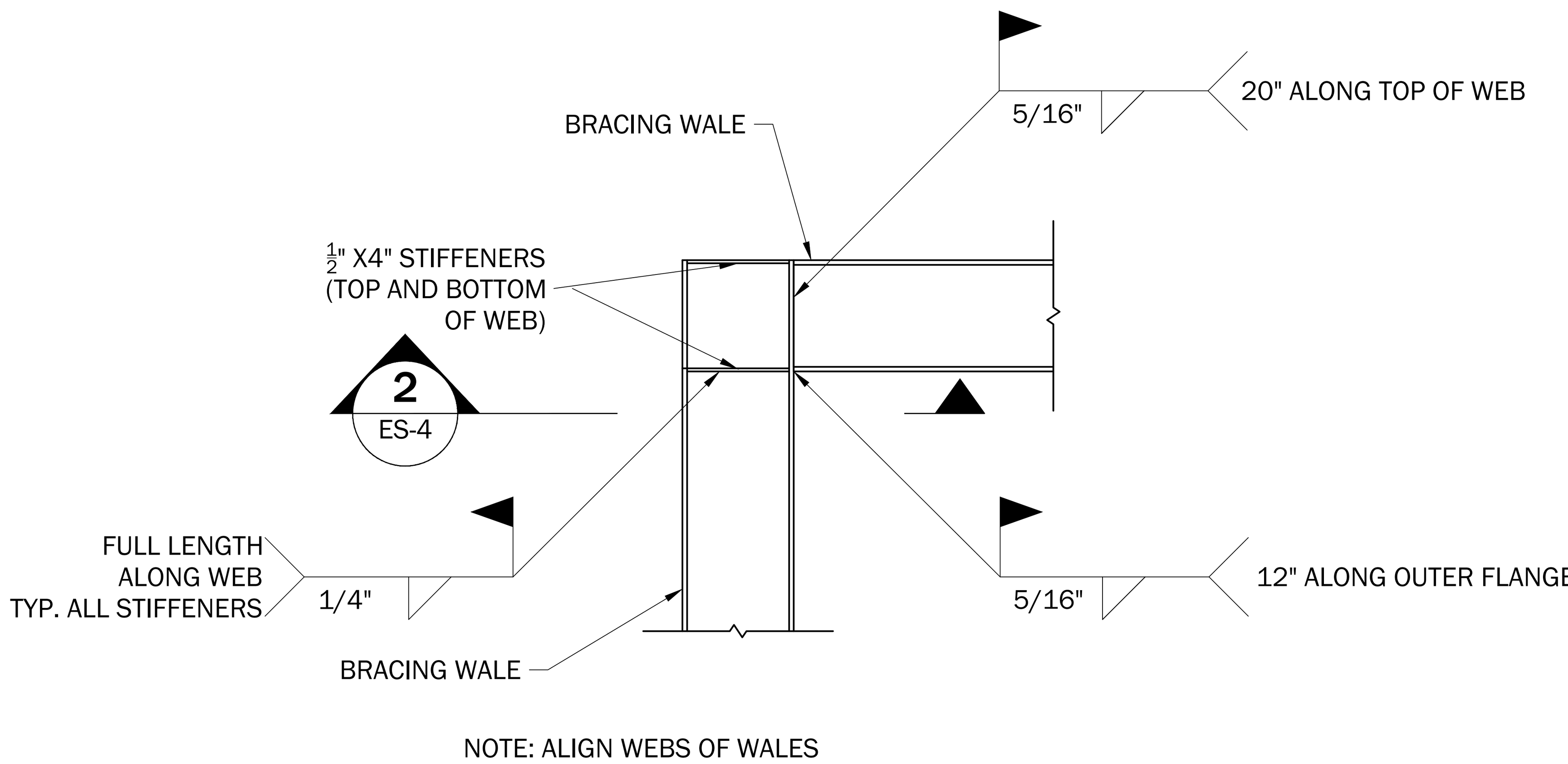
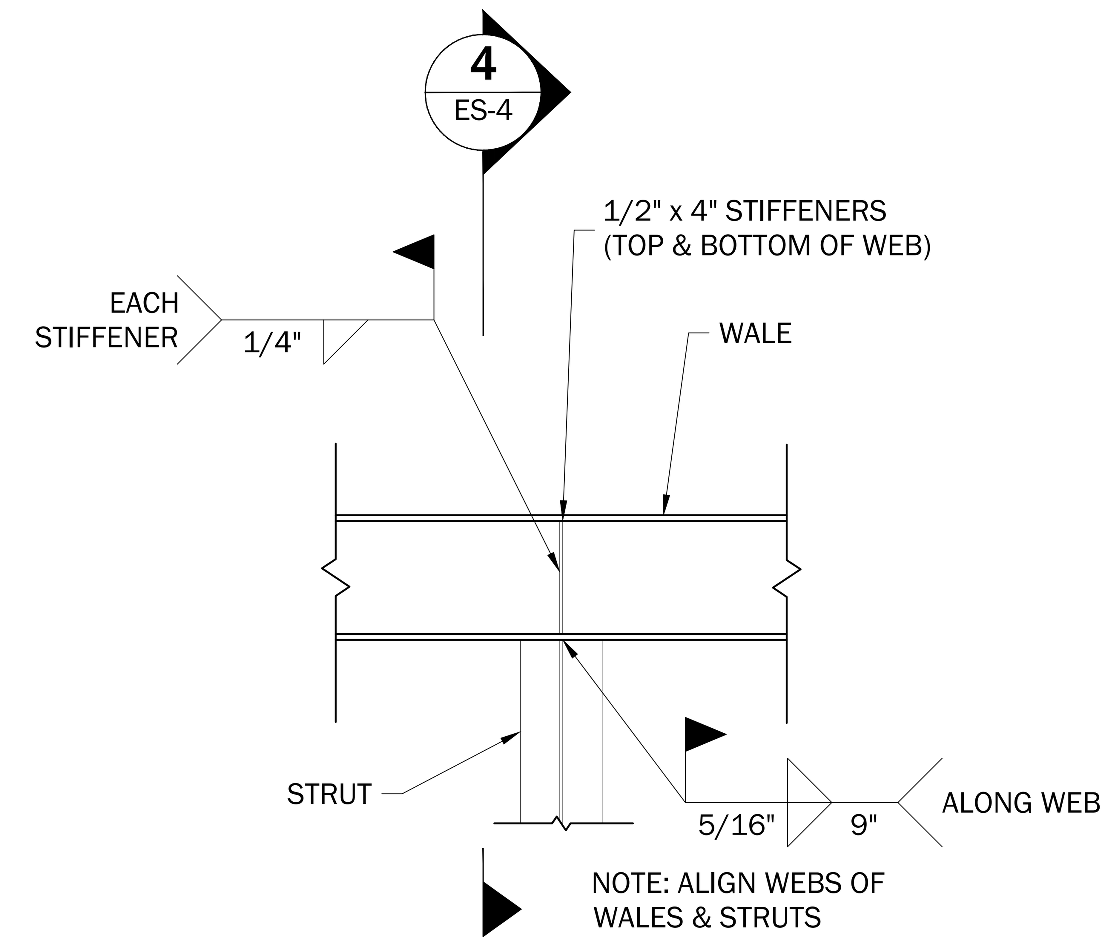
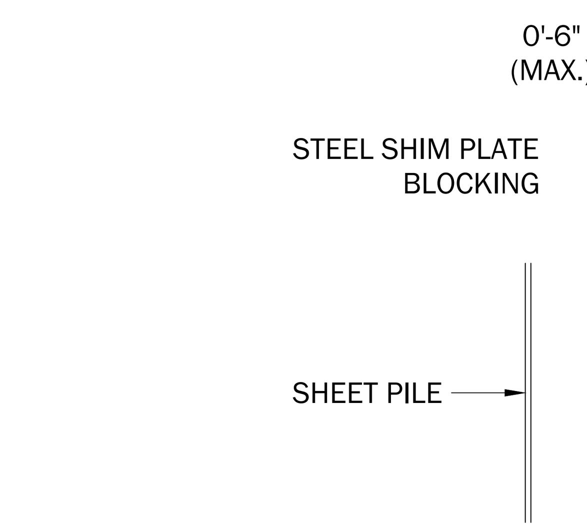
ALICE BAY, SKAGIT COUNT
SUPPORT OF EXC
SECTION VI



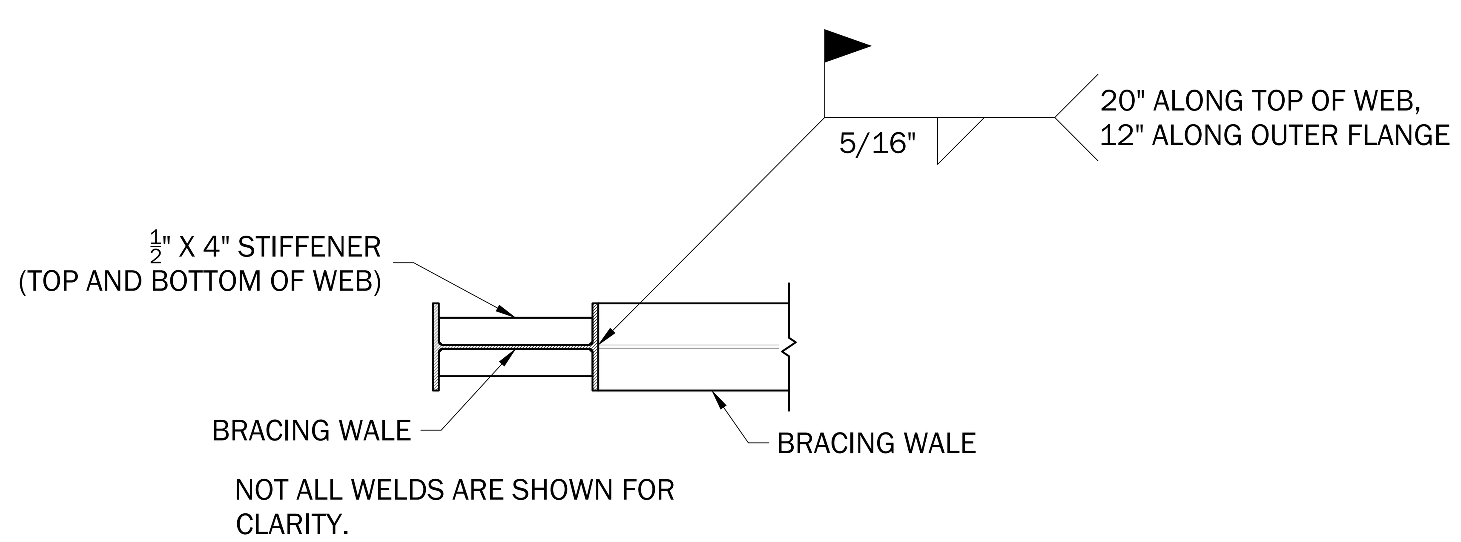
PLAN - 90° CORNER
WALE CONNECTION DETAIL (1)
SCALE: N.T.S.



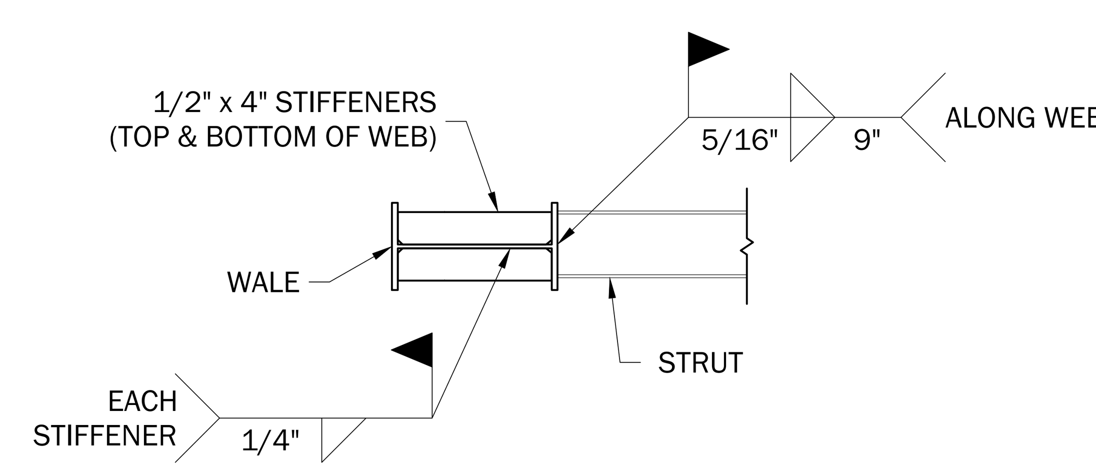
PLAN - 90° STRUT TO
WALE CONNECTION DETAIL (3)
SCALE: N.T.S.



WALE S
CONNEC
SCALE: N.T.S



SECTION - CORNER
WALE CONNECTION DETAIL (2)
SCALE: N.T.S.



SECTION - 90° STRUT TO
WALE CONNECTION DETAIL (4)
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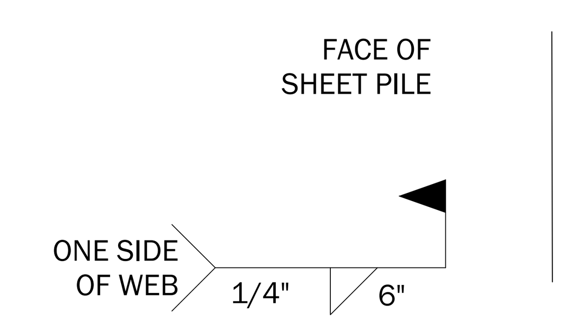

NOTES:
1. PROVIDE \
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2. WALE AND
WELDED I

WALE S
CONNEC
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Subject: Wall Analysis Summary for the Temporary Support of Excavation for Northwest Hydraulic Consultants, Inc. - Alice Bay Tide Gate project located in Skagit County, WA.

References:

- Geotechnical Report by GeoEngineers dated December 30, 2022.
- American Institute of Steel Construction (AISC) - Allowable Stress Design (ASD) Design Manual.

Assumptions: Steel Properties $F_{y50} := 50 \cdot ksi$ $F_{y36} := 36 \cdot ksi$

Soil Profile/Parameters:

Unit Weight of Water $\gamma_w := 62.4 \cdot pcf$

1- Fill (ML) $\gamma_1 := 120 \cdot pcf$ $\gamma'_1 := \gamma_1 - \gamma_w$ $\gamma'_1 = 58\ pcf$

$\phi_1 := 28 \cdot deg$ $C_1 := 0 \cdot psf$

2- Alluvium (SP) $\gamma_2 := 125 \cdot pcf$ $\gamma'_2 := \gamma_2 - \gamma_w$ $\gamma'_2 = 63\ pcf$

$\phi_2 := 30 \cdot deg$ $C_2 := 0 \cdot psf$

Assumptions:

- Groundwater is assumed to be at Elevation 8 ft for high tide conditions at the east and west walls of the cofferdam and be lowered to Bottom of Excavation (BOE) by dewatering within the tide gate site.
- Elevations are in NAVD 88 datum.
- Design tide elevation is 10 ft at the north wall based on water level top 10 report from NOAA Tide Data for Cherry Point. See image below.
- An assumed yielding wall condition was considered for design of the temporary Support of Excavation (SOE).
- Construction Vertical Surcharge of 500 psf considered at the top of the wall with a 2-ft setback for the east and west walls.
- Design earth pressures are based on Figure 3 Earth Pressure Diagram in the Geotech Report and are presented below.
- Passive pressures from Getoech report 125 pcf with a factor of safety of 1.5 have been evaluated in DeepEx with a 187.5 pcf with a minimum factor of safety of 1.2 for length, embedment and 1.5 for rotation.
- Support of Excavation Wall Analyses performed using DeepEX V20.01 Software, by Deep Excavation LLC., for Design & Analysis of Soldier Pile & Lagging Walls.

NOAA Tide Report for Cherry Point

Highest and Lowest Values

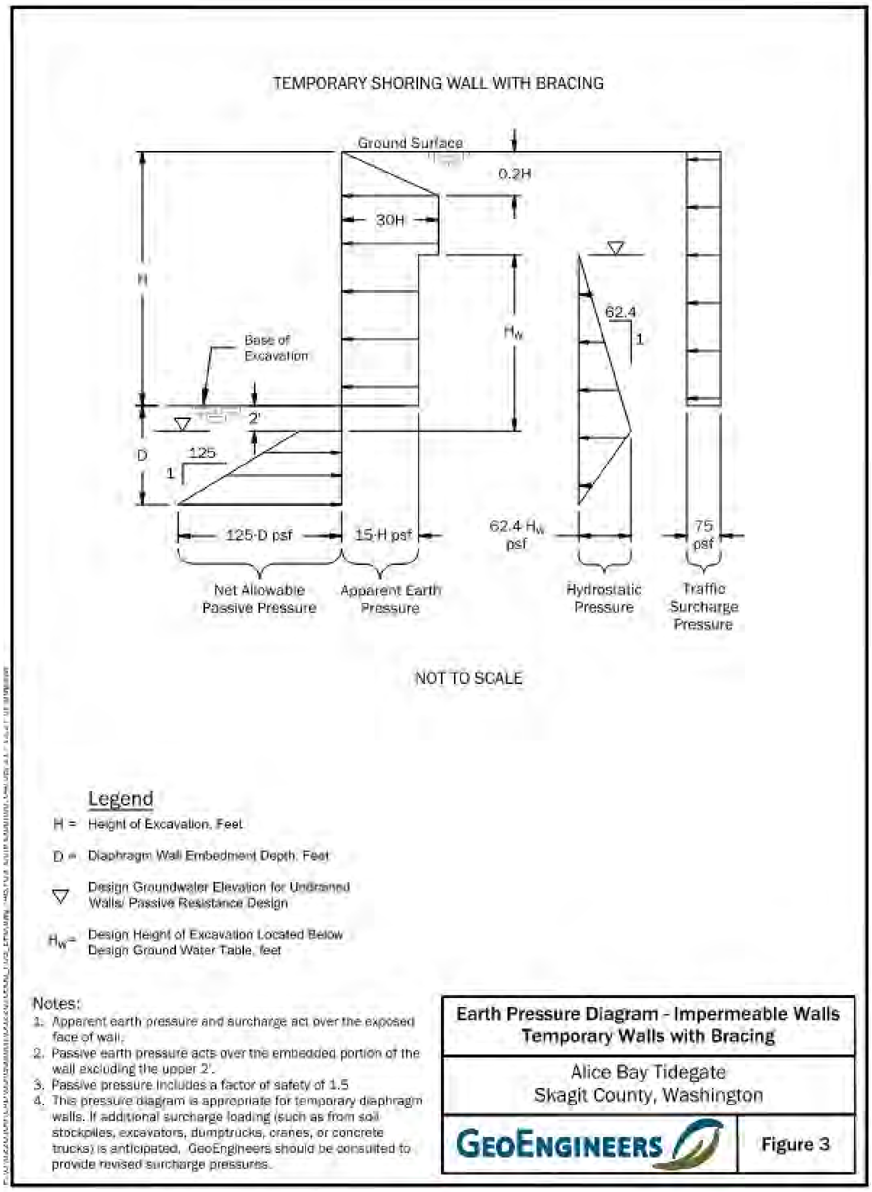
Station: 9449424
Name: Cherry Point, WA
Product: High/Low
Datum: MLLW

Begin Date: 19750105
End Date: 20230105
Units: Feet
Quality: Verified

*Note: data in table is MLLW datum. To convert to NAVD 88 subtract 2.75 ft from the MLLW elevation

Rank	Highest	Highest Date	Zone	Lowest	Lowest Date	Zone
1	12.84	19821215 23:24	GMT	-4.26	19851212 15:18	GMT
2	12.42	19830126 20:48	GMT	-4.10	19891212 14:42	GMT
3	12.38	19870103 00:36	GMT	-4.05	20090112 07:12	GMT
4	12.31	20060204 17:06	GMT	-4.04	19860623 03:42	GMT
5	12.27	19871209 01:00	GMT	-4.03	20071126 07:30	GMT
6	12.21	20030103 14:42	GMT	-4.01	19851211 14:30	GMT
7	12.13	19821216 23:42	GMT	-4.00	19861202 15:30	GMT
8	12.08	20051231 14:48	GMT	-3.95	19891114 15:48	GMT
9	12.06	19771215 01:36	GMT	-3.95	19871222 16:18	GMT
10	12.02	20031224 15:12	GMT	-3.94	20071225 07:18	GMT

Earth Pressure Diagram



Design Summary

Temporary Wall Analysis Summary				
Wall	Design Section	Max Wall Displacement (in)	Wall Moment (k-ft/ft)	Bracing Reaction (klf)
EAST	AZ 19-700	0.89	57.9	7.91
WEST	AZ 19-700	0.88	58.4	8.28
SOUTH	AZ 19-700	0.66	44.8	4.61
NORTH	AZ 19-700	0.66	44.8	4.61

Maximum moment on sheet pile wall $M_{max} := 58.4 \ \frac{kip \cdot ft}{ft}$

Bracing reaction $R_B := 8.28 \ klf$

Sheet Pile Check

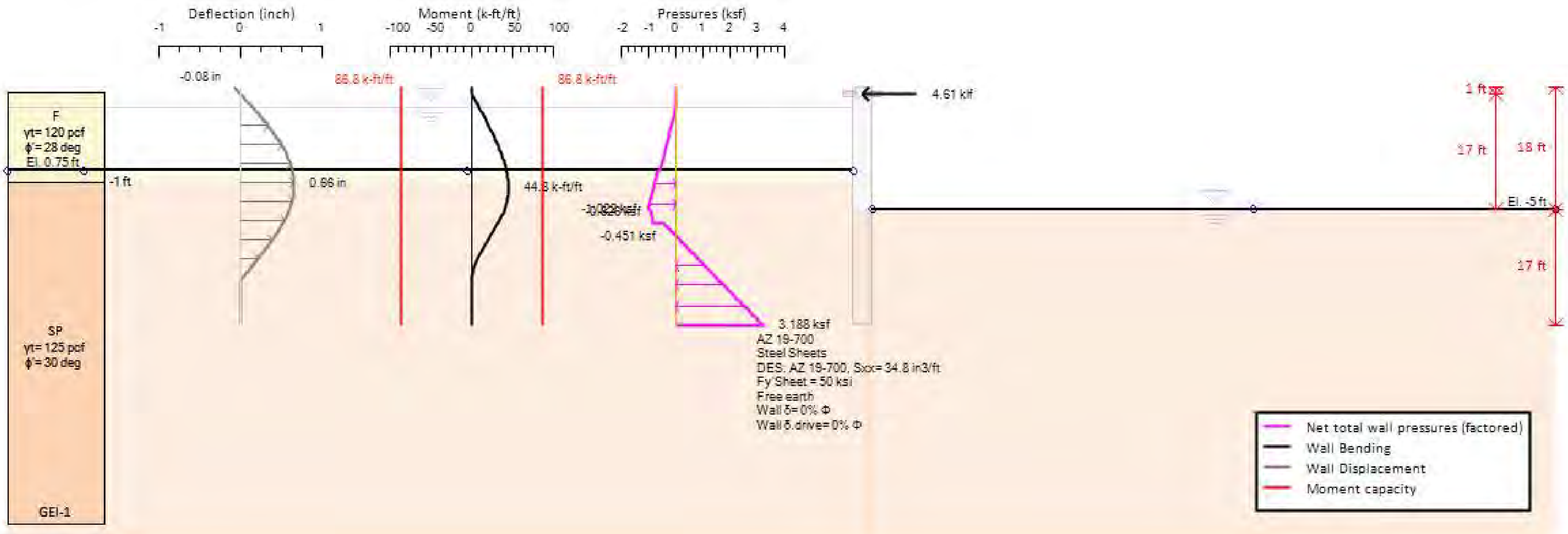
Maximum design moment $M_{max} = 58.4 \ \frac{kip \cdot ft}{ft}$

Check AZ 19-700 Sheet Piles $S_{sp} := 34.8 \cdot \frac{in^3}{ft}$

Structural Check $F_y := \frac{M_{max}}{S_{sp}} = 20.1 \ ksi$ $\quad f_y := 0.6 \cdot F_{y50} = 30 \ ksi$

$\frac{F_y}{f_y} = 0.67 \quad < 1.2$ OK for temporary construction

Wall Toe Safety:	AZ 19-700
Min FS=	1.633
FS Embed=	1.633
FS Rot.=	2.798
Req. toe FS=1:	10.412 ft
Toe El. FS=1:	-15.412 ft
Note:	Toe FS >=1
FS Basal=	2.605
Basal standard	2.605
Basal standard	2.605



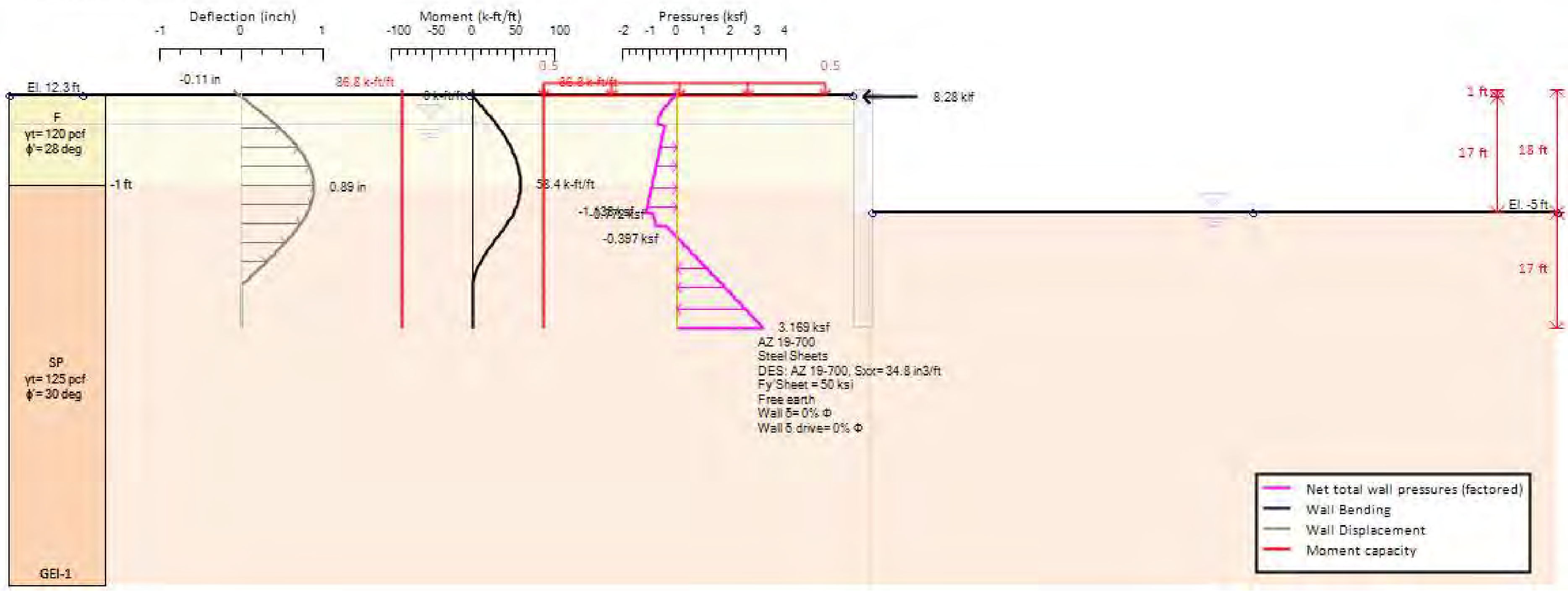
DeepEX Output –North Wall Final Stage

Northwest Hydraulic – Alice Bay Tide Gate
Skagit County, WA

GEOENGINEERS

Figure 1

Wall Toe Safety:	AZ 19-700
Min FS=	1.563
FS Embed=	1.563
FS Rot.=	2.596
Req. toe FS=1:	10.873 ft
Toe El. FS=1:	-15.873 ft
Note:	Toe FS >=1
FS Basal=	2.806
Basal standard	2.806
Basal standard	2.806



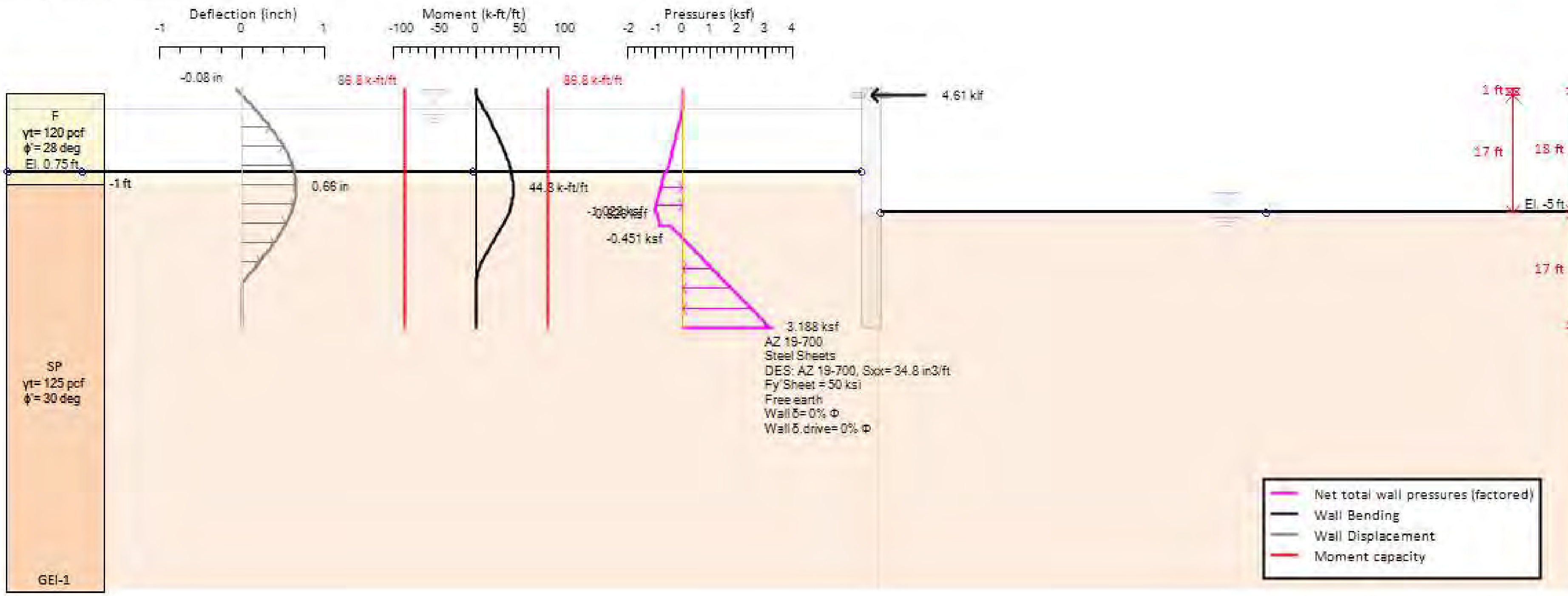
DeepEX Output –West Wall
Final Stage

Northwest Hydraulic – Alice Bay Tide Gate
Skagit County, WA

GeoEngineers

Figure 2

Wall Toe Safety:	AZ 19-700
Min FS=	1.633
FS Embed=	1.633
FS Rot.=	2.798
Req. toe FS=1:	10.412 ft
Toe El. FS=1:	-15.412 ft
Note:	Toe FS >=1
FS Basal=	2.605
Basal standard	2.605
Basal standard	2.605



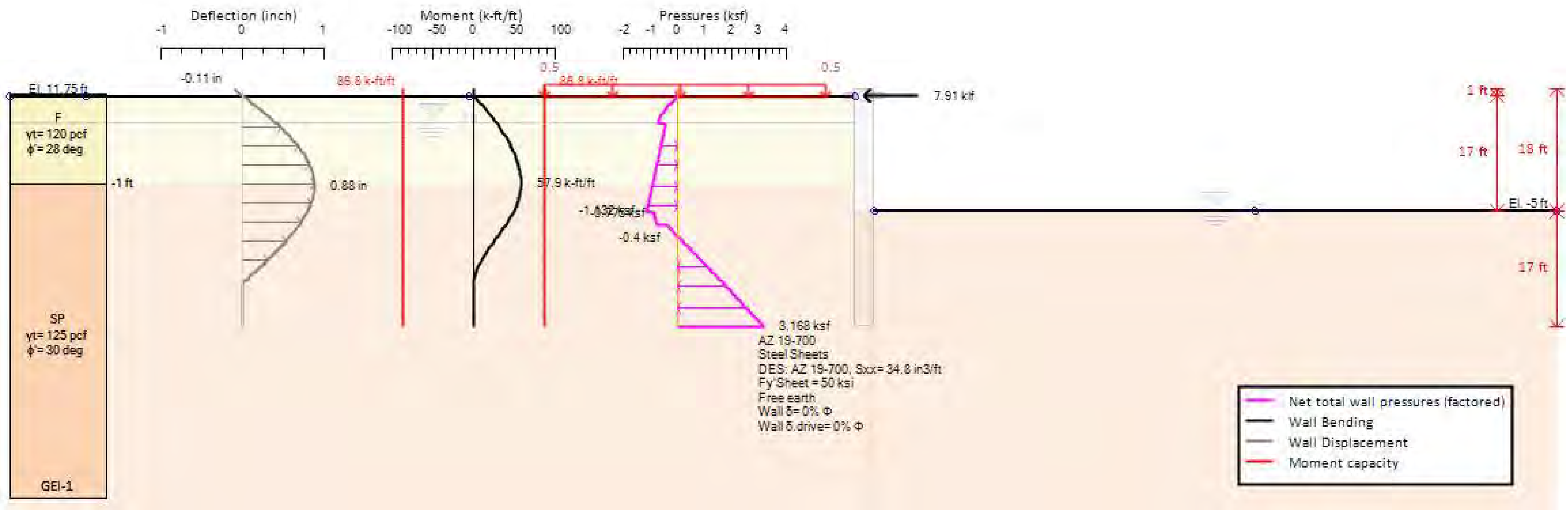
DeepEX Output – South Wall
Final Stage

Northwest Hydraulic – Alice Bay Tide Gate
Skagit County, WA

GeoEngineers

Figure 3

Wall Toe Safety:	AZ 19-700
Min FS=	1.565
FS Embed=	1.565
FS Rot.=	2.6
Req. toe FS=1:	10.86 ft
Toe El. FS=1:	-15.86 ft
Note:	Toe FS >=1
FS Basal=	2.814
Basal standard	2.814
Basal standard	2.814



DeepEX Output – East Wall
Final Stage

Northwest Hydraulic – Alice Bay Tide Gate
Skagit County, WA

GeoEngineers

Figure 4

Bracing Design Worksheet - Wale

GeoEngineers

Job No.:	0220-106-00	Design by:	TB
Project:	Northwest Hydraulic - Alice Bay Tide Gate	Reviewed by:	AG
Subject:	Level 1 Long Wale	Date:	12/30/2022

- Member Design - AISC Manual of Steel Construction, ASD, 9th Edition -

Input Parameters

1. Uniform Distributed Load,w (kips/ft)	8.28	6. Max Cantilever Span, L2 (ft)			0
2. Tributary Area Acting on Wale (Axial) ft	25.50	7a. Lb (compression flange, ft)			14
3. Axial Load, P (kips)	211.1	7b.Transverse Stiffener Spacing, Ls (ft)			0.00
4. Number of interior spans, n	1	8a. Lx (ft)	30.00	8b. Ly (ft)	14
5. Max Interior Span, L1 (ft)	30.00	9a. Kx	1	9b. Ky	1

Wale Forces

10. Bending moment factor (8,10,12, etc)		8	14. Interior shear factor (0.5,0.6, etc)			0.5
11. Max interior moment, M1x	(ft-kips) =	932	15. Max interior shear, V1		(kips) =	124
12. Cantilever moment 0.5	(ft-kips) =	0	16. Cantilever shear, V2		(kips) =	0
13. Maximum moment, Mx	(ft-kips) =	932	17. Max shear*1.2, V		(kips) =	149

Wale Section Properties *(Based on AISC, LRFD, 3rd Edition)*

W30X173   Fy (ksi) 50

wt (lb/ft) =	173	Ix (in^4) =	8230	18. Self wt moment, My (ft-kips)=	4.2
A (in^2) =	51	Sx (in^3) =	541		
d (in) =	30.4	rx (in) =	12.7	19a. Compact Section Check	
tw (in) =	0.655	Iy (in^4) =	598	bf/2tf = 7.0	compact flange
bf (in) =	15.0	Sy (in^3) =	79.8	d/tw = 46.4	compact web
tf (in) =	1.070	ry (in) =	3.42		
k (in) =	1.85	rT (in) =	4.0	19b. Unbraced Length Check & Fb equations	
T (in) =	26.7	Lc (ft) =	13.4	Lb > Lc	Fbx = 0.60 Fy
		Lu (ft) =	17.6	Lu > = Lb	
		Lb/rT =	42.4	ASD F1.3 -	Fbx = ASD (F1-6) is N/A
				F1.3 is N/A	Fbx = ASD (F1-7) is N/A
					Fbx = ASD (F1-8) is N/A

Deflection

20. Cantilever Deflection (in) =	0.00		
21. Midspan Deflection (in) =	0.63	Fby =	0.75 Fy
21a. Self Weight Deflection (in)=	0.18	Max Fbx =	0.60 Fy

Stresses

22. Cc	=	107.0		28. X-Bending, fbx	(ksi) =	20.7
23. Kx(Lx)/rx	=	28.3		29. Allowable, Fbx	(ksi) =	30.0
24. Ky(Ly)/ry	=	49.1		30. Y-Bending, fby	(ksi) =	0.6
25. Max KL/r	=	49.1	< Cc	31. Allowable, Fby	(ksi) =	37.5
26. Axial, fa	(ksi) =	4.1		32. Shear, fv	(ksi) =	7.5
27. Allowable, Fa	(ksi) =	24.5		33. Allowable, Fv	(ksi) =	20.0

Unit Stresses

34. fa/Fa	=	0.17	H1-1 & H1-2 apply	
35. fbx/Fbx	=	0.69		
36. fby/Fby	=	0.02		
37. Cmx		1.0		
38. Cmy		1.0		
39. F`ex	(ksi) =	185.8		
40. F`ey	(ksi) =	61.9		
41. fv/Fv	=	0.37	<= 1.0	**OK**

Combined Stresses

	Axial	X-Bending	Y-Bending	Sum
42. H1-1:	0.17	0.70	0.02	0.89
43. H1-2:	0.14	0.69	0.02	0.84
44. H1-3:	0.17	0.69	0.02	0.87

H1-1 Sum = 0.89 <= 1.20 **OK**

Bracing Design Worksheet - Wale

GeoEngineers

Job No.:	0220-106-00	Design by:	TB
Project:	Northwest Hydraulic - Alice Bay Tide Gate	Reviewed by:	AG
Subject:	Level 1 Short Wale	Date:	12/30/2022

- Member Design - AISC Manual of Steel Construction, ASD, 9th Edition -

Input Parameters

1. Uniform Distributed Load,w (kips/ft)	4.61	6. Max Cantilever Span, L2 (ft)			0
2. Tributary Area Acting on Wale (Axial) ft	8.50	7a. Lb (compression flange, ft)			14
3. Axial Load, P (kips)	39.2	7b.Transverse Stiffener Spacing, Ls (ft)			0.00
4. Number of interior spans, n	1	8a. Lx (ft)	46.00	8b. Ly (ft)	14
5. Max Interior Span, L1 (ft)	46.00	9a. Kx	1	9b. Ky	1

Wale Forces

10. Bending moment factor (8,10,12, etc)		8	14. Interior shear factor (0.5,0.6, etc)		0.5
11. Max interior moment, M1x	(ft-kips) =	1219	15. Max interior shear, V1	(kips) =	106
12. Cantilever moment 0.5	(ft-kips) =	0	16. Cantilever shear, V2	(kips) =	0
13. Maximum moment, Mx	(ft-kips) =	1219	17. Max shear*1.2, V	(kips) =	127

Wale Section Properties *(Based on AISC, LRFD, 3rd Edition)*

W30X173   Fy (ksi) 50

wt (lb/ft) =	173	Ix (in^4) =	8230	18. Self wt moment, My (ft-kips)=	4.2
A (in^2) =	51	Sx (in^3) =	541		
d (in) =	30.4	rx (in) =	12.7	19a. Compact Section Check	
tw (in) =	0.655	Iy (in^4) =	598	bf/2tf = 7.0	compact flange
bf (in) =	15.0	Sy (in^3) =	79.8	d/tw = 46.4	compact web
tf (in) =	1.070	ry (in) =	3.42		
k (in) =	1.85	rT (in) =	4.0	19b. Unbraced Length Check & Fb equations	
T (in) =	26.7	Lc (ft) =	13.4	Lb > Lc Fbx =	0.60 Fy
		Lu (ft) =	17.6	Lu > = Lb	
		Lb/rT =	42.4	ASD F1.3 - Fbx =	ASD (F1-6) is N/A
				F1.3 is N/A Fbx =	ASD (F1-7) is N/A
				Fbx =	ASD (F1-8) is N/A

Deflection

20. Cantilever Deflection (in) =	0.00		
21. Midspan Deflection (in) =	1.95	Fby =	0.75 Fy
21a. Self Weight Deflection (in)=	1.00	Max Fbx =	0.60 Fy

Stresses

22. Cc	=	107.0		28. X-Bending, fbx	(ksi) =	27.0
23. Kx(Lx)/rx	=	43.5		29. Allowable, Fbx	(ksi) =	30.0
24. Ky(Ly)/ry	=	49.1		30. Y-Bending, fby	(ksi) =	0.6
25. Max KL/r	=	49.1	< Cc	31. Allowable, Fby	(ksi) =	37.5
26. Axial, fa	(ksi) =	0.8		32. Shear, fv	(ksi) =	6.4
27. Allowable, Fa	(ksi) =	24.5		33. Allowable, Fv	(ksi) =	20.0

Unit Stresses / **Combined Stresses**

34. fa/Fa	=	0.03	H1-3 applies		Axial	X-Bending	Y-Bending	Sum
35. fbx/Fbx	=	0.90						
36. fby/Fby	=	0.02		42. H1-1:	0.03	0.91	0.02	0.96
37. Cmx		1.0		43. H1-2:	0.03	0.90	0.02	0.94
38. Cmy		1.0		44. H1-3:	0.03	0.90	0.02	0.95
39. F`ex	(ksi) =	79.0						
40. F`ey	(ksi) =	61.9						
41. fv/Fv	=	0.32	<= 1.0 **OK**		H1-3 Sum =	0.95	<= 1.20	**OK**

Bracing Design Worksheet - Strut

GeoEngineers

Job No.:	0220-106-00	Design by:	TB
Project:	Northwest Hydraulic - Alice Bay Tide Gate	Reviewed by:	AG
Subject:	Brace - Strut W-Flange	Date:	12/30/2022

Wideflange Strut Section Properties 1

6. Uniform Load on Wale,w (kips/ft)	8.28	3. Strut Length,L (ft)	46.00
		4a. Lbx (ft) 46.00 4b. Lby (ft)	46.00
7. Tributary Area Acting on Strut (ft)	23.50	5. Strut Angle from Wale (deg)	90

W14X145 Fy (ksi) 50

ORIENTATION: (●) WEB VERTICAL ( ) WEB HORIZONTAL

wt (lb/ft) =	145	Ix (in^4) =	1710
A (in^2) =	42.7	Sx (in^3) =	232
d (in) =	14.8	rx (in) =	6.3
tw (in) =	0.680	Iy (in^4) =	677
bf (in) =	15.5	Sy (in^3) =	87.3
tf (in) =	1.090	ry (in) =	3.98
k (in) =	1.69	rT (in) =	4.3
T (in) =	11.4	Lc (ft) =	13.9
		Lu (ft) =	38.1
		Lbx/rT =	128.5

32. Self wt moment, M (ft-kips)= 38.4

bf/2tf = 7.1 compact flange
d/tw = 21.8 compact web

Unbraced Ck -Applies only for web vertical
Lbx > Lc Fbx = Refer to ASD F1.3
Lbx > Lu
ASD F1.3 - Fbx = ASD (F1-6) is N/A
(F1-7) applies Fbx = 0.21 Fy (F1-7)
(F1-8) applies Fbx = 0.50 Fy (F1-8)

Fby = 0.75 Fy

Deflection/P-Delta
33. Midspan Deflection (in) = 0.29
34. 2nd Order Moment (ft-kips) = 5.9

Wideflange Strut Section Stresses

35. Cc	=	107.0		41. X-Bending, fbx (ksi) =	2.3
36. Kx(Lbx)/rx	=	87.2		42. Allowable, Fbx (ksi) =	24.8
37. Ky(Lby)/ry	=	138.7		43. Y-Bending, fby (ksi) =	0.0
38. Max KL/r	=	138.7	>= Cc	44. Allowable, Fby (ksi) =	37.5
39. Axial, fa	(ksi) =	5.6			
40. Allowable, Fa	(ksi) =	7.8			

Wideflange Unit Stresses

45. fa/Fa	=	0.72	H1-1 & H1-2 apply
46. fbx/Fbx	=	0.09	
47. fby/Fby	=	0.00	
48. Cmx		1.0	
49. Cmy		1.0	
50. F`ex	ksi =	19.6	
51. F`ey	ksi =	7.8	

	Axial	X-Bending	Y-Bending	Sum
52. H1-1:	0.72	0.13	0.00	0.85
53. H1-2:	0.19	0.09	0.00	0.28
54. H1-3:	0.72	0.09	0.00	0.81

H1-1 Sum = 0.85 <= 1.0 **OK**

Subject: Internal Bracing Connection Design for the temporary support of excavation of Dike District 12 - No Name Slough Tide Gate project located in Skagit County, WA.

References:

- American Institute of Steel Construction (AISC) - Allowable Stress Design (ASD) Design Manual, 9th Ed.

Assumptions:

Use A992, Gr. 50 Steel $F_{y50} := 50\ ksi$ $F_{u50} := 65\ ksi$ $E := 29000\ ksi$

Steel plate (A36) $F_{y36} := 36\ ksi$ $F_{360} := 58\ ksi$

Electrodes $F_{exx} := 70\ ksi$ $F_v := 0.3 \cdot F_{exx} = 21\ ksi$

Wale to Wale Connection

Bracing Properties:

Design Section C:

Wale A is W30X173

Member A Size	W30X173	T (in)=	26.50		

$wt_A = 173\ plf$ $A_A = 51\ in^2$ $d_A = 30.4\ in$ $k_A = 1.85\ in$

$T_A = 26.5\ in$ $b_{fA} = 15\ in$ $t_{fA} = 1.07\ in$ $t_{wA} = 0.66\ in$

Wale B is W30X173

Member B Size	W30X173	T (in)=	26.50		

$wt_B = 173\ plf$ $A_B = 0.35\ ft^2$ $d_B = 30.4\ in$ $k_B = 1.85\ in$

$T_B = 26.5\ in$ $b_{fB} = 15\ in$ $t_{fB} = 1.07\ in$ $t_{wB} = 0.66\ in$

Design Loads:

Wale A will be framed into Wale B $R_A := 4.61\ klf$

Maximum Bearing Load $P_b := R_A \cdot \dfrac{46\ ft}{2} = 106.03\ kip$

Angle of connection $\theta := 90\ deg$

Maximum shear load $V_d := P_b = 106.03\ kip$

Connection Design:

Design for axial load transfer in bearing in Accordance with AISC J-8.

Allowable Bearing Stress $F_p := 0.9 \cdot F_{y50} = 45\ ksi$

Bearing area $A_b := A_A = 51\ in^2$

Check Bearing Compressive Stress $f_p := \dfrac{P_b}{A_b} = 2.08\ ksi$

$$Evaluate\_Bearing\_Compressive\_Stress := \text{if } F_p > f_p$$
"Bearing compressive stress is OK"
else
"Bearing compressive stress is NOT GOOD"

$Evaluate\_Bearing\_Compressive\_Stress =$ "Bearing compressive stress is OK"

Transfer shear load from strut to wale with fillet weld

Check thicknesses of welds $t_{weld} := \dfrac{5}{16}\ in = 0.31\ in$

$$\text{if } t_{weld} < min\left(t_{fB}, t_{wA}\right) - \frac{1}{16}\ in$$
"Weld's thickness is adequate"
else
"Weld's thickness is NOT adequate"

= "Weld's thickness is adequate"

Compute effective throat of fillet weld $t_e := t_{weld} \cdot \cos\left(\dfrac{90}{2}\ deg\right) = 0.22\ in$

Compute capacity of fillet weld $R_w := t_e \cdot F_v = 4.64\ \dfrac{kip}{in}$

Compute minimum required length of fillet weld $L_w := \dfrac{V_d}{R_w} = 22.85\ in$

Weld length along web $l_{web} := T_A = 26.5\ in$ Say, $l_{web} := 20\ in$

Weld length along outside flange $l_{f1} := min\left(b_{fA}, b_{fB}\right) = 15\ in$ Say, $l_{f1} := 12\ in$

Total weld length $l_{total} := l_{web} + l_{f1} = 32\ in$

if $l_{total} > L_w$
    "Weld length is adequate "
else
    "Weld length is NOT adequate"
= "Weld length is adequate "

Verify Strength of Weld Controls Design

Verify that strength of weld controls the design as assumed for above check
Minimum base material thickness controls (i.e. thickness of web)

Critical weld is fillet weld along web of wale

Ultimate tensile strength of A572 (Gr. 50) $F_{u50} := 65\ ksi$

Compute allowable web shear stress $R_{web} := t_{wA} \cdot 0.4 \cdot F_{y50} = 13.1\ \frac{kip}{in}$

Compute web shear rupture stress $R_{webr} := t_{wA} \cdot 0.3 \cdot F_{u50} = 12.77\ \frac{kip}{in}$

Determine controlling stress:

Determine_Controlling_Stress := if $R_{webr} < R_{web}$
    "Web shear rupture stress controls the design"
else
    "Web shear stress controls the design"

Determine_Controlling_Stress = "Web shear rupture stress controls the design"

Check the weld strength $R_{weld} := t_e \cdot F_v = 4.64\ \frac{kip}{in}$

if $R_{weld} < R_{webr}$
    "Strength of fillet weld controls the design"
else
    "Web shear rupture stress controls the design"
= "Strength of fillet weld controls the design"

Stiffener Requirements:

Determine if stiffeners are required per AISC Chapter-K.
Check connection at the interior of the wale

Bearing force as delivered by the wale (from above)

$$P := P_b = 106.03\ kip$$

Length of bearing is the bearing length of the wale

$$N := \frac{d_A}{\sin(\theta)} = 30.4\ in$$

Check Local Web Yielding
(AISC K1-3)

$$\frac{P}{t_{wB} \cdot (N + 2.5 \cdot k_B)} = 4.62\ ksi$$

$$0.66 \cdot F_{y50} = 33\ ksi$$

$$\text{if } \frac{P}{t_{wB} \cdot (N + 2.5 \cdot k_B)} < 0.66 \cdot F_{y50} \ \| \text{“OK”} \ \text{else} \ \| \text{“NOT GOOD”} = \text{“OK”}$$

Check Web Crippling
(AISC K1-5)

$$R := 34 \cdot \left(\frac{t_{wB}}{in}\right)^2 \cdot \left(1 + 3 \cdot \frac{N}{d_B} \cdot \left(\left(\frac{t_{wB}}{t_{fB}}\right)^{1.5}\right)\right) \cdot \sqrt[2]{\frac{F_{y50}}{ksi} \cdot \frac{t_{fB}}{t_{wB}}}\ kip = 321.25\ kip$$

$$P = 106.03\ kip$$

$$\text{if } R > P \ \| \text{“OK”} \ \text{else} \ \| \text{“NOT GOOD”} = \text{“OK”}$$

<u>Check Web Buckling</u>
(AISC K1-7)

$d_c := d_A - 2 \cdot k_A = 2.23\ ft$

$b_f := b_{fA} = 1.25\ ft$

$L_1 := 32\ ft$

$t_w := t_{wA} = 0.05\ ft$

$h_A = 1.25\ ft$

Since the loaded flange is not restrained against rotation:

$$R := \text{if } \frac{\frac{d_c}{t_w}}{\frac{L_1}{b_f}} < 1.7 \;\; \left\| \; 6800 \cdot kip \cdot \frac{t_w^{\,3}}{in^2 \cdot h_A} \left(0.4 \cdot \left(\frac{\frac{d_c}{t_w}}{\frac{L_1}{b_f}} \right)^3 \right) \right. \;\; \text{else} \;\; \| \text{"Eq 1-6 check is not required"} \;\; = 205.73\ kip$$

$P = 106.03\ kip$

$$\text{if } R > P \;\; \| \text{"OK"} \;\; \text{else} \;\; \| \text{"NOT GOOD"} \;\; = \text{"OK"}$$

Stiffener are not required. Design stiffeners for conservatism.

Design stiffeners for wale:

Try 1/2" thick stiffener $t_s := \frac{1}{2}\ in$

Compute Maximum depth of stiffener $b_s := \text{trunc}\left(\frac{b_{fB} - t_{wB}}{2} \div in\right) \cdot in = 7\ in$ Say, $b_s := 4\ in$

Try 1/2" thick x 4" wide stiffeners
Compute area the pair of stiffeners $A_s := 2\ (t_s \cdot b_s) = 4\ in^2$

Compute length of web in compression $L_w := min\left(25 \cdot t_{wB} + 25 \cdot t_{wB}, N + 25 \cdot t_{wB}\right) = 32.75\ in$

Compute total area of web in compression $A_w := L_w \cdot t_{wB} = 21.45\ in^2$

Compute Moment of inertia of stiffened section $I := 2 \cdot \frac{t_s \cdot \left(2 \cdot b_s + t_{wB}\right)^3}{12} = 54.03\ in^4$

Compute Radius of Gyration of stiffened section $r := \sqrt{\frac{I}{2 \cdot A_s + A_w}} = 1.35\ in$

Compute slenderness ratio separating elastic and inelastic buckling of stiffened section $C_c := \sqrt{\frac{2 \cdot \pi^2 \cdot E}{F_{y36}}} = 126.1$

Depth of web (excluding flanges) $h := d_B - 2 \cdot t_{fB} = 28.26\ in$

Compute effective length of stiffened section $KL := 0.75 \cdot h = 21.2\ in$

Check effective slenderness for elastic buckling

if $C_c > \frac{KL}{r}$
  "Effective slenderness is adequate"
= "Effective slenderness is adequate"

Compute stress in web & stiffeners $f_a := \frac{P}{2 \cdot A_s + A_w} = 3.6\ ksi$

Compute allowable stress in web & stiffeners

$$F_a := \frac{\left(1 - \frac{\left(\frac{KL}{r}\right)^2}{2 \cdot C_c^{\,2}}\right) \cdot F_{y36}}{\frac{5}{3} + \frac{3 \cdot \frac{KL}{r}}{8 \cdot C_c} - \frac{\left(\frac{KL}{r}\right)^3}{8 \cdot C_c^{\,3}}} = 20.85\ ksi$$

Check stress in web and stiffeners

$$Stress\_in\_web\_and\_stiffeners := \text{if } F_a > f_a \;\; \| \; \text{"OK"} \;\; \text{else} \;\; \| \; \text{"Redesign"} \quad = \text{"OK"}$$

Stiffener connection:

Weld stiffener to web for compressive force to transfer per stiffener

Transfer compressive force taken by stiffeners using a 1/4" fillet weld

Check thickness of weld

$$t_{weld} := \frac{1}{4}\ in = 0.25\ in$$

$$min\left(t_s, t_{wB}\right) - \frac{1}{16}\ in = 0.44\ in$$

$$\text{if } t_{weld} < min\left(t_s, t_{wB}\right) - \frac{1}{16}\ in \;\; \| \; \text{"Weld's thickness is adequate"} \;\; \text{else} \;\; \| \; \text{"Weld's thickness is NOT adequate"} \quad = \text{"Weld's thickness is adequate"}$$

Compute effective throat of fillet weld

$$t_e := t_{weld} \cdot \cos\left(\frac{90 \cdot deg}{2}\right) = 0.18\ in$$

Compute Shear force on stiffener

$$V_s := f_a \cdot \left(\frac{A_s}{2}\right) = 7.2\ kip$$

Compute capacity of fillet weld $R_w := t_e \cdot F_v = 3.71\ \frac{kip}{in}$

Compute minimum required length of fillet weld $L_w := \frac{V_s}{R_w} = 1.94\ in$

Weld continuously along one side of stiffener plate (Assume that inside corners are cut by 1-in. @ea. end to account for web fillets)

<u>Check length of weld</u> $L_s := \text{trunc}\left(\frac{h - 2 \cdot in}{in}\right) \cdot in = 26\ in$

if $L_s > L_w$
  "Weld's length is adequate"
else
  "Weld's length is NOT adequate"

= "Weld's length is adequate"

Compute stiffener bearing area $A_b := \left(b_s - 1\ in\right) \cdot t_s = 1.5\ in^2$

Compute allowable stiffener bearing stress $F_p := 0.9 \cdot F_{y36} = 32.4\ ksi$

Compute actual stiffener bearing stress $f_b := \frac{V_s}{A_b} = 4.8\ ksi$

<u>Check bearing stress on end of stiffener plate</u>

if $F_p > f_p$
  "Bearing stress is adequate"
else
  "Bearing stress is NOT adequate"

= "Bearing stress is adequate"

<u>Summary:</u>

Provide 5/16-in fillet welds for 20" along top of web and 12" outer flange (see plans) . Provide 1/2-in thick x 4-in wide stiffener plates ea. side of wale web, welded to web along one side of stiffener plate for full depth using a 1/4-in fillet weld. See plans for connection details

90 Degree Corner Strut to Wale Connection

Strut load $P_{ax} := 238 \cdot kip$

Strut angle from wale $\alpha := 90\ deg$

Normal force at connection $P_n := P_{ax} \cdot \sin(\alpha) = 238\ kip$

Shear transfer at connection $P_v := 0.2 \cdot P_n = 47.6\ kip$

Wale - W30x173

Member A Size	W30X173	T (in)=	26.50		

$wt_A = 173\ plf$ $A_A = 0.35\ ft^2$ $d_A = 30.4\ in$ $k_A = 1.85\ in$

$T_A = 26.5\ in$ $b_{fA} = 15\ in$ $t_{fA} = 1.07\ in$ $t_{wA} = 0.66\ in$

Strut - W14x120:

Member A Size	W14X145	T (in)=	10.00		

$wt_B = 145\ plf$ $A_B = 0.3\ ft^2$ $d_B = 14.8\ in$ $k_B = 1.69\ in$

$T_B = 10\ in$ $b_{fB} = 15.5\ in$ $t_{fB} = 1.09\ in$ $t_{wB} = 0.68\ in$

Design for axial load transfer in bearing in Accordance with AISC J-8.

Allowable Bearing Stress $F_p := 0.9 \cdot F_{y50} = 45\ ksi$

Bearing area $A_b := A_B - \left(\left(b_{fB} - b_{fA}\right) \cdot t_{fB} \cdot 2\right) = 41.61\ in^2$

Check Bearing Compressive Stress $F_p = 45\ ksi$

$f_p := \frac{P_n}{A_b} = 5.72\ ksi$

if $F_p > f_p$
  "OK"
else
  "NOT GOOD"
= "OK"

Transfer shear with weld:

Check thickness of weld

Web weld

$$t_{min} := min\left(t_{wA}, t_{wB}\right) - \frac{1}{16} \cdot in = 0.5925\ in$$

OK

$$t_{weld} := \frac{5}{16} \cdot in = 0.3125\ in$$

$$\begin{array}{l} \text{if } t_{weld} < t_{min} \\ \quad \| \text{"OK"} \\ \text{else} \\ \quad \| \text{"NOT GOOD"} \end{array} = \text{"OK"}$$

Effective throat of
90-deg fillet weld

$$t_e := t_{weld} \cdot \cos\left(\frac{90 \cdot deg}{2}\right) = 0.22\ in$$

$$R_{w1} := t_e \cdot F_v = 4.64\ \frac{kip}{in}$$

Flange weld - open angle:

$$t_{weld} := \frac{5}{16}\ in = 0.31\ in$$

Effective throat

$$t_e := t_{weld} \cdot \cos\left(\frac{180 \cdot deg - \alpha}{2}\right) = 0.22\ in$$

$$R_{w2} := t_e \cdot F_v = 4.64\ \frac{kip}{in}$$

Flange weld - interior angle

$$t_{pjp} := \frac{5}{16}\ in = 0.31\ in$$

$$t_{min} := min\left(t_{wA}, t_{wB}\right) - \frac{1}{16} \cdot in = 0.5925\ in$$

$$\begin{array}{l} \text{if } t_{weld} < t_{min} \\ \quad \| \text{"OK"} \\ \text{else} \\ \quad \| \text{"NOT GOOD"} \end{array} = \text{"OK"}$$

Effective throat $t_e := t_{pjp} - \frac{1}{8} \cdot in = 0.19\ in$

$R_{w3} := t_e \cdot F_v = 3.94\ \frac{kip}{in}$

Length of weld along web $l_{web} := \frac{d_B - 2 \cdot k_B}{\cos(90\ deg - \alpha)} = 11.42\ in$ Say, $l_{web} := 18\ in$

Length of weld along flange $l_{fl} := 2 \cdot b_{fA} - 2 \cdot k_B = 26.62\ in$ Say, $l_{fl} := 0\ in$

Weld 9" along web both sides Web Vertical - no room for top weld along flange

Weld strength $P_{weld} := l_{web} \cdot R_{w1} + l_{fl} \cdot (R_{w2} + R_{w3}) = 83.53\ kip$

$P_v = 47.6\ kip$

$$\text{if } P_{weld} > P_v \ \| \text{"OK"} \ \text{else} \ \| \text{"NOT GOOD"} = \text{"OK"}$$

Determine if stiffeners are required per AISC Chapter-K

Axial force as delivered by the brace (from above) $P := P_n = 238\ kip$

Length of bearing is the bearing length of the brace $N := \frac{d_B}{\cos(90\ deg - \alpha)} = 14.8\ in$

Check Local Web Yielding (AISC K1-3): $\frac{P}{t_{wB} \cdot (N + 5 \cdot k_A)} = 14.6\ ksi$

$0.6 \cdot F_{y50} = 30\ ksi$

$$\text{if } \frac{P}{t_{wB} \cdot (N + 5 \cdot k_A)} < 0.6\ F_{y50} \ \| \text{"OK"} \ \text{else} \ \| \text{"NOT GOOD"} = \text{"OK"}$$

Check Web Crippling (AISC K1-5):

$$R := 67.5 \cdot \left(\frac{t_{wA}}{in}\right)^2 \cdot \left(1 + 3 \cdot \frac{N}{d_A} \cdot \left(\left(\frac{t_{wA}}{t_{fA}}\right)^{1.5}\right)\right) \cdot \sqrt{\frac{F_{y50}}{ksi} \cdot \frac{t_{fA}}{t_{wA}}} \cdot kip = 444.8\ kip$$

$$P = 238.00\ kip$$

$$\begin{array}{l} \text{if } R > P \\ \quad \text{"OK"} \\ \text{else} \\ \quad \text{"NOT GOOD"} \end{array} = \text{"OK"}$$

Stiffeners are not required. However provide stiffeners to increase stability.

Try 1/2" thick stiffener to full depth of flange $t_s := \frac{1}{2} \cdot in$

Compute Maximum depth of stiffener $b_s := \frac{b_{fA} - t_{wA}}{2} = 7.17\ in$

Try 1/2" thick x 4" wide stiffeners
to full depth of flange say $b_s := 4 \cdot in$

Compute area of the pair of stiffeners $A_s := 2 \cdot (t_s \cdot b_s) = 4\ in^2$

Compute total area of web in compression $A_w := N \cdot t_{wA} + 25 \cdot t_{wA}^2 = 20.42\ in^2$

Compute Moment of inertia of stiffened section $I := \frac{2 \cdot t_s \cdot (2 \cdot b_s + t_{wA})^3}{12} = 54.03\ in^4$

Compute Radius of Gyration of stiffened section $r := \sqrt{\frac{I}{2 \cdot A_s + A_w}} = 1.38\ in$

Compute slenderness ratio separating elastic and inelastic buckling of stiffened section $C_c := \sqrt{\frac{2 \cdot \pi^2 \cdot E}{36 \cdot ksi}} = 126.1$

Depth of web (excluding flanges) $h := d_A - 2 \cdot t_{fA} = 28.26\ in$

Compute effective length of stiffened section $KL := 0.75 \cdot h = 21.2\ in$

Check effective slenderness for elastic buckling

$C_c = 126.1$

$\frac{KL}{r} = 15.37$

$$\text{if } C_c > \frac{KL}{r} \;\; \| \text{“OK”} \;\; \text{else} \;\; \| \text{“NOT GOOD”} \quad = \text{“OK”}$$

Compute stress in web & stiffeners

$$f_a := \frac{P}{2 \cdot A_s + A_w} = 8.37 \ ksi$$

Compute allowable stress in web & stiffeners

$$F_a := \frac{\left(1 - \frac{\left(\frac{KL}{r}\right)^2}{2 \cdot C_c^{\ 2}}\right) \cdot 36 \cdot ksi}{\frac{5}{3} + \frac{3 \cdot \frac{KL}{r}}{8 \cdot C_c} - \frac{\left(\frac{KL}{r}\right)^3}{8 \cdot C_c^{\ 3}}} = 20.87 \ ksi$$

Check stress in web & stiffeners

$f_a = 8.37 \ ksi$

$$\text{if } F_a > f_a \;\; \| \text{“OK”} \;\; \text{else} \;\; \| \text{“NOT GOOD”} \quad = \text{“OK”}$$

Weld stiffener to web for compressive force to transfer per stiffener

Transfer compressive force taken by stiffeners using a 1/4-in fillet weld

Check thickness of weld

$$t_{weld} := \frac{1}{4} \cdot in = 0.25 \ in$$

$$t_s - \frac{1}{16} \cdot in = 0.438 \ in$$

$$\text{if } t_{weld} < t_s - \frac{1}{16}\,in \;\; \text{"OK" else "NOT GOOD"} = \text{"OK"}$$

Compute effective throat of fillet weld $t_e := t_{weld} \cdot \cos\left(\frac{90 \cdot deg}{2}\right) = 0.177\ in$

Compute capacity of fillet weld $R_w := t_e \cdot F_v = 3.71\ \frac{kip}{in}$

Compute Shear force on stiffener $V_s := f_a \cdot \left(\frac{A_s}{2}\right) = 16.75\ kip$

Compute minimum required length of fillet weld $L_w := \frac{V_s}{R_w} = 4.51\ in$

Weld continuously along one side of stiffener plate (Assume that inside corners are cut by 1-in. @ ea. end to account for web fillets)

Check length of weld $L_s := h - 2 \cdot in = 26.26\ in$

$L_w = 4.5\ in$

$$\text{if } L_s > L_w \;\; \text{"OK" else "NOT GOOD"} = \text{"OK"}$$

Compute stiffener bearing area $A_b := \left(b_s - 1 \cdot in\right) \cdot t_s = 1.5\ in^2$

Compute allowable stiffener bearing stress $F_p := 0.9 \cdot 36 \cdot ksi = 32.4\ ksi$

Compute actual stiffener bearing stress $f_p := \frac{V_s}{A_b} = 11.17\ ksi$

Check bearing stress on end of stiffener plate

$F_p = 32.4\ ksi$

```
if Fp > fp      | = "OK"
  || "OK"
else
  || "NOT GOOD"
```

Summary:

Provide 5/16-in fillet welds for 9-in along both sides of web Strut (see plans) . Provide 1/2-in thick x 4-in wide stiffener plates ea. side of Wale web, welded to web along one side of stiffener plate for full depth using a 1/4-in fillet weld. See plans for connection details.

Subject: Internal Bracing Wale Seat Design for Alice Bay Temporary SOE

References:

- American Institute of Steel Construction (AISC) - Allowable Stress Design (ASD) Design Manual, 9th Ed.

Assumptions:

Use A992, Gr. 50 Steel	$F_{y50} := 50\ ksi$	$F_{u50} := 65\ ksi$	$E := 29000\ ksi$
Steel plate (A36)	$F_{y36} := 36\ ksi$	$F_{360} := 58\ ksi$	
Electrodes	$F_{exx} := 70\ ksi$	$F_v := 0.3 \cdot F_{exx} = 21\ ksi$	

Design Loads:

Consider that the seat carries wale weight. Add another 50lb/ft to account for soil or other live loads acting on the wale during erection of the bracing system:

Weight of the heaviest Wale (W30X173) $w_w := 173\ plf$

$w_{wale} := w_w + 50\ plf = 223\ plf$

Length of the Wale Supported by One Seat
(maximum spacing of every 3 sheets) $L_{wale} := 14\ ft$

Reaction from Wales $R := w_{wale} \cdot L_{wale} = 3.12\ kip$

Design Critical Wale Seat Section

Consider eccentricity of vertical wale load due to geometry, as-built tolerances, & wall deflection.

Consider a maximum eccentricity of 6-in from flange of wale.

Max. Eccentricity ot Wale
(blocking depth) $e := 6\ in$

Depth of Wale Section $d_w := 30.4\ in$

Max. Design Eccentricity $e_w := e + \frac{d_w}{2} = 21.2\ in$

Total Length of Wale Seat $l_s := e + d_w = 36.4\ in$

Max. Seat Length of 38-in *Say,* $l_s := 38\ in$

Determine Design Forces

Consider eccentricity of vertical wale load due to geometry and as-built tolerances

Design wale seat for the moment at the top due to wale weight, live load, and eccentricity.

Max. Moment in Wale Seat $M_x := R \cdot e_w = 5.52\ ft \cdot kip$

Check Wale Seat Structural Capacity

Try an HP12x53 section

Member A Size	HP12X53	T (in)=	9.50		

$d_A = 11.8\ in$ $A_A = 15.5\ in^2$ $b_{fA} = 12\ in$ $r_{xA} = 5.03\ in$ $S_{xA} = 66.7\ in^3$

$T_A = 9.5\ in$ $t_{wA} = 0.44\ in$ $t_{fA} = 0.44\ in$ $r_{yA} = 2.86\ in$ $S_{yA} = 21.1\ in^3$

Check Bending Capacity

Compute Bending Stress: $f_b := \frac{M_x}{S_{xA}} = 0.99\ ksi$

Evaluate Compact Section Criteria
(per ASD Table B5.1)

if $\frac{b_{fA}}{2 \cdot t_{fA}} > \frac{95}{\sqrt{F_{y50} \div ksi}}$
  "Flange is Non-Compact"
else
  "Flange is Compact"

= "Flange is Non-Compact"

if $\frac{d_A}{t_{wA}} < \frac{640}{\sqrt{F_{y50} \div ksi}}$
  "Web is Compact"
else
  "Web is Non-Compact"

= "Web is Compact"

Compute Allowable Bending Stress
(per ASD Eq. F1-3)

Allowable Bending Stress of Non-Compact Section

$$F_b := F_{y50} \cdot \left(0.79 - 0.002 \cdot \frac{b_{fA}}{2 \cdot t_{fA}} \cdot \sqrt{\frac{F_{y50}}{ksi}}\right) = 29.75\ ksi$$

Check Allowable Bending Stress

The allowable bending stress is the minimum of AISC Eq. F1-3 & F1-5

$$\text{if } f_b < min\left(F_b, 0.6 \cdot F_{y50}\right) \ \Vert\ \text{“OK”} \ \text{else} \ \Vert\ \text{“NOT GOOD”} = \text{“OK”}$$

Check Shear Capacity

$$f_v := \frac{R}{d_A \cdot t_{wA}} = 0.61\ ksi$$

$$F_v := 0.4 \cdot F_{y50} = 20\ ksi$$

$$\text{if } f_v < F_v \ \Vert\ \text{“OK”} \ \text{else} \ \Vert\ \text{“NOT GOOD”} = \text{“OK”}$$

Design Wale Seat Connection

Determine required amount of weld at wale seat to pile connection

Min. Base Material Thickness $t_w := 0.44\ in$

Try Weld Size $s := \frac{1}{4}\ in$

Check thickness of weld

$$\text{if } t_w - \frac{1}{16}\ in > s \ \Vert\ \text{“Weld's thickness is adequate”} \ \text{else} \ \Vert\ \text{“Weld's thickness is NOT adequate”} = \text{“Weld's thickness is adequate”}$$

Effective Weld Thickness $t_e := s \cdot \cos(45\ deg) = 0.18\ in$

Allowable Weld Stress (per AISC) $F_v := 0.3 \cdot F_{exx} = 21\ ksi$

Check Combined Shear & Bending Stress

Design weld along top of each flange and one side web

Length of Weld Along Each Flange $b_w := b_{fA} = 12\ in$ Say, $b_w := 6\ in$

Length of Weld Along One Side of Web $d_w := T_A = 9.5\ in$ Say, $d_w := 6\ in$

Compute Area of Welds $A_w := (d_w + 2 \cdot b_w) \cdot t_e = 3.18\ in^2$

Compute Moment of Inertia of Weld Group *(using superposition)*

Moment of Inertia of Flange Weld $I_{flanges} := 2 \cdot (t_e \cdot b_w) \cdot \left(\frac{d_A}{2}\right)^2 = 73.84\ in^4$

Moment of Inertia of Web Weld $I_{web} := \frac{t_e \cdot d_w^3}{12} = 3.18\ in^4$

Moment of Inertia of Weld Group $I_w := I_{web} + I_{flanges} = 77.03\ in^4$

Compute Weld Group Shear Stress $f_v := \frac{R}{A_w} = 0.98\ ksi$

Compute Weld Group Bending Stress $f_b := \frac{M_x \cdot \left(\frac{d_A}{2}\right)}{I_w} = 5.07\ ksi$

Check Combined vs. Allowable Stress
(using interaction equation)

if $\sqrt{f_v^2 + f_b^2} < F_v$ = "OK"
  "OK"
else
  "NOT GOOD"

Verify Strength of Weld Controls Design

Verify that strength of weld controls the design as assumed for above check.
Minimum base material thickness controls (i.e. thickness of sheet pile flange)

Min. Thickness of Base Material $t_w := 0.375\ in$

Compute Allowable Web Shear Stress $R_{web} := t_w \cdot 0.4 \cdot F_{y50} = 7.5 \ \frac{kip}{in}$

Compute Web Shear Rupture Stress $R_{webr} := t_w \cdot 0.3 \cdot F_{u50} = 7.31 \ \frac{kip}{in}$

Determine Controlling Stress $min\left(R_{web}, R_{webr}\right) = 7.31 \ \frac{kip}{in}$

Check the Weld Strength
(1/4-in fillet weld) $R_{weld} := t_e \cdot F_v = 3.71 \ \frac{kip}{in}$

$Weld\_Strength :=$ if $R_{weld} < min\left(R_{web}, R_{webr}\right)$
  "Strength of fillet weld controls the design"
else
  "Strength of fillet weld does NOT control the design"

$Weld\_Strength =$ "Strength of fillet weld controls the design"

Summary

Use HP12x53 x 38-in (max.) long (Gr. 50) min. wale seats welded to flange of sheet pile using a 1/4-in fillet weld for 6-in along both the top and bottom flanges and for 6-in along one side of the web (typ.).

ATTACHMENT F

Structural Design Drawings

STRUCTURAL NOTES

GENERAL REQUIREMENTS

BUILDING CODE & REFERENCE STANDARDS: The "International Building Code" (IBC), 2015 Edition, as adopted and modified by Skagit County, and Mount Vernon, Wa, governs the design and construction of this project. Reference to a specific section in the Code does not relieve the contractor from compliance with the entire materials reference standards noted below. The latest edition of the materials reference standards shall be used.

SCOPE OF STRUCTURAL WORK: Concrete tide gate structure.

DEFINITIONS: The following definitions apply to these general notes:
- "Structural Engineer of Record" (EOR) - The structural Engineer who is legally responsible for stamping & signing the structural documents for the project. The EOR is responsible for the design of the Primary Structural System.
- "Specialty Structural Engineer" (SSE) - A licensed professional Engineer, not the EOR, who performs specialty structural engineering services necessary to complete the structure, who has experience and training in the specific specialty. The General Contractor, subcontractor, or supplier who is responsible for the design, fabrication and installation of specialty-engineered elements shall retain the SSE. Submittals shall be stamped and signed by the SSE. Documents stamped and signed by the SSE shall be completed by or under the direct supervision of the SSE with a PE or SE license issued by the State of Washington.
- "Deferred Submittals - Deferred Submittal is engineering work to be designed-by-others or bidder-designed.

NOTE PRIORITIES: Notes on the individual drawings shall govern over these general notes.

SPECIFICATIONS: Refer to the contract specifications for information in addition to that contained in these notes and the structural drawings.

STRUCTURAL DETAILS: The structural drawings are intended to show the general character and extent of the project and are not intended to show all details of the work.

STRUCTURAL RESPONSIBILITIES: The EOR is responsible for the strength and stability of the Primary Structure in its completed state.

CONTRACTOR RESPONSIBILITIES: The contractor is responsible for the means and methods of construction and all job related safety standards such as OSHA and WSHA. The contractor is responsible for the strength and stability of the structure during construction and shall provide temporary shoring, bracing and other elements required to maintain stability until the structure is completed. It is the contractor's responsibility to be familiar with the work required in the construction documents and the requirements for executing it properly.

DISCREPANCIES: In case of discrepancies between these general notes, the contract drawings and specifications, and/or reference standards, the Engineer shall determine which shall govern. Discrepancies shall be brought to the attention of the Engineer before proceeding with the work. Accordingly, any conflict in or between the Contract Documents shall not be a basis for adjustment in the Contract Price.

SITE VERIFICATION: The contractor shall verify all dimensions & conditions at the site prior to fabrication and/or construction. Conflicts between the drawings & actual site conditions shall be brought to the attention of the Engineer before proceeding with the work. All underground utilities shall be determined by the Contractor prior to excavation or drilling.

ADJACENT UTILITIES: The contractor shall determine the locations of all adjacent underground utilities prior to excavation. Any utility information shown on the drawings & details is approximate and not necessarily complete.

DESIGN CRITERIA

CONSTRUCTION LOADS: Loads on the structure during construction shall not exceed the design loads or the capacity of the partially completed construction.

SEISMIC DESIGN: Earthquake design is determined using Chapter 12 ASCE 7-10 in accordance with IBC Chapter 16 with the following factors:

Importance Factor Ie = 1.0
Risk Category= II

Ss = 1.055 g	Sds = 0.844 g
S1 = 0.373 g	Sd1 = 0.623 g
Site Class = E	Seismic Design Category = E

LIVE LOADS:

Traffic - AASHTO	
Guard Fence:	50plf @ Top Rail

SUBMITTALS

SUBMITTALS: Shop Drawings shall be submitted to the Architect/Engineer prior to any fabrication or construction for all structural items as noted below. The contractor shall review and place a shop drawings stamp on the submittal before forwarding to the Engineer. Submittals shall be made in time to provide a minimum of one week for review by the Engineer. Additional submittals required for this project are specified in the specific sections below. Reference the individual material section for specific information to be included in the submittal. .

If the shop drawings differ from or add to the design of the Structural drawings, they shall bear the seal and signature of the Washington State Registered Professional Engineer who is responsible for the design..
Concrete reinforcing
Structural steel
Concrete Mix Design

ALTERNATES: Alternates for specified items may be submitted to the Engineer for review. Contractor shall submit a current ICC-ES report identifying that an alternative component has the same or greater load capacity than the specified item.

SHOP DRAWING REVIEW: Review by the Architect/Engineer is for general compliance with the design concept and the contract documents. Dimensions and quantities are not reviewed by the EOR, and therefore, must be verified by the General Contractor. Markings or comments shall not be construed as relieving the contractor from compliance with the project plans and specifications, nor departures therefrom. The contractor remains responsible for details and accuracy; for confirming and correlating all quantities and dimensions; for selecting fabrication processes; for techniques of assembly; and for performing work in a secure manner. When shop drawings (component design drawings) differ from or add to the requirements of the Structural drawings they shall be designed and stamped by the responsible SSE. Allow one week for Engineer review time.

NON-STRUCTURAL COMPONENTS: Design, detailing & anchorage of all nonstructural components shall be in accordance with ASCE 7-10, Chapter 13 & the project specifications. Nonstructural components designed by others shall not induce torsional loading into supporting steel structural members without additional bracing of those members to eliminate torsional forces. Torsional bracing shall be designed by the nonstructural component designer & approved by the Engineer. Anchorage to the primary structure is per the bidder-design contractor or supplier.

TESTS & INSPECTIONS

INSPECTIONS: All construction is subject to inspection by the Building Official in accordance with IBC Sec 110. The contractor shall coordinate all required inspections with the Building Official. Submit copies of all inspection reports to the Architect/Engineer for review. The Building Official may accept inspection of and reports by approved inspection agencies in lieu of Building Official's inspections. The contractor shall obtain approval of Building Official to use the third-party inspection agency and contractor shall alert the Architect/Engineer as such.

SPECIAL INSPECTIONS: In addition to the inspections required by IBC Sec 110, a Special Inspector shall be hired by the Owner as an independent third-party inspector to perform this work. Per Chapter 17, special inspections shall be performed by an approved testing agency as outlined in the Special Inspection Schedule, the contract documents, inspection list below and/or the project specification. Special Inspectors shall meet the specific material requirements of IBC Sec 1705. The contractor is responsible for scheduling the inspections, per the city/Building Official requirements.

Reference plans for the Special Inspection Schedule for this project containing all inspection, special inspection, and structural observation requirements. The registered design professional in responsible charge shall prepare a Statement of Special Inspections in accordance with Section 1704.3.1 for submittal in accordance with Sec 1704.2.3.

Concrete
Periodic inspection of reinforcing steel and cast-in-place anchors
Periodic verification of the use of the required design mix.
Continuous inspection during the sampling of fresh concrete and during slump, air content and temperature determinations.
Continuous inspection during the placing of reinforced concrete.
Continuous inspection during the grouting operation of bolts or rebar dowels.

Special Cases
Continuous inspection of post-installed anchors during grouting of anchors and reinforcing bars.

STRUCTURAL OBSERVATIONS: When required by the provisions of Section 1704.6.1 or 1704.6.2, the Owner or the Owner's authorized agent shall employ the EOR or third-party special inspector to perform structural observations. Structural observations do not include or waive the responsibility for the inspections in Section 110 or the special inspections in Section 1705 or other sections in the code.

SOILS AND FOUNDATIONS

REFERENCE STANDARDS: Conform to IBC Chapter 18 "Soils and Foundations."

GEOTECHNICAL REPORT: Recommendations contained in "Geotechnical Engineering Services - Proposed Alice Bay Tidegate Replacement" Report by GeoEngineers, dated April 8, 2021, and were used for design.

GEOTECHNICAL INSPECTION: The Geotechnical Engineer or third-party inspector shall inspect all prepared soil bearing surfaces prior to placement of concrete and reinforcing steel and provide a letter to the Owner stating that soils are adequate to support the "Allowable Foundation Pressure" shown below. Soil compaction shall be supervised by an approved testing agency or Geotechnical Engineer. Site soil conditions, fill placement and load-bearing requirements shall be as required by Section 1705.6 and Table 1705.6. Assumed values shall be field verified by the Building Official or the Geotechnical Engineer prior to placing concrete. The Building Official shall be permitted to waive the requirement for a geotechnical investigation where satisfactory data from adjacent area is available that demonstrates an investigation is not necessary for any of the conditions in Sections 1803.5.1 - 1803.5.6 and Sections 1803.5.10 - 1803.5.11.

DESIGN SOIL VALUES:

Allowable Soil Bearing Pressure
2500 PSF DL + LL
3325 PSF DL + LL + Seismic/wind

Retaining Walls	
Active Lateral Pressure (unrestrained)	Reference 8/S1.0 for loading diagrams
Active Lateral Pressure (restrained)	" " " " "
Uniform Seismic	" " " " "
Traffic Surcharge	" " " " "
Coefficient of Sliding Friction	Per Geotech Report

SLABS-ON-GRADE & FOUNDATIONS: All foundations shall bear on structural compacted fill or competent native soil per the Geotechnical report. All slabs-on-grade shall be founded on appropriate sub-grade preparation as noted in the Geotechnical report. Exterior perimeter footings shall bear not less than 18 inches below finish grade, or as required by the Geotechnical Engineer & the Building Official.

COMPACTION: Shall be as directed in the Geotechnical report.

CAST-IN-PLACE CONCRETE

REFERENCE STANDARDS: Conforms to the latest editions of the following:
(1) ACI 318 "Building Code Requirements for Structural Concrete and Commentary".
(2) IBC Chapter 19.

FIELD REFERENCE: The contractor shall keep a copy of ACI Field Reference manual, SP-15, "Standard Specifications for Structural Concrete (ACI 301) with Selected ACI and ASTM References."

CONCRETE MIXTURES: Conform to ACI 318 Chapter 5 "Concrete Quality, Mixing, and Placing."

MATERIALS: Conform to ACI 318 Chapter 3 "Materials" for requirements for cementitious materials, aggregates, mixing water and admixtures.

SUBMITTALS: Provide all submittals required by ACI 301 Sec 4.1.2. Submit mix designs for each mix in the table below.

TABLE OF MIX DESIGN REQUIREMENTS

Member Type/Location	Strength (psi)	Test Age (days)	Maximum Aggregate	Exposure Classification	Max W/C Ratio	Minimum Air Content
Foundations/Walls	5000	28	1"	F1, C1	0.45	4.5%
Exterior Slabs-on-Grade	5000	28	1"	F3, C2	0.40	6.0%
Lid Slab/Guardrails	6000	28	1"	F3, C2	0.40	6.0%

MIX DESIGN NOTES:
(1) W/C Ratio: Water-cementitious material ratios shall be based on the total weight of cementitious materials. Ratios not shown in the table above are controlled by strength requirements.
(2) Cementitious Content:
- The use of fly ash, other pozzolans, silica fume, or slag shall conform to ACI 301 Sec 4.2.2 9b. Maximum amount of fly ash shall be 20% of total cementitious content unless reviewed and approved otherwise by EOR.
- For concrete used in elevated floors, Portland cement content shall conform to ACI 301 Sec 4.2.2.1. Acceptance of lower cement content is contingent on providing supporting data to the Engineer for review and acceptance.

(3) Air Content: Conform to ACI 301 Sec 4.2.2.4. Horizontal exterior surfaces in contact with the soil require entrained air. Use Exposure Category F0, S0, P0, C0 unless noted otherwise. Tolerance is +/- 1.5%. Air content shall be measured at point of placement.
(4) Exposure Classification: The mix design provided shall meet the requirements of ACI 318 Section 4.3, based on the exposure classification indicated in the table above.
(5) Slump: Conform to ACI 301 Sec 4.2.2.2. Slump shall be determined at point of placement.
(6) Shrinkage Limit: Concrete used in elevated slabs and beams shall have a shrinkage limit of .045% at 28 days measured in accordance with ASTM C157.
(7) Non-chloride accelerator: Non-chloride accelerating admixture may be used in concrete slabs placed at ambient temperatures below 50F at the contractor's option.
(8) Calcium Nitrite: Beams & pile caps with a marine exposure shall contain 4-1/2 gallons of calcium nitrite per cubic yard. Topping slabs exposed to deicing salts shall contain 2-1/2 gallons of calcium nitrite per cubic yard.

FORMWORK: Conform to ACI 301 Sec 2 "Formwork and Form Accessories." Removal of Forms shall conform to Sec 2.3.2 except strength indicated in Sec 2.3.2.5 shall be 0.75 f'c. Re-shoring shall conform to Sec 2.3.3.

MEASURING, MIXING, AND DELIVERY: Conform to ACI 301 Sec 4.3.

HANDLING, PLACING, CONSTRUCTING AND CURING: Conform to ACI 301 Sec 5.

CONCRETE CURING: Provide curing compounds for concrete as follows:
(1) Apply specified curing compound to concrete slabs as soon as final finishing operations are complete (within 2 hours and after surface water sheen has disappeared). Apply uniformly in continuous operation by power spray or roller in accordance with manufacturer's directions. Recoat areas subjected to heavy rainfall within 3 hours after initial application. Maintain continuity of coating and repair damage during curing period.
(2) Use membrane curing compounds that will not affect surfaces to be covered with finish materials applied directly to concrete.
(3) Apply curing compound at rate equivalent to rate of application at which curing compound was originally tested for conformance to requirements of ASTM C309.
(4) Use curing compound compatible with & applied under direction of system manufacturer of protective sealer.
(5) All concrete must achieve [2500] PSI compressive strength before being subjected to freezing & thawing cycles.
(6) Apply two separate coats with first allowed to become tacky before applying second. Direction of second application shall be at right angles to direction of first.

CONCRETE SEALER: Concrete silane sealer containing 40% solids shall be applied to all supported slab surfaces and extended up vertical surfaces 24 inches.

CONSTRUCTION JOINTS: Conform to ACI 301 Sec 2.2.2.5, 5.1.2.3a, 5.2.2.1, and 5.3.2.6. Construction joints shall be located and detailed as on the construction drawings. Use of an acceptable adhesive, surface retarder, Portland cement grout, or roughening the surface is not required unless specifically noted on the drawings. Where shear bond is required, roughen surfaces to 1/4" amplitude.

EMBEDDED ITEMS: Position and secure in place expansion joint material, anchors and other structural and non-structural embedded items before placing concrete. Contractor shall refer to mechanical, electrical, plumbing and tidegate drawings and coordinate all other embedded items.

BONDING AGENT: Use Master Builders Concresive Liquid (LPL). Apply in accordance with manufacturer's instructions.

JOINT COMPOUND: Provide acid resistant silicone caulk where noted on the drawings. Submit product data for review.

CONCRETE CRACK REPAIR AND MAINTENANCE PROGRAM: Since concrete shrinks and continues to shrink for up to two years after construction, a crack repair and maintenance program is recommended to be implemented for those slabs exposed to water or chemicals. It is common for cracking due to shortening to occur. These cracks do not normally impair the structural integrity of the slab, however, these slabs should have a one-time crack maintenance operation, which consists of:
- Inspecting slabs and supporting members 2 years after construction
- Determine cracks to be repaired
- Repairing cracks

The total length of cracking can be estimated at 0.009-feet of cracks per sq/ft of slab area. The Owner should reserve funds for this one time maintenance program, which is to take place two years after the completion of construction.
Even though cracking is normal and most often not structurally significant, when cracking occurs during construction the contractor shall contact the Engineer for review. The contractor should budget 0.004-ft of epoxy injected crack repair per sq/ft of the slab.

TESTING AND ACCEPTANCE:
Testing: Obtain samples and conduct tests in accordance with ACI 301 Sec 1.6.4.2. Additional samples may be required to obtain concrete strengths at alternate intervals than shown below.

- Cure 4 cylinders for 28-day test age. Test 1 cylinder at 7 days, test 2 cylinders at 28 days, and hold 1 cylinder in reserve for use as the Engineer directs. After 56 days, unless notified by the Engineer to the contrary, the reserve cylinder may be discarded without being tested for specimens meeting 28-day strength requirements.

Acceptance: Strength is satisfactory when:
- The averages of all sets of 3 consecutive tests equal or exceed the specified strength. No individual test falls below the specified strength by more than 500 psi. A "test" for acceptance is the average strength of the two cylinders tested at the specified test age.

CONCRETE REINFORCEMENT

REFERENCE STANDARDS: Conform to:
(1) ACI 301 "Standard Specifications for Structural Concrete", Sec 3 "Reinforcement and Reinforcement Supports."
(2) IBC Chapter 19, Concrete.
(3) ACI 318 and ACI 318R.
(4) ACI SP-66 "ACI Detailing Manual" including ACI 315 "Details and Detailing of Concrete Reinforcement."
(5) CRSI MSP-2 "Manual of Standard Practice."
(6) ANSI/AWS D1.4 "Structural Welding Code - Reinforcing Steel."

SUBMITTALS: Conform to ACI 301 Sec 3.1.1 "Submittals, data and drawings." Submit placing drawings showing fabrication dimensions and locations for placement of reinforcement and reinforcement supports.

MATERIALS:

Epoxy Coated Reinforcing Bars	ASTM A775 or A934, Grade 60, deformed bars.
Bar Supports	CRSI MSP-2, Chapter 3 "Bar Supports."
Tie Wire	16.5 gage or heavier, black annealed.

FABRICATION: Conform to ACI 301, Sec 3.2.2 "Fabrication", and ACI SP-66 "ACI Detailing Manual."

WELDING: Bars shall not be welded unless authorized. When authorized, conform to ACI 301, Sec 3.2.2.2. "Welding" and provide ASTM A706, Grade 60 reinforcement.

PLACING: Conform to ACI 301, Sec 3.3.2 "Placement." Placing tolerances shall conform to Sec 3.3.2.1 "Tolerances."

CONCRETE COVER: Conform to the following cover requirements from ACI 301, Table 3.3.2.3.

Concrete cast against earth	3"
Concrete exposed to earth or weather (#5 & smaller)	1-1/2"
Concrete exposed to earth or weather (#6 & larger)	2"
Ties in slabs and walls & columns	1-1/2"

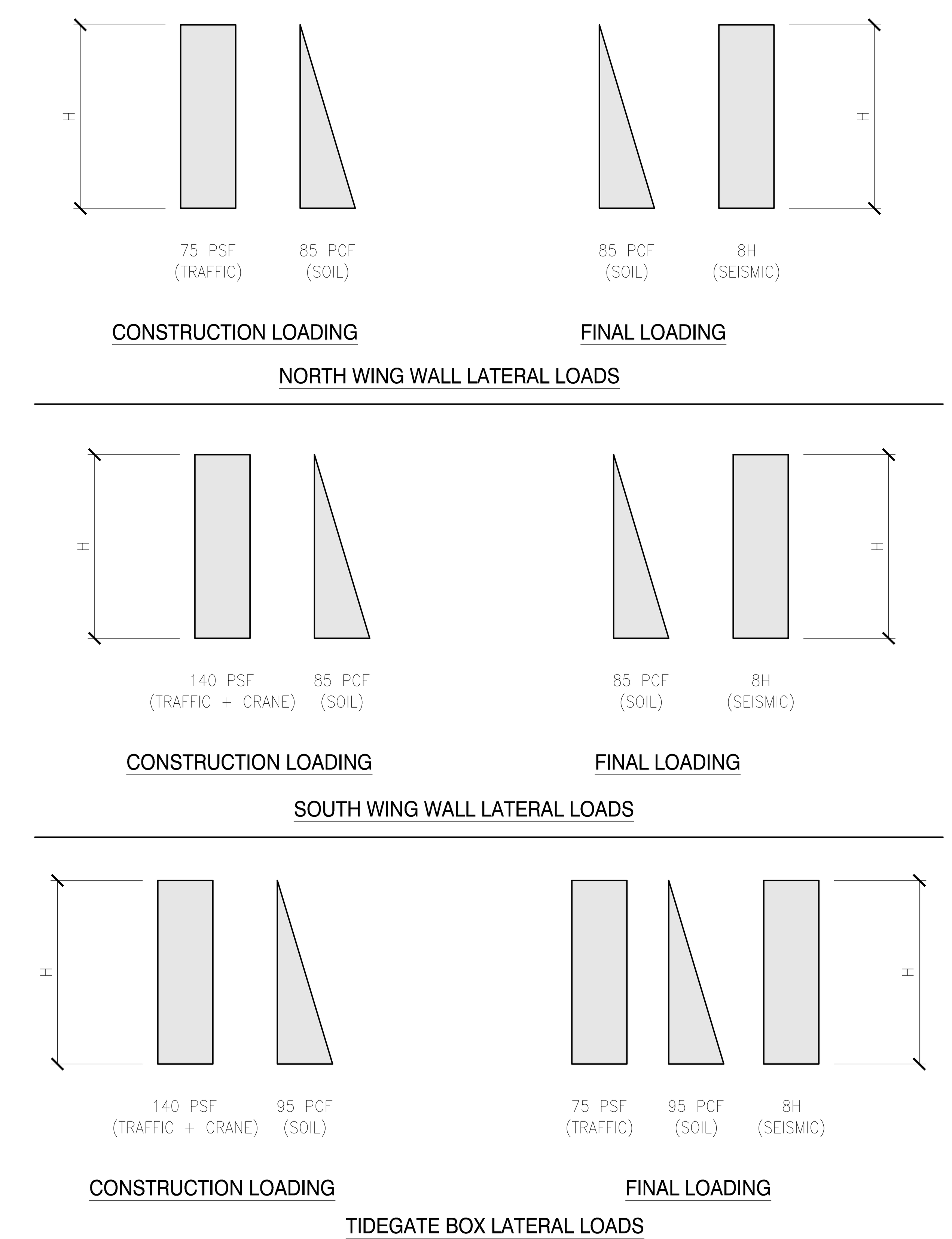
PLACING EPOXY COATED REINFORCEMENT: Conform to CRSI MSP-2, Chapter 3.5 "Bar Supports for Epoxy-Coated Reinforcing Bars."

SPLICES & DEVELOPMENT LENGTH: Conform to ACI 301, Sec 3.3.2.7. Refer to "Lap Splice & Development Schedule" on plans for typical splices. Lap all continuous reinforcement and corner bars per Lap Splice Schedule. The splices and development lengths indicated on individual sheets control over the schedule. Use Class B splices unless otherwise noted. Mechanical connections may be used when approved by the EOR.

LAP & DEVELOPMENT SCHEDULE: Reference 3 & 4/S4.2.

FIELD BENDING: Conform to ACI 301 Sec 3.3.2.8. "Field Bending or Straightening." Bar sizes #3 through #5 may be field bent cold the first time. Other bars require preheating. Do not twist bars.

CORNERS BARS: Provide matching-sized "L" corner bars for all horizontal wall and footing bars with the appropriate splice length, UNO.



LATERAL LOAD DIAGRAMS (8)

SCALE: NTS

STRUCTURAL ABBREVIATIONS

AB	ANCHOR BOLT
ADD'L	ADDITIONAL
ALT	ALTERNATE
ARCH	ARCHITECT(URAL)
ATR	ALL-THREADED ROD
B/	BOTTOM OF
BLDG	BUILDING
BLKG	BLOCKING
BRG	BEARING
BTWN	BETWEEN
℄	CENTERLINE
CJ	CONSTRUCTION or CONTROL JOINT
CLR	CLEAR(ANCE)
CONC	CONCRETE
CONN	CONNECTION
CONST	CONSTRUCTION
CONT	CONTINUOUS
CTRD	CENTERED
CTSK	COUNTERSINK
DBL	DOUBLE(R)
DF	DOUGLAS FIR
DIAG	DIAGONAL
EL	ELEVATION
EQ	EQUAL
EW	EACH WAY
(E)	EXISTING
EXP	EXPANSION
F/	FACE OF
FNDN	FOUNDATION
FRMG	FRAMING
FTG	FOOTING
GALV	GALVANIZED
GR	GRADE
HD	HOLDOWN
HDR	HEADER
HF	HEM-FIR
HORIZ	HORIZONTAL
Ld	DEVELOPMENT LENGTH
LLH	LONG LEG HORIZONTAL
LLV	LONG LEG VERTICAL
LONGIT	LONGITUDINAL
Ls	SPLICE LENGTH
(N)	NEW
NTS	NOT TO SCALE
OC	ON CENTER
OPNG	OPENING
OPP	OPPOSITE
PL	PLATE
PERM	PERIMETER
PERP	PERPENDICULAR
PLY	PLYWOOD
PRE-MFR	PRE-MANUFACTURED
P.T.	PRESSURE TREATED
REF	REFERENCE
REINF	REINFORCING
REQ'D	REQUIRED
SCHED	SCHEDULE
SHTG	SHEATHING
SIM	SIMILAR
SOG	SLAB-ON-GRADE
STAGG	STAGGERED
STIFF	STIFFENER
SW	SHEAR WALL
SYM	SYMMETRICAL
T/	TOP OF
T&B	TOP & BOTTOM
T&G	TONGUE & GROOVE
THK, THK'N	THICK, THICKENED
THRU	THROUGH
TRANSV	TRANSVERSE
TYP	TYPICAL
UNO	UNLESS NOTED OTHERWISE
VERT	VERTICAL
WHS	WELDED HEADED STUD

STRUCTURAL SHEET INDEX

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12/2/21

Revisions

No.	Date	Description
	8.18.21	60% DRAFT
	10.29.21	90% DRAFT
	12.02.21	90% FINAL

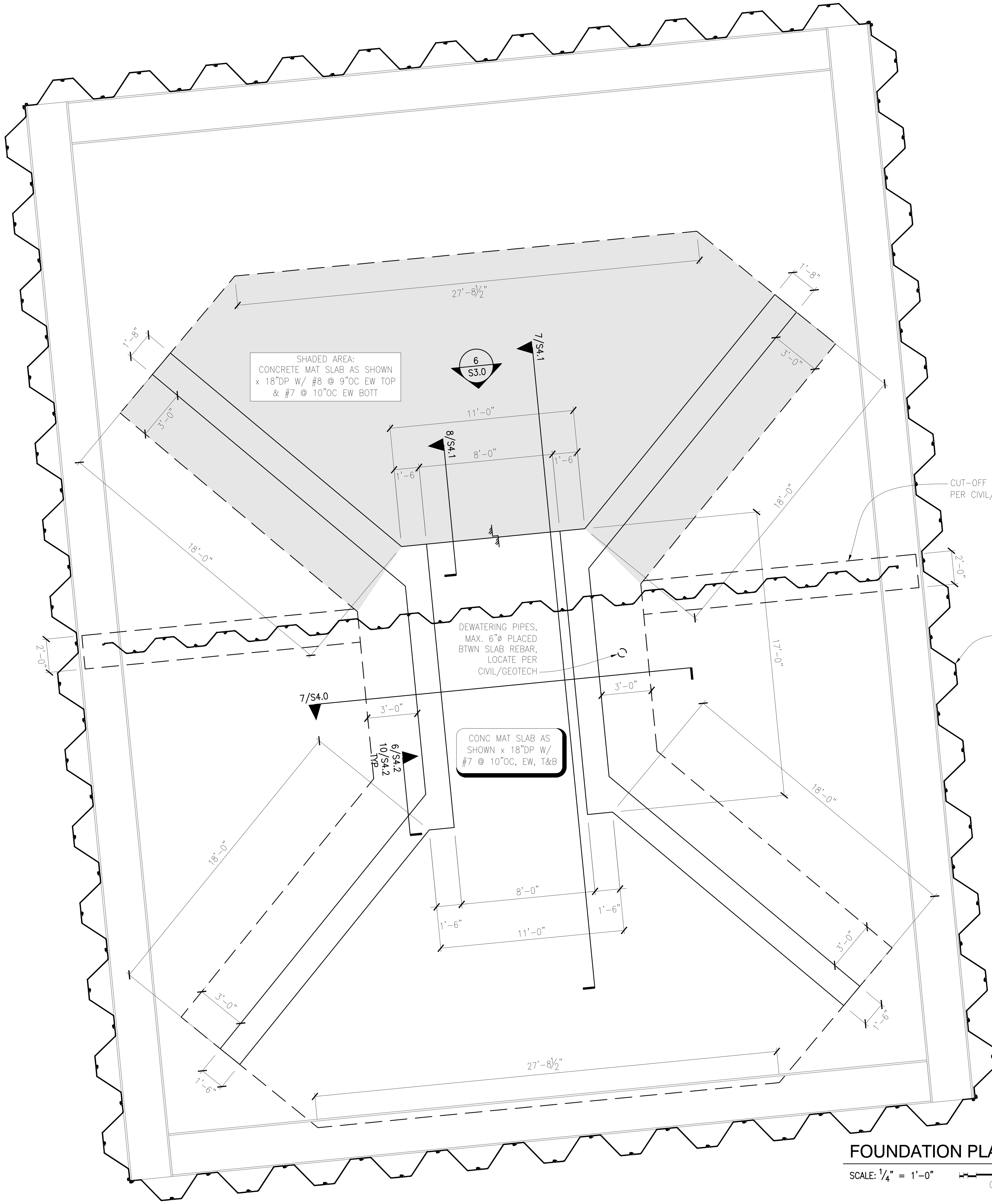
Drawing Information

Date	02 December 2021 (12:23)
Status	
Designer	BAJ
Drafter	TLT
Checked	BAJ
File Name	20-368 S1.0 (GSN)
Plotted Scale	0 1/2 1

Skagit River Delta Flood Drainage
Alice Bay Culvert
STRUCTURAL GENERAL NOTES
ABBREVIATIONS, SHEET INDEX
& LOAD DIAGRAMS

Job Number

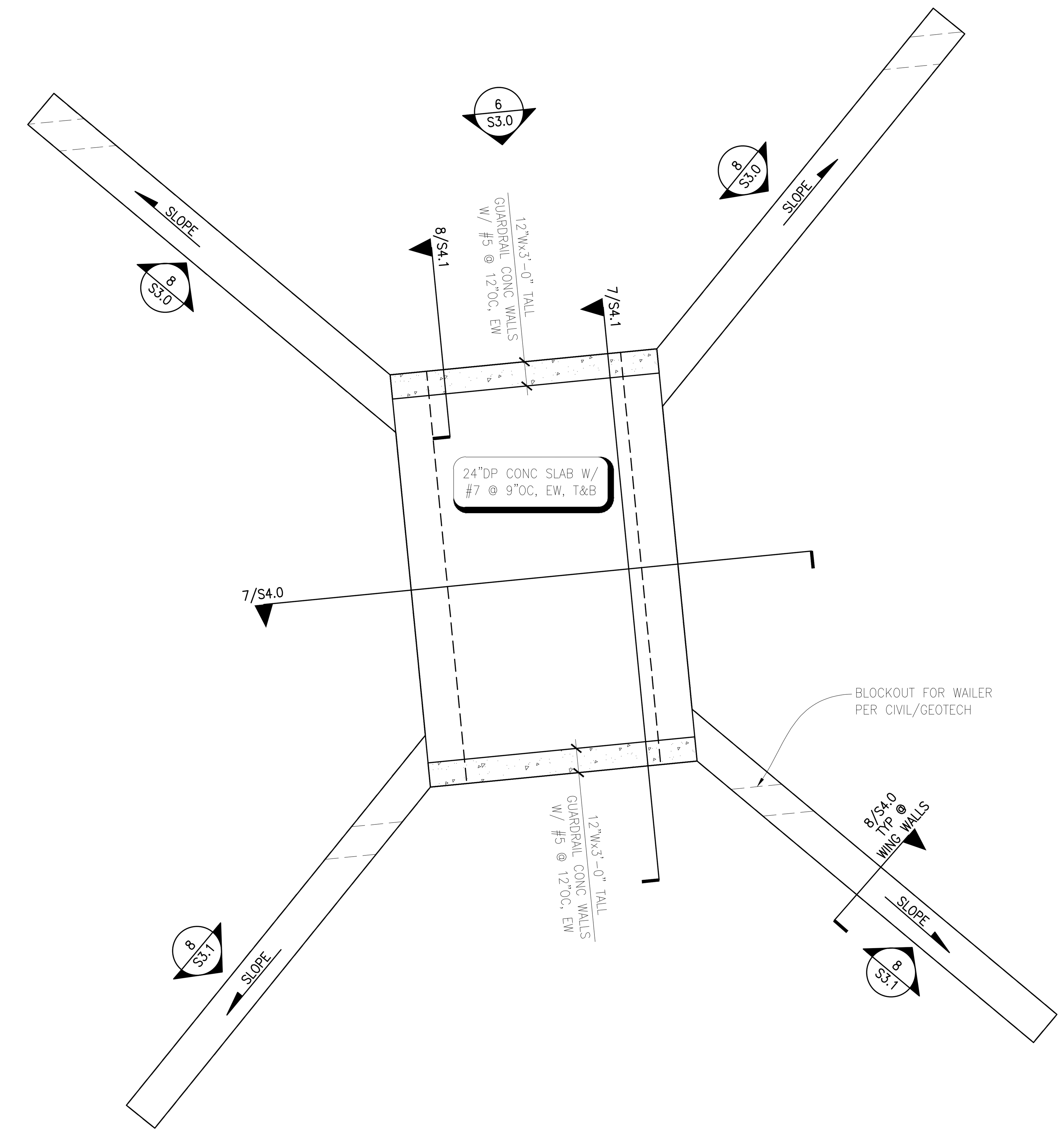
Sheet Number
S1.0



FOUNDATION PLAN

SCALE: ¼" = 1'-0"

(PROJECT)



TIDEGATE LID PLAN

SCALE: ¼" = 1'-0"

(PROJECT)

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Skagit River Delta Flood Drainage
Alice Bay Culvert

FOUNDATION & TIDEGATE LID PLANS

Job Number

Sheet Number

S2.0

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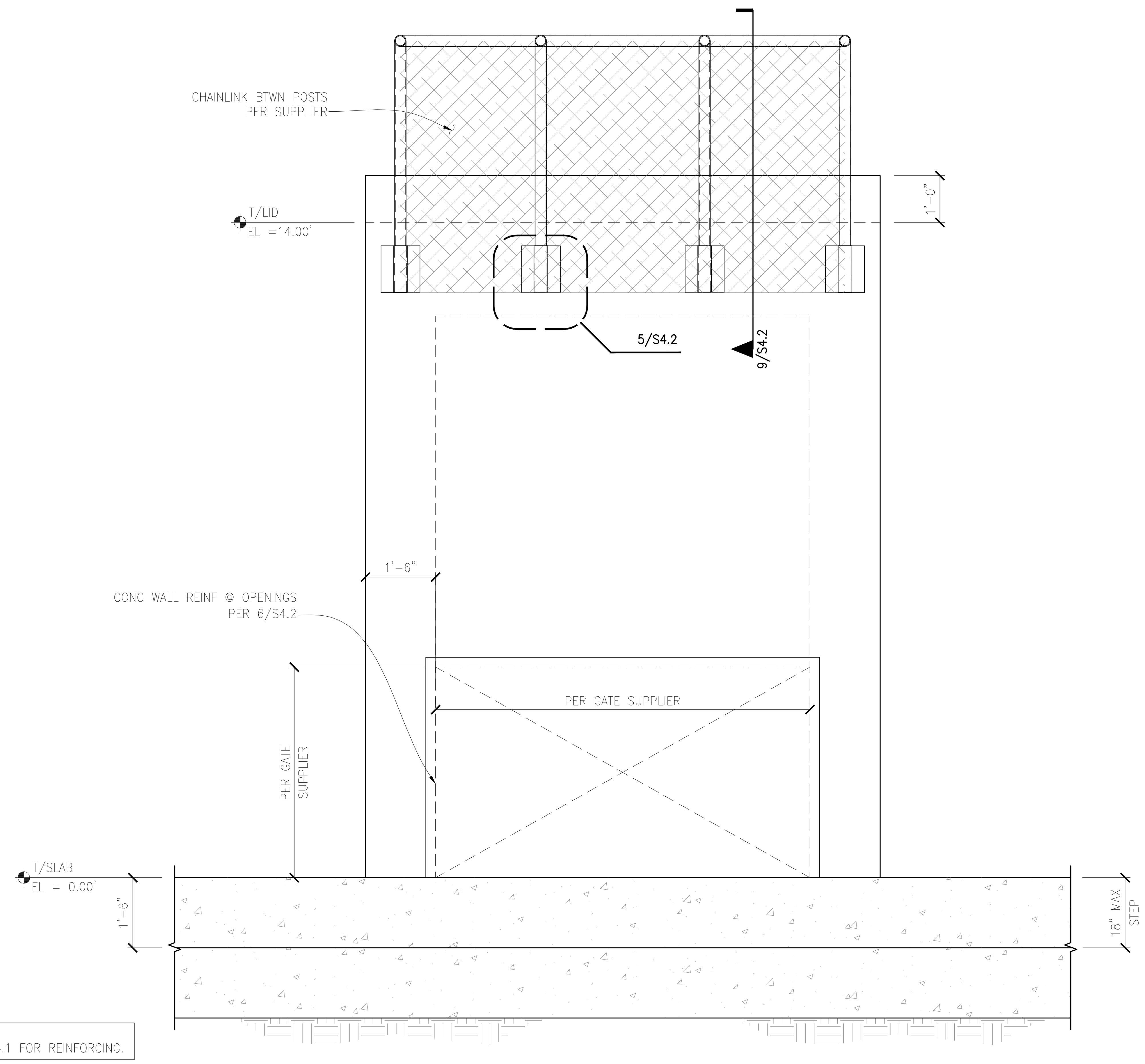
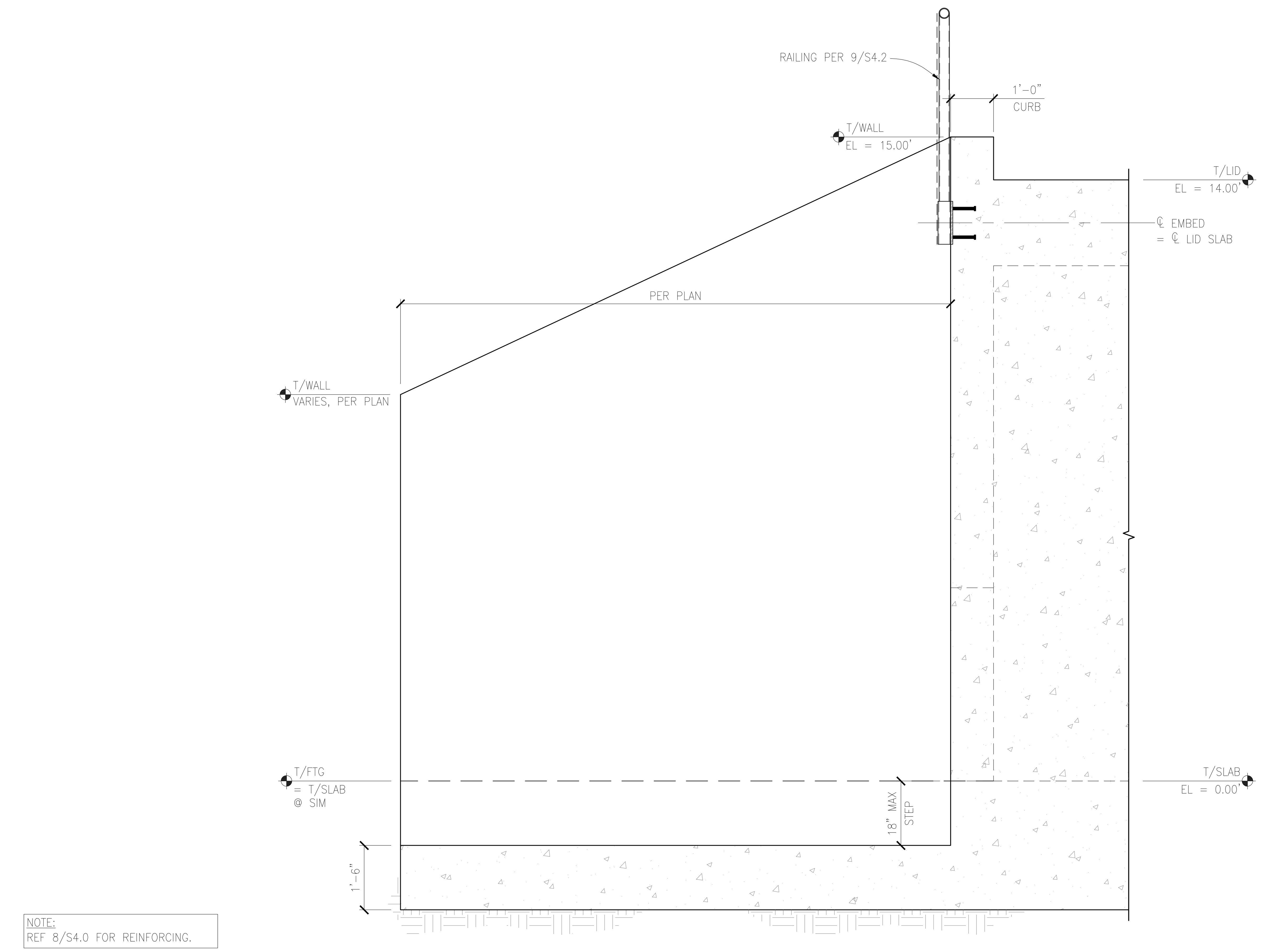


NORTH ELEVATION 6

SCALE: 1/2"=1'-0"



NORTH WING WALL ELEVATION 8

SCALE: 1/2"=1'-0"

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Checked	BAJ
File Name	20-368 S3.0 (West Elevs)
Plotted Scale	0 1/2 1

Skagit River Delta Flood Drainage
Alice Bay Culvert

NORTH ELEVATION & NORTH WING WALL ELEVATION

Job Number

Sheet Number

S3.0

LAST SAVED BY:tlyler LAST DATE SAVED: 11/17/2021 14:34
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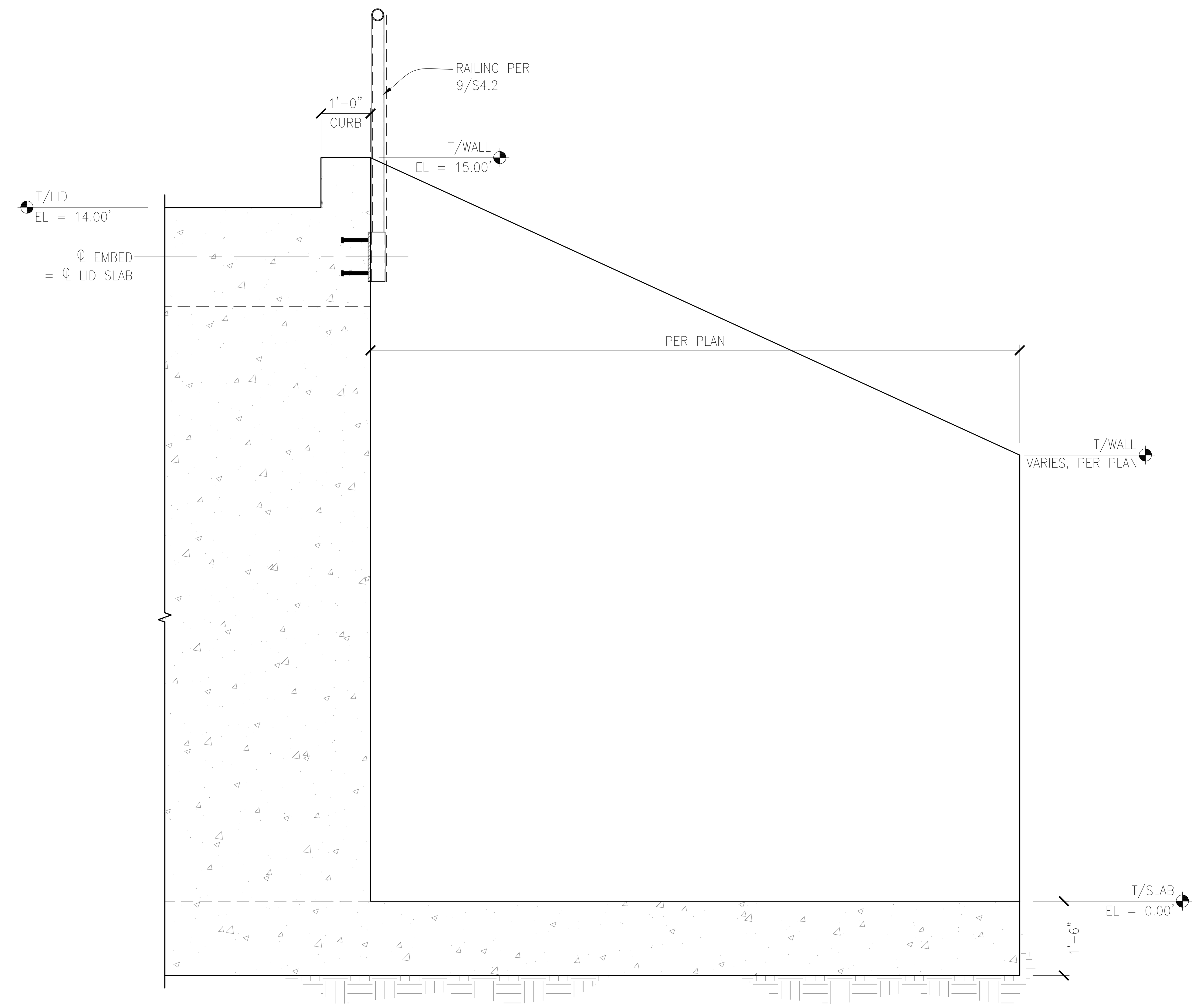

NOTE:
REF 8/S4.0 FOR REINFORCING.

SOUTH WING WALL ELEVATION

SCALE: 1/2"=1'-0"

8

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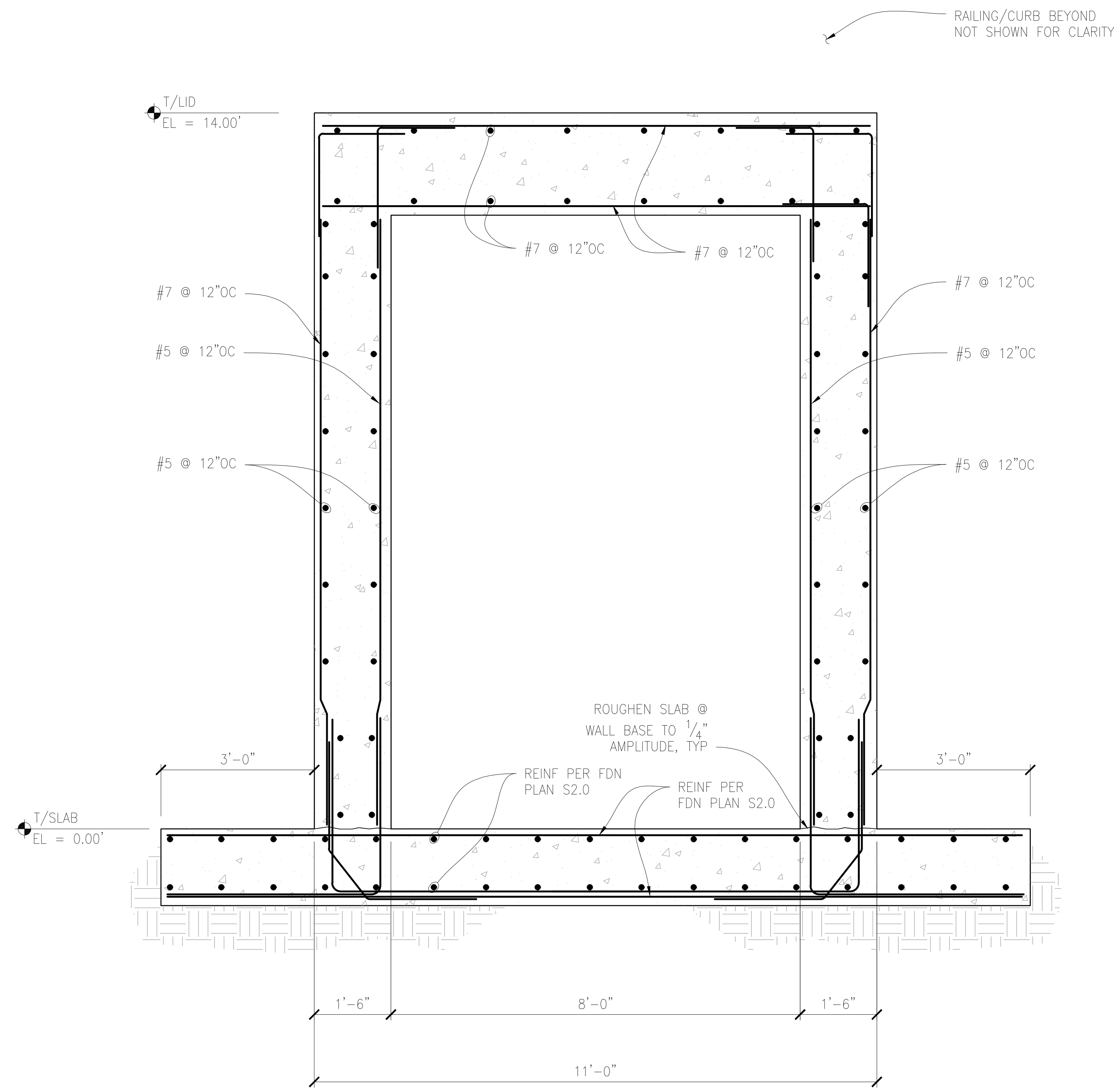
Plotted Scale	0 1/2 1

Skagit River Delta Flood Drainage
Alice Bay Culvert
SOUTH WING WALL ELEVATION

Job Number

Sheet Number

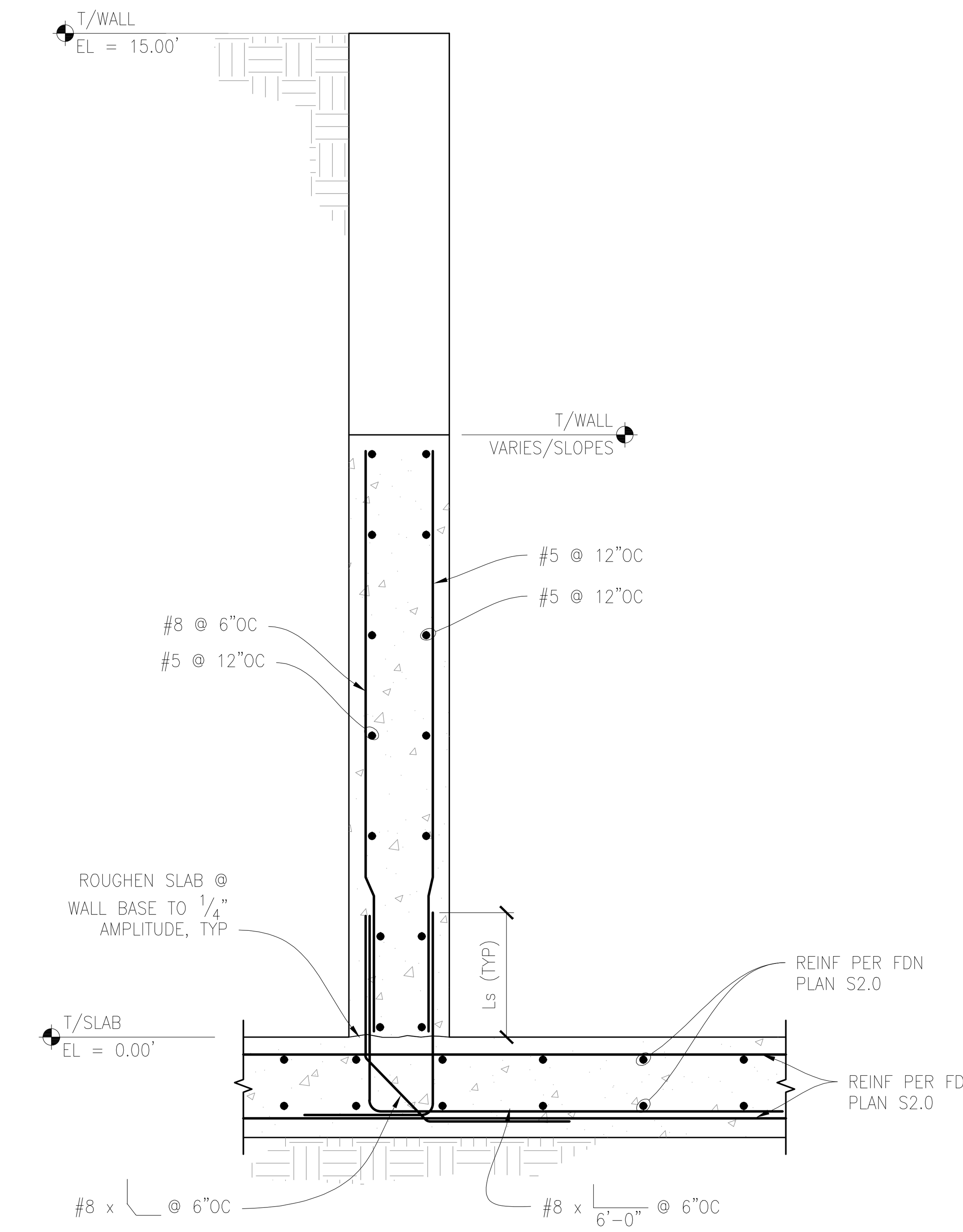
S3.1



TRANSVERSE SECTION

SCALE: 1/2"=1'-0"

7



NOTE:
REINFORCING TYPICAL FOR
NORTH/SOUTH WING WALLS.

TYPICAL WING WALL SECTION

SCALE: 1/2"=1'-0"

8

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Plotted Scale	0 1/2 1

Skagit River Delta Flood Drainage
Alice Bay Culvert

TRANSVERSE SECTIONS &
WING WALL

Job Number

Sheet Number

S4.0

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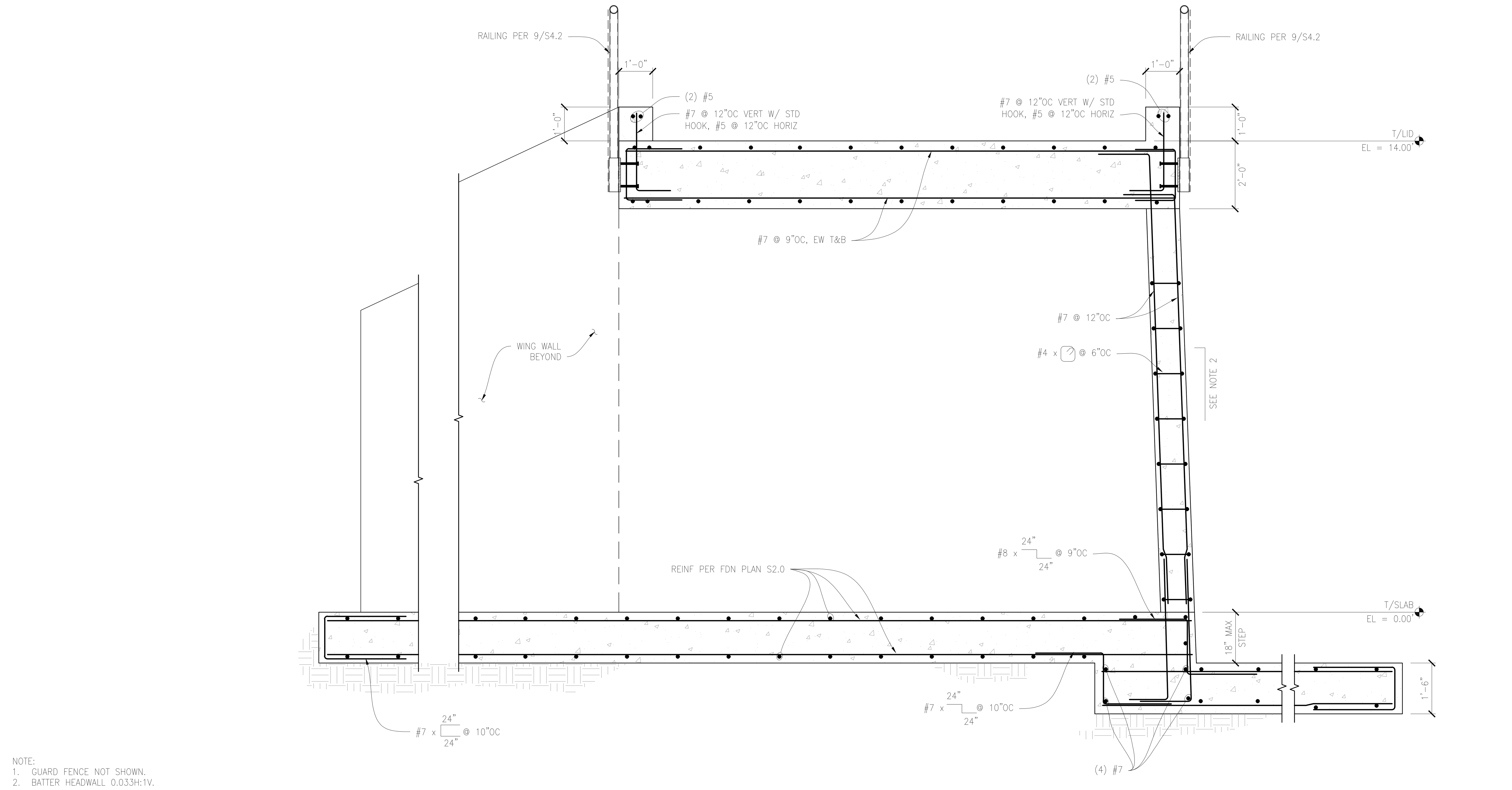
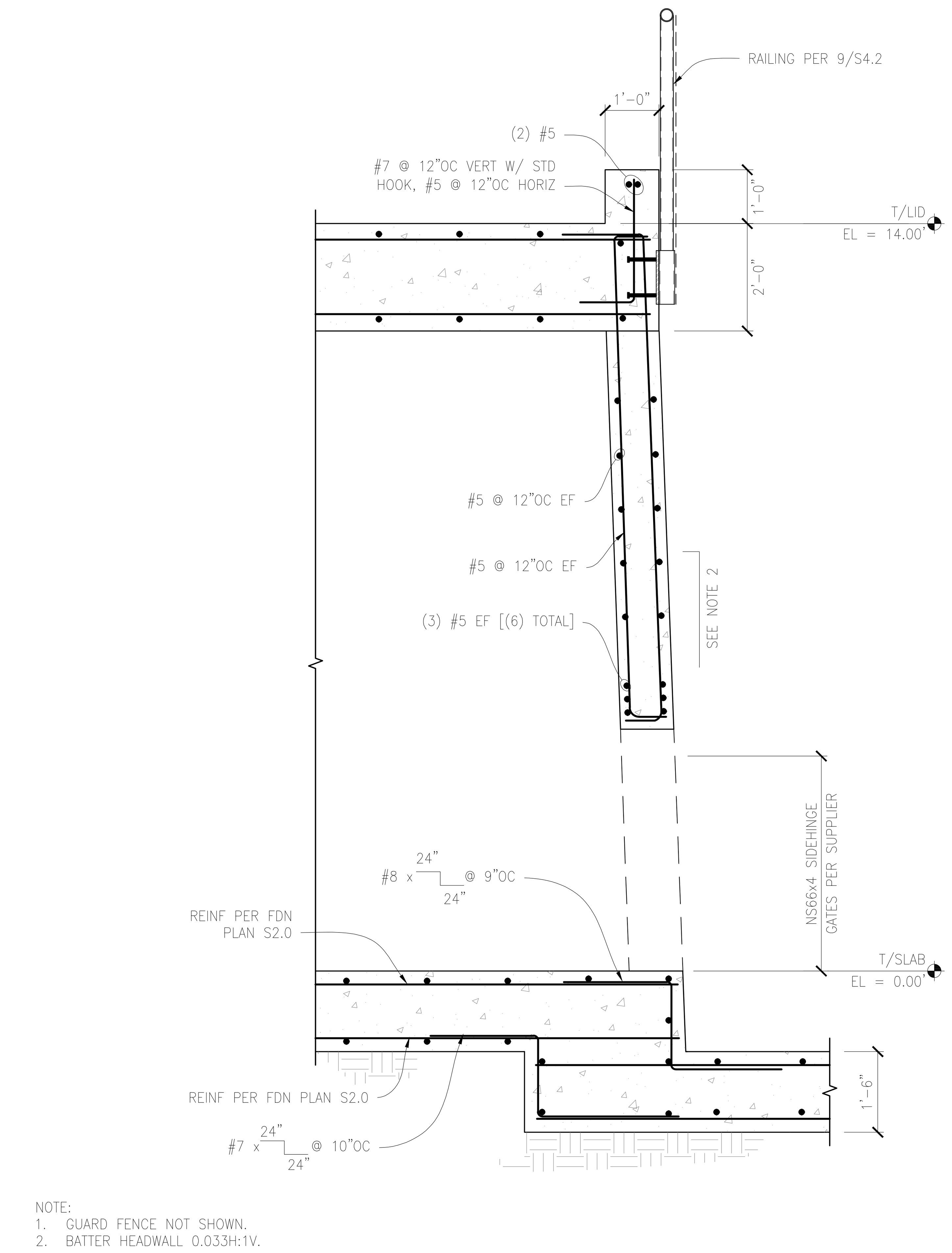


LONGITUDINAL BOX SECTION 7

SCALE: 1/2"=1'-0"



SECTION AT GATE OPENING 8

SCALE: 1/2"=1'-0"

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Skagit River Delta Flood Drainage
Alice Bay Culvert

LONGITUDINAL SECTIONS

Job Number

Sheet Number

S4.1

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LAP SPLICE & DEVELOPMENT SCHEDULE

BAR SIZE	DEVELOPMENT LENGTH, Ld		CLASS B SPLICE, Ls		Ldh
	STANDARD	TOP (3)	STANDARD	TOP (3)	
f'c = 6000 psi					
#3	12	16	16	21	6
#4	16	21	21	28	8
#5	20	26	26	34	10
#6	24	31	32	41	12
#7	34	45	45	59	14
#8	39	51	51	67	16
#9	44	57	58	75	18
#10	50	64	65	84	20
#11	55	71	72	93	22

NOTES:
1. VALUES FOR UNCOATED REINFORCING AND NORMAL WEIGHT CONCRETE WITH CLEAR SPACING > db, CLEAR COVER > db AND MINIMUM STIRRUPS OR TIES THROUGHOUT Ld OR CLEAR SPACING > 2db AND CLEAR COVER > db.
2. DEVELOP ALL REINFORCING IN STRUCTURAL SLABS WITH MINIMUM DEVELOPMENT LENGTH Ld.
3. TOP BAR = HORIZONTAL BAR WITH MORE THAN 12" OF FRESH CONCRETE BELOW OR AS NOTED ON DOCUMENTS AS "TOP BAR".
4. UNO, ALL LAPS SHALL BE MINIMUM CLASS B.
5. ALL TABULATED VALUES ARE IN INCHES.
6. Ldh = HOOKED BAR DEVELOPMENT LENGTH.

TYPICAL LAP SPLICE & DEVELOPMENT LENGTH SCHEDULE (3)

SCALE: NTS

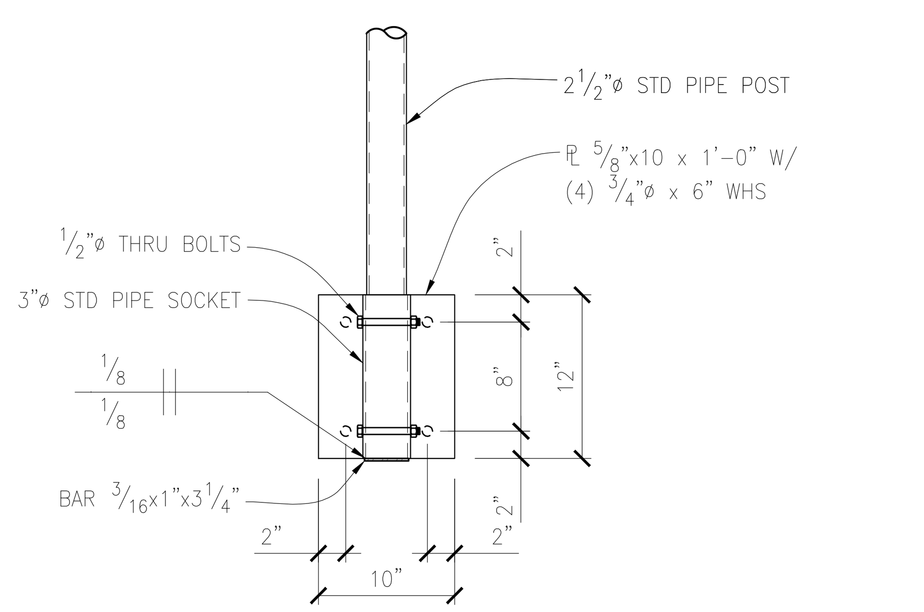
LAP SPLICE & DEVELOPMENT SCHEDULE

BAR SIZE	DEVELOPMENT LENGTH, Ld		CLASS B SPLICE, Ls		Ldh
	STANDARD	TOP (3)	STANDARD	TOP (3)	
f'c = 4000 psi / 4500 psi					
#3	15	19	20	25	8
#4	19	25	25	33	10
#5	24	31	32	41	12
#6	29	37	38	49	15
#7	42	54	55	71	17
#8	48	62	63	81	19
#9	54	70	71	91	22
#10	61	79	80	103	25
#11	67	87	88	114	27

NOTES:
1. VALUES FOR UNCOATED REINFORCING AND NORMAL WEIGHT CONCRETE WITH CLEAR SPACING > db, CLEAR COVER > db AND MINIMUM STIRRUPS OR TIES THROUGHOUT Ld OR CLEAR SPACING > 2db AND CLEAR COVER > db.
2. DEVELOP ALL REINFORCING IN STRUCTURAL SLABS WITH MINIMUM DEVELOPMENT LENGTH Ld.
3. TOP BAR = HORIZONTAL BAR WITH MORE THAN 12" OF FRESH CONCRETE BELOW OR AS NOTED ON DOCUMENTS AS "TOP BAR".
4. UNO, ALL LAPS SHALL BE MINIMUM CLASS B.
5. ALL TABULATED VALUES ARE IN INCHES.
6. Ldh = HOOKED BAR DEVELOPMENT LENGTH.

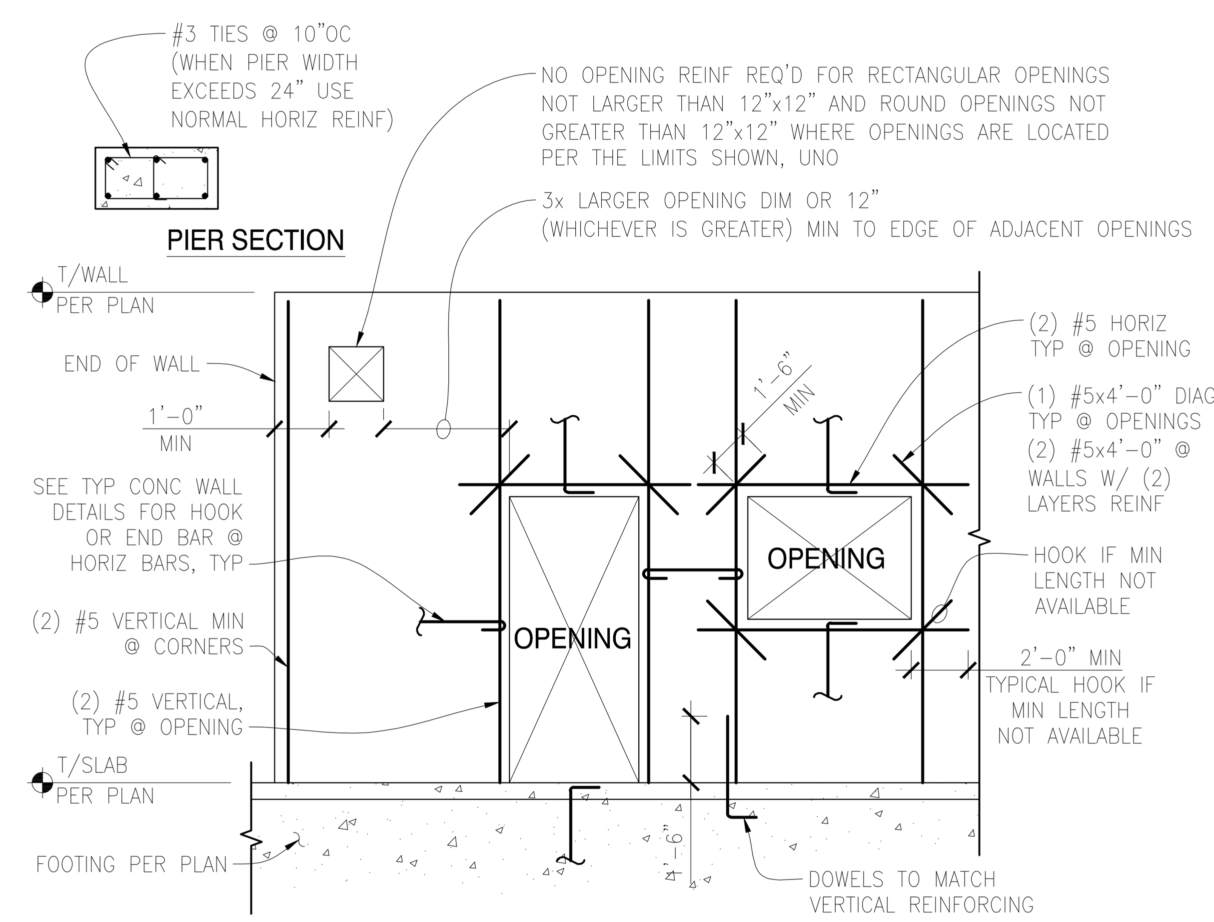
TYPICAL LAP SPLICE & DEVELOPMENT LENGTH SCHEDULE (4)

SCALE: NTS



RAILING DETAIL (5)

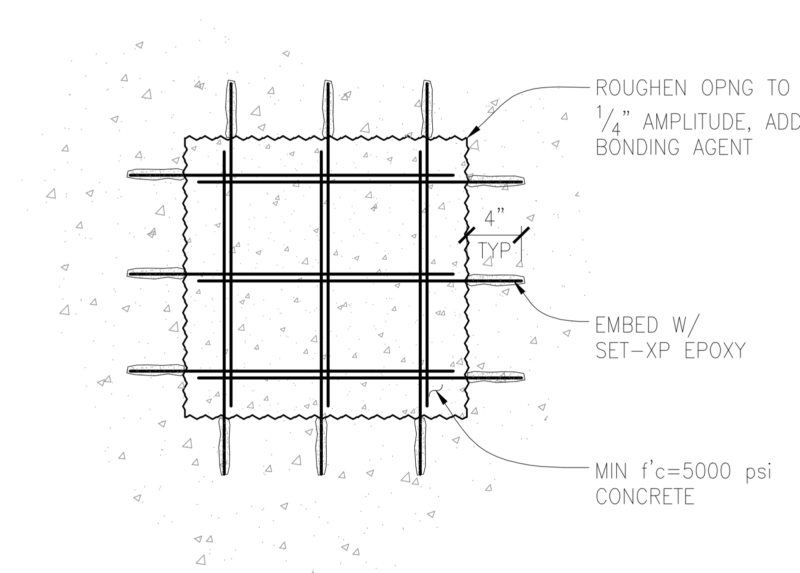
SCALE: N.T.S.



NOTE:
1. FOR TYPICAL REINFORCING, SEE STRUCTURAL NOTES.
2. FOR INFORMATION NOT SHOWN, SEE TYPICAL SECTIONS.

TYPICAL REINFORCING IN CONCRETE WALLS (6)

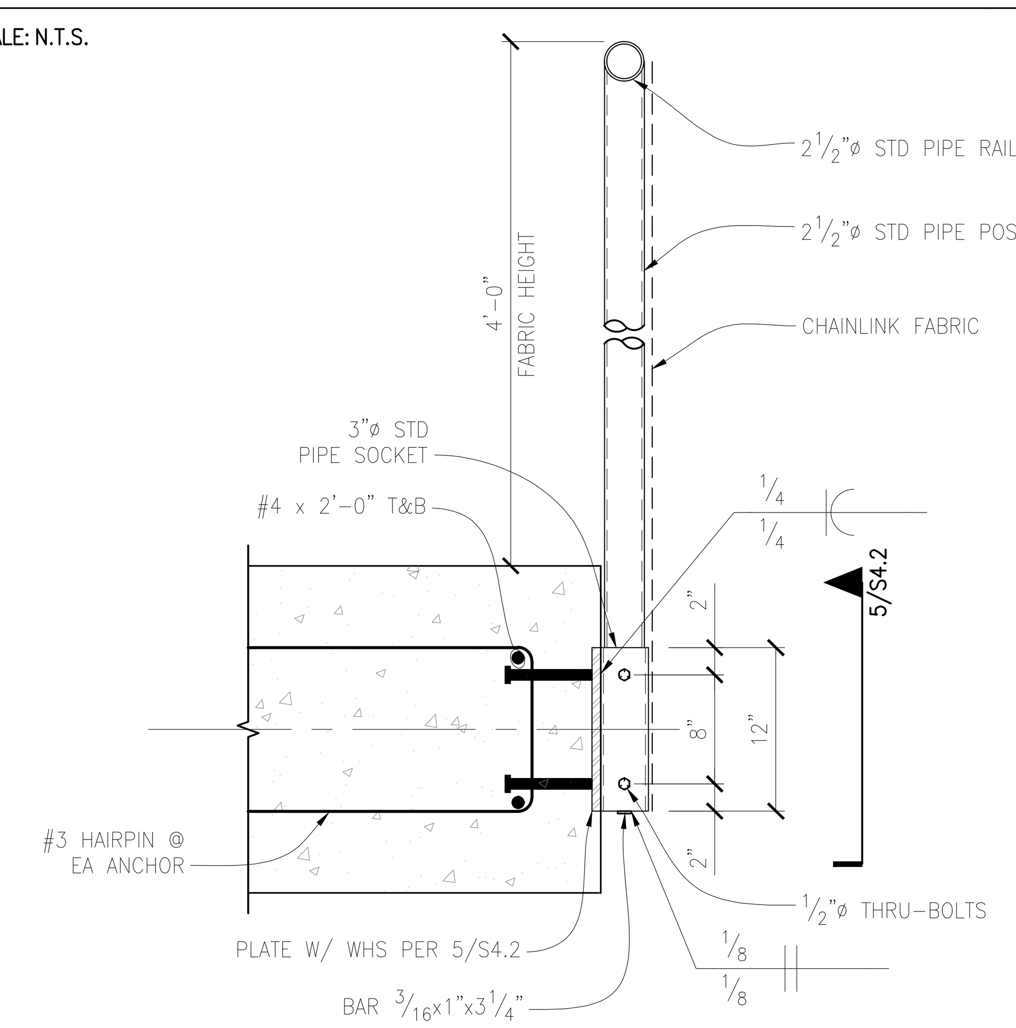
SCALE: N.T.S.



NOTE:
REBAR SIZE/SPACING TO MATCH WING WALL/BOX CULVERT EA WAY, EA FACE.

WALER OPENING REINFORCING (7)

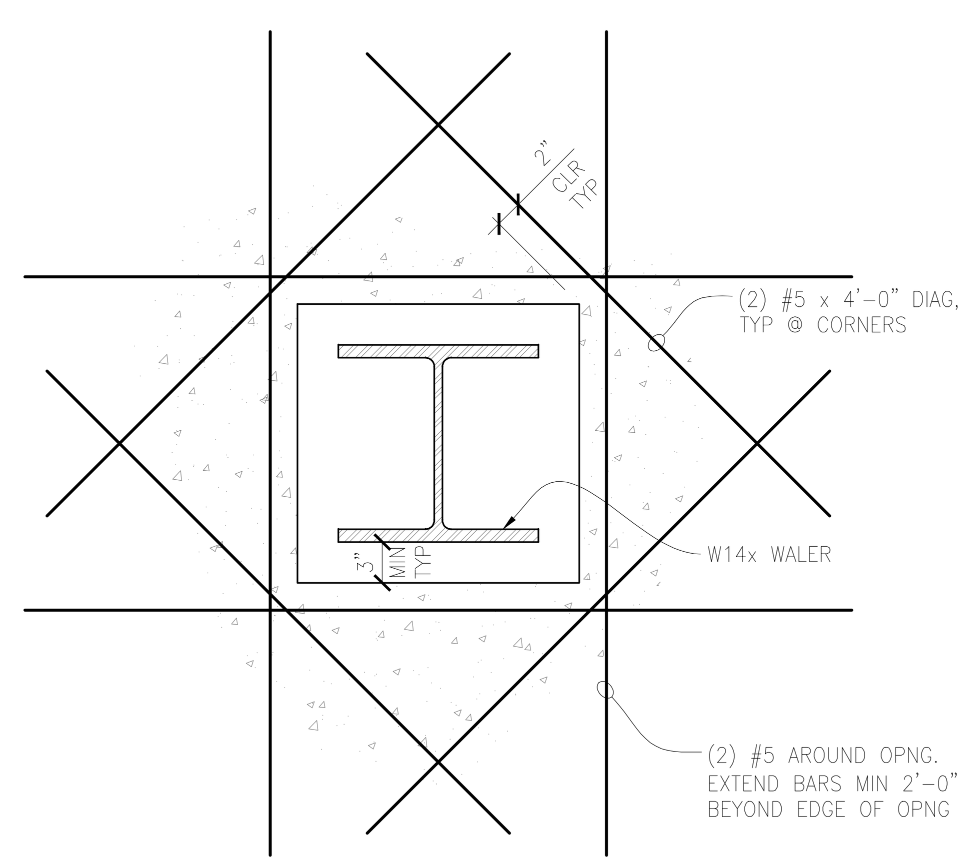
SCALE: N.T.S.



NOTE:
- SLAB REINFORCING NOT SHOWN FOR CLARITY.
- EXCEPT FOR EMBEDDED ITEMS, ALL STEEL CONNECTORS TO BE GALVANIZED.

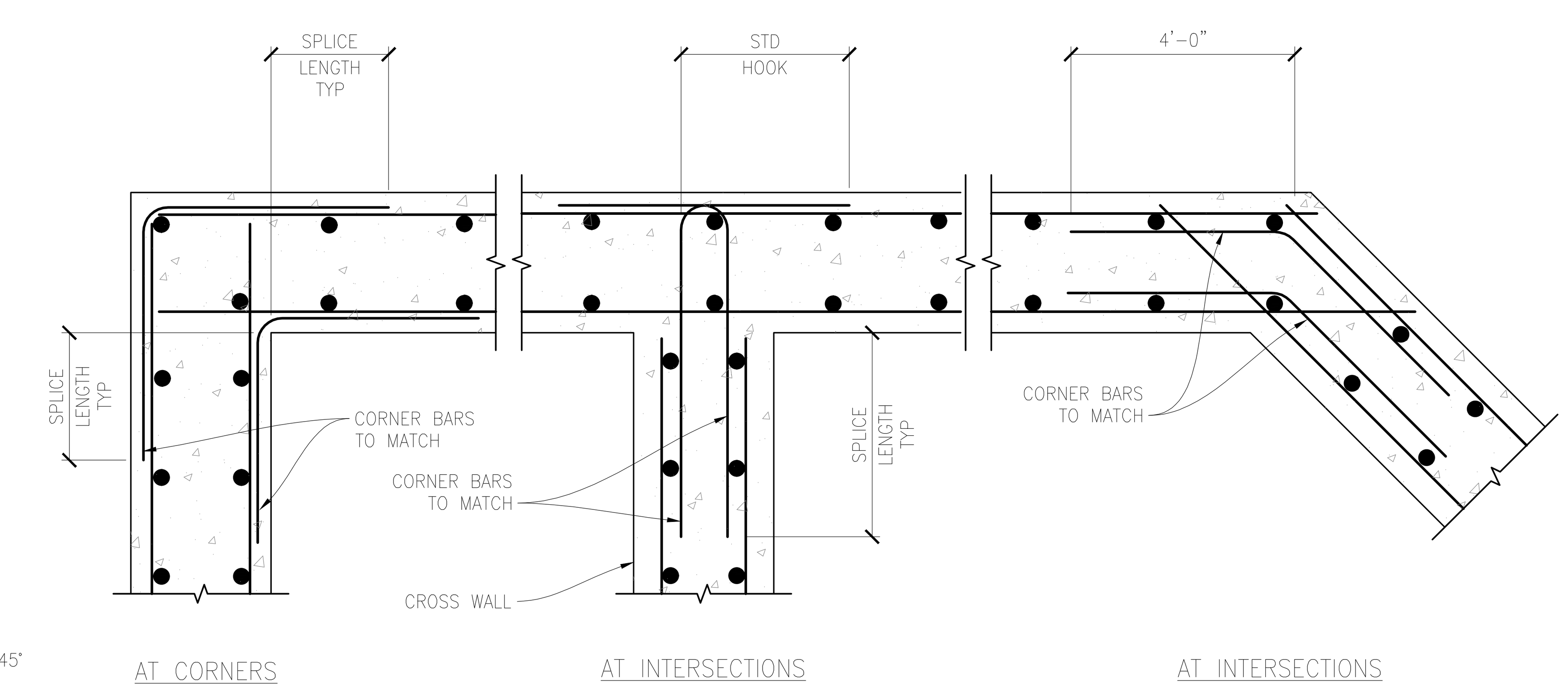
RAILING SECTION (9)

SCALE: N.T.S.



WALER OPENING IN WING WALL / BOX CULVERT (10)

SCALE: N.T.S.



1. CORNER CONDITION APPLIES TO 45° CORNERS AND 90° CORNERS.

TYPICAL CORNER BARS AT CONCRETE WALLS - DBL MAT (12)

SCALE: NTS

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Skagit River Delta Flood Drainage
Alice Bay Culvert
DETAILS

Job Number

Sheet Number
S4.2

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ATTACHMENT G

Cost Estimate

				Item	Description of Item	Qty	Units	Unit Rate	Total	Comments
1				OVERHEAD					$ 82,887	
	1			Mob/demob						
		1		Superintendent	1	8	h	$ 93.15	$ 745	RDM Rate (2020)
		2		Foreman	1	8	h	$ 76.95	$ 616	RDM Rate (2020)
		3		Labourers	3	8	h	$ 52.65	$ 1,264	RDM Rate (2020)
		4		30 T Excavator	1	4	h	$ 186.30	$ 745	RDM Rate (2020)
		5		20 T Excavator	1	4	h	$ 145.80	$ 583	RDM Rate (2020)
		6		Rubber Tire Loader	1	4	h	$ 186.30	$ 745	RDM Rate (2020)
		7		30 T off-road truck	1	4	h	$ 133.65	$ 535	RDM Rate (2020)
		8		10 T Compactor (Roller)	1	4	h	$ 105.30	$ 421	RDM Rate (2020)
		10		Truck with Transit for Equip. Delivery	5	20	h	$ 129.60	$ 12,960	RDM Rate (2020)
	2			Safety						
		1		EMT (technician, vehicles, supplies)		45	d	$ 243.00	$ 10,935	
	3			Servicing						
		1		Power		45	d	$ 202.50	$ 9,113	
		2		Office Trailer Rental	1	2	mo.	$ 405.00	$ 810	
		3		Office Trailer Mob. & Demob.	1	4	LS	$ 405.00	$ 1,620	
		4		Storage Trailer Rental	1	2	mo.	$ 405.00	$ 810	
		5		Storage Trailer Mob. & Demob.	1	4	LS	$ 405.00	$ 1,620	
		6		40 cu. m Dumpster Rental		2	mo.	$ 405.00	$ 810	
		7		40 cu. m Dumpster Service		2	mo.	$ 405.00	$ 810	
		8		Lavatory Rental & Service		2	mo.	$ 405.00	$ 810	
		9		Signage, communications, other		1	LS	$ 810.00	$ 810	
		10		Misc.		1	LS	$ 4,050.00	$ 4,050	
	4			OT	2 h / d for 45 d @ $40 / h (x10)	990	h	$ 32.40	$ 32,076	
2				DECOMMISSIONING					$ 665,999	
	1			Site Prep.	Clearing, veg. removal, set-up, mega bag filling, trailer set-up, etc.	20	h	$ 980.10	$ 19,602	1-Superintendent, 1-Foreman, 3-Labourers, 1-30T Excavator, 1-20T Excavator, 1-Loader, 1-30T O/R Truck
	2			Bulk Excavation	@ 65 cu.y/h	1,428	cu.y	$ 14.72	$ 21,013	1-Superintendent, 1-Foreman, 3-Labourers, 1-30T Excavator, 1-20T Excavator, 1-Loader, 1-30T O/R Truck
	3			Isolation						
		1		Coffer Dam		1	LS	$ 617,283.95	$ 617,284	2021-06-30 Verbal Est. from Geoengineers Range: $300k - $500k (USD)
	4			Existing Culvert, Headwall and Gate						
		1		Haul + Dispose		1	LS	$ 8,100.00	$ 8,100	
3				CONSTRUCTION					$ 437,892	
	1			Base Prep.						
		1		Fine-grading		20	h	$ 980.10	$ 19,602	1-Superintendent, 1-Foreman, 3-Labourers, 1-30T Excavator, 1-20T Excavator, 1-Loader, 1-30T O/R Truck
		2		Bedding						
			1	Supply	9 cu.y per load	38	cu.y	$ 30.96	$ 1,175	
			2	Transport		5	h	$ 113.40	$ 614	
			3	Placement and Compaction		30	h	$ 1,032.75	$ 30,983	1-Superintendent, 1-Foreman, 3-Labourers, 1-30T Excavator, 1-20T Excavator, 1-Loader, 1-30T O/R Truck
	2			Culvert						
		2		Cast-in-Place	Rebar, formwork, testing, etc.	144	cu.y	$ 1,548.22	$ 222,750	(typ. Range = $1,500 - $2,500)
	3			Gate						
		1		Supply		1	LS	$ 38,000.00	$ 38,000	Verbal estimate from Leo Kuntz
		2		Freight		1	LS	$ 1,620.00	$ 1,620	
		3		Installation		10	h	$ 660.15	$ 6,602	1-Superintendent, 1-Foreman, 3-Labourers, 1-30T Excavator, 1-20T Excavator
	4			Dike Re-construction						
		1		General Fill	re-used excavated material @ 26 cu.y / hr	55	h	$ 1,085.40	$ 59,154	1-Superintendent, 1-Foreman, 3-Labourers, 1-30T Excavator, 1-20T Excavator, 1-Loader, 1-30T O/R Truck; 1-10T Compact
		2		Dike Capping Crush						
			1	Supply		38	cu.y	$ 30.96	$ 1,175	
			2	Transport	9 cu.y per load	5	h	$ 113.40	$ 614	Truck and Pony (RDM)
			3	Placement and Compaction		20	h	$ 1,138.05	$ 22,761	1-Superintendent, 1-Foreman, 3-Labourers, 1-30T Excavator, 1-20T Excavator, 1-Loader, 1-30T O/R Truck; 1-10T Compact
		3		Erosion Protection (assume 50 kg)						
			1	Supply		52	cu.y	$ 49.54	$ 2,592	
			2	Transport	9 cu.y per load	7	h	$ 113.40	$ 848	Truck and Pony (RDM)
			3	Placement		30	h	$ 980.10	$ 29,403	1-Superintendent, 1-Foreman, 3-Labourers, 1-30T Excavator, 1-20T Excavator, 1-Loader, 1-30T O/R Truck
4				MANAGEMENT					$ 27,743	
	1			Project Manager		113	h	$ 121.50	$ 13,669	25% of 450 hours
	2			Project Coordinator		45	h	$ 76.95	$ 3,463	10% of 450 hours
	3			Construction Technician			h			
		1		Lay-out and Control Surveys		30	h	$ 109.35	$ 3,281	
		2		Quantity and As-built Surveys		30	h	$ 109.35	$ 3,281	
	4			Misc. Supplies and Materials		1	LS	$ 4,050.00	$ 4,050	
				UNFACTORED CONSTRUCTION COSTS	Items 1-4				$ 1,214,521	
	1			Construction Escalation	estimated inflation to 2022		3%		$ 36,436	
	2			Construction Contingency	Class D factor		25%		$ 303,630	
				TOTAL FACTORED COST					**$ 1,554,586**	

APPENDIX G

EDISON SLOUGH MONITORING AND RECOMMENDATION MEMORANDUM

301 W. Holly St., Suite U3 | Bellingham, WA 98225 | 206.241.6000 | www.nhcweb.com

northwest hydraulic consultants

NHC Ref. No. 2002084

September 26, 2022

Skagit County Public Works Natural Resources Division
1800 Continental Place
Mount Vernon, WA 98273

Attention: **Michael See and Karina Siliverstova**

Via email: michaels@co.skagit.wa.us; karinas@co.skagit.wa.us

Re: **Edison Slough Tide Gate Evaluation**

Dear Michael and Karina:

Northwest Hydraulic Consultants (NHC) has completed monitoring and review of the conditions at the Edison Slough tide gates as outlined in Task Assignment #3 for the Skagit River Delta Flood Drainage Project. The County requested that NHC investigate the gates following reports that salt-water was reaching the upstream side of the crossing. A summary of our observations and a list of recommended next steps follows.

1 BACKGROUND

Edison Slough is a tidally influenced channel with headwaters that originate approximately 1.5 miles southwest of the intersection of the Interstate-5 Bow Hill Road interchange and flow west through residential and agricultural developments near Bow and Edison, WA before ultimately discharging to Samish Bay approximately one mile north of the Samish River. The upstream movement of water through the slough from Samish Bay during high tide is controlled at the Main Street crossing by seven tide gates of varying designs and ages mounted to four culverts that cross beneath the roadway. Figure 1.1 shows the site location.

Six of the seven gates are top-hinged tide gates designed to open only when the upstream water level is greater than the downstream water level. The remaining seventh gate is a side-hinged, self-regulating tide gate (SRT) manufactured by Golden Harvest and designed to remain open until a specified downstream water surface elevation is exceeded. The tubes and gates are referenced in this report using the following numbers (numbered from the river left or south side) which are also included on photos and descriptions of the slough crossing in Figure 1.2 and Figure 1.3:

- Tube 1 is controlled by Gates 1 and 2 (both top hinged)
- Tube 2 is controlled by Gates 3 and 4 (both top hinged)
- Tube 3 is controlled by Gate 5 (top hinged) and Gate 6 (side hinged SRT)
- Tube 4 is controlled by Gate 7

Figure 1.1 Location Map

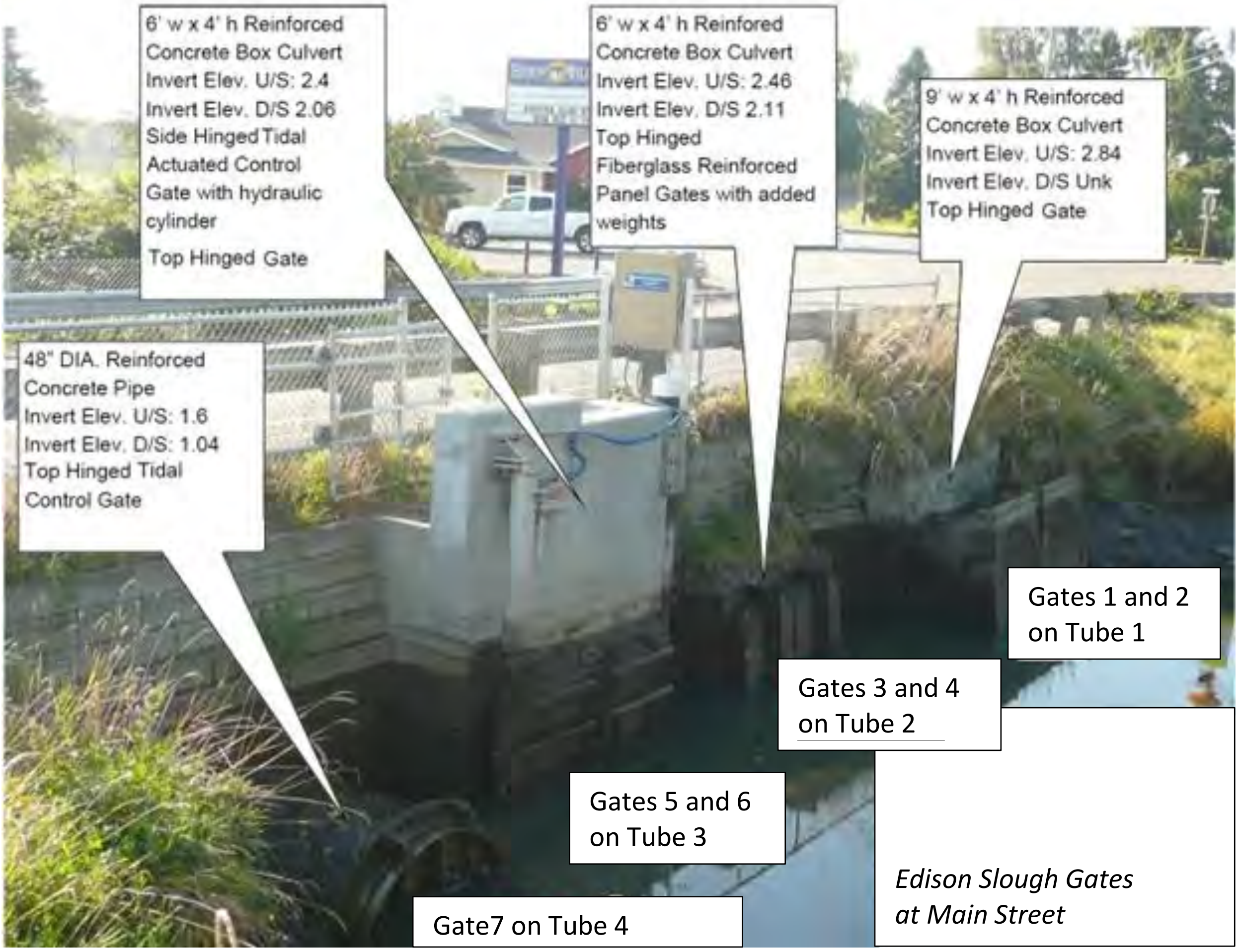


Figure 1.2 Upstream side of Edison Slough crossing at Main Street (looking south, by Skagit County)

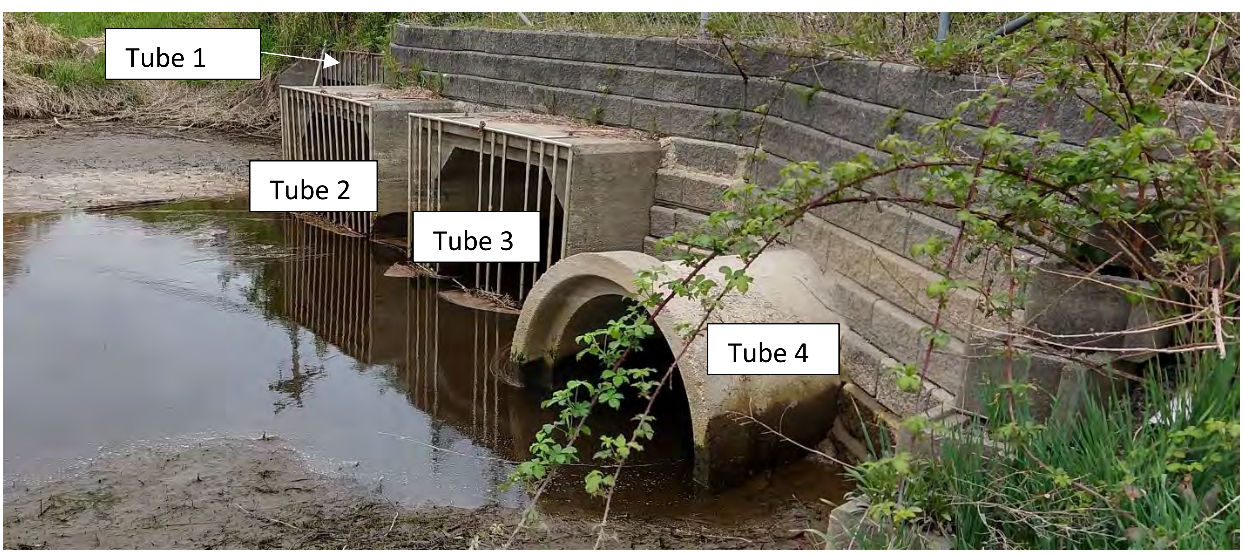


Figure 1.3 Upstream side of Edison Slough crossing at Main Street (taken by NHC, April 2020)

2 MONITORING AND INSPECTION

Monitoring at Edison Slough was carried out in four phases between April 2020 and May 2022, with each phase aimed at answering specific questions regarding the structure:

- Phase 1 was performed to try and get an understanding of the conditions at the site.
- Phase 2 included installation of gate position sensors, water level loggers on the upstream and downstream sides of the crossing, fixed frequency photographs, and conductivity sensors on each tube (aimed at identifying which gates leak and how salt water moves through the system).
- Phase 3 involved redeployment of conductivity sensors and modified SRT operation.
- Phase 4 was an inspection of the interior of the gates.

The dates of specific actions related to monitoring are summarized in Table 2.1.

Table 2.1 Summary of Monitoring and Inspection Action dates

Date/Time	Action
Phase 1 Reconnaissance	
4/26/2020	Preliminary reconnaissance
5/19/2020	Reconnaissance/video of upstream flow in outer gates during the incoming
9/21/2020	Supplemental reconnaissance
Phase 2 Gate Position Monitoring	
10/14/2020	Initial monitoring equipment installed - Upstream and downstream water-level loggers - 7 gate position sensors - 2 trail cameras
12/10/2020	First download, lost 3 position sensors to rust, one camera was stollen
1/11/2021	Reinstall upgrade - Upstream and downstream water-level loggers - Installed stainless steel mounts for gate position sensors - Redeployed remaining camera - Installed 4 conductivity sensors (one in each tube)
Phase 3 Redeployed Conductivity Sensors and Modified SRT	
2/9/2021	Download/remove conductivity sensors - redeploy 1 on upstream side of crossing - redeploy 1 at bus access bridge approximately 1000 feet upstream
3/25/2021	Meeting to discuss preliminary conductivity data
4/6/2021	Disengaged SRT
4/27/2021	Install 3rd conductivity sensor at Doser Street
5/2/2021	Last date of bus access bridge conductivity data
5/10/2021	Re-engaged the arm of the SRT
6/11/2021	Disengaged SRT
6/30/2021	Re-engaged the arm of the SRT
7/7/2021	Download/removed Doser Road conductivity sensor
Phase 4 Inspection of Interior of Gates	
5/26-5/27/2022	Inspection/photos of Interior of Gate Tubes

2.1 Phase 1 – Reconnaissance and Site Observations from May 19, 2020

NHC staff visited the Edison Slough Self Regulating Tide Gate (SRT) system on May 19, 2020. It had been reported to the County and NHC that the SRT system remaining open too long during incoming tide periods, which could be allowing an influx of saline water into the slough. The site visit was conducted at 15:30 (PDT) during the incoming tide cycle with the intention of observing the upstream movement of flow. On this day, the NOAA tide predictions for the Everett station estimated low tide to occur at approximately 10:00 with an elevation of -0.7 ft NAVD and high tide at approximately 16:50 with an elevation of 7.0ft NAVD (https://tidesandcurrents.noaa.gov/). The Everett station is referenced as it is the closest station tied to the NAVD vertical datum but elevations reported by NOAA for the Cherry Point station also provide a useful tide reference. The actual tide elevations at Edison Slough differ slightly due to its distance to Everett or Cherry Point, WA. At 15:30 the tide gate system was in the fully closed position (Figure 2.1). Using RTK survey equipment, the water surface on the upstream and downstream side of the system were surveyed to be at elevation 3.6 and 4.7 feet relative to the NAVD 1988 vertical datum respectively. Although all of the gates were closed, visual movement of the water (via surface film) and audible flow within the tubes was noted at three of the four tubes. Table 2.2 summarizes the site observations at the time of the site visit. The greatest movement of water was visible on the upstream side of Tubes 1 and 4 (the outer most).

Figure 2.1 Downstream side of gates, taken May 19, 2020 15:30 (looking north)

Table 2.2 Site Observations During Rising Tide, May 19, 2020 15:30 PST

	Tube 1	Tube 2	Tube 3		Tube 4
			Gate 3	Gate 4 (SRT)	
Downstream observations	No visible leakage	No visible leakage	No visible leakage	No visible leakage	Visible and audible flow into the tide gate
Upstream observations	Visible and audible flow moving upstream	Visible and audible flow moving upstream	No visible flow	No visible flow	Visible flow moving upstream

* Tubes and tide gates are numbered from left to right, looking downstream

2.2 Phase 2 – Gate Position and Conductivity Monitoring

Following the reconnaissance in May 2020 the County asked NHC to collect monitoring data of the gates to better characterize the timing of when each of the gates closed relative to the rising tide. This was achieved through the deployment of:

- gate position sensors on each gate (Figure 2.2)
- water-level loggers on the upstream and downstream sides of the crossing
- time lapse photographs taken with two game cameras (one looking down at the SRT [Figure 2.3] and the other looking across the channel from the right bank [Figure 2.4])

The instrumentation was installed on October 14, 2020 and downloaded on December 10, 2020. This first deployment had mixed success, with several of the sensors lost due to rapid corrosion of the mounting hardware (which was not as corrosion resistant as expected) and theft of the trail camera that had been looking downward from directly above the SRT. The installation was redeployed on January 11, 2021 with improved hardware, the addition of conductivity sensors on the upstream side of each of the four tubes, and one trail camera looking down at the SRT. The data was downloaded again on February 9, 2021.

Figure 2.2 Gate Position Sensors and downward looking trail camera (top hinged gates left and center; SRT control arm at right)

Figure 2.3 Example trail camera photo sequence looking downward at the SRT

Figure 2.4 Gate opening photo sequence from right bank trail camera (October 15, 2020 images taken 15 minutes apart)

Results from the monitoring data were used to evaluate how much time passes between the time that the tide begins to rise on the downstream side of the crossing and how saltwater moves through the gates. An example of this data for January 16, 2021 is presented in Figure 2.5. The graphic is busy but presents a range of inter-related parameters including:

- Head difference between the upstream and downstream sides of the gate
- Gate opening position in degrees
- Conductivity in uS/cm

It is important to note that due to the manner by which the gate position sensors are attached to the gates, the plotted gate opening angles do not reflect the actual gate opening angle. The position sensor data should be used to look for the timing of gate position change rather than specific angles. The changes in the gate opening angle in Figure 2.5 are much more subtle for the top hinged gate than that for the SRT. The top hinged gate changes by as little as 2 degrees when closing vs. more than 25 degrees for the SRT.

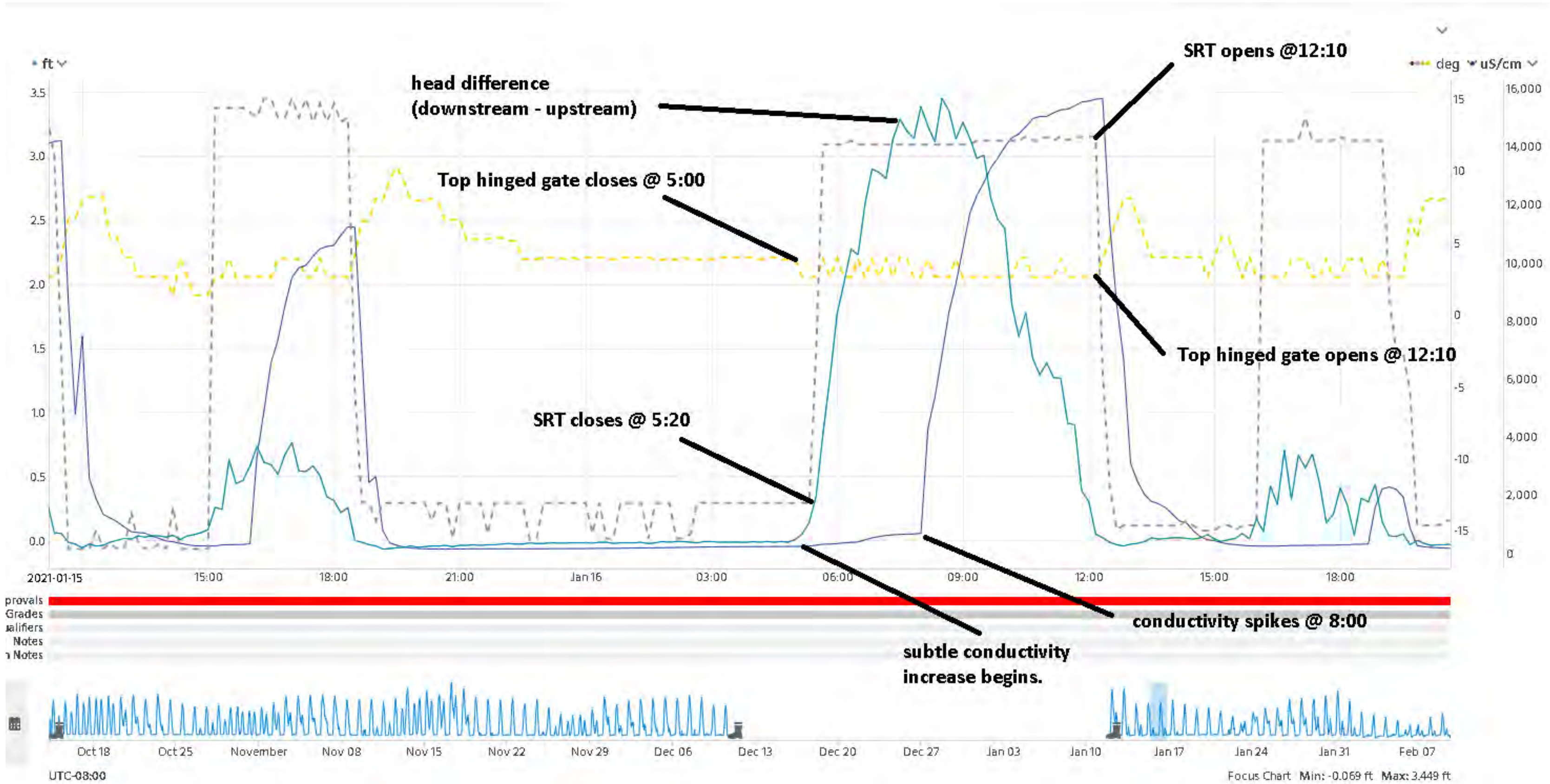


Figure 2.5 Example SRT Data Open-Close Timing (January 16, 2021): Light blue solid line - head difference (left axis); dashed yellow and dashed gray lines - gate opening position in degrees (first right axis); dark blue solid line - Conductivity in uS/cm (far right axis)

There are a few observations from Figure 2.5 that are worth making note of.

1) The top hinged gate closes at 5:00, nearly instantaneously when the head difference rises above zero also at 5:00 (i.e. as soon as the downstream head begins to increase).

2) The SRT closes at 5:20, about 20 minutes after the head difference rises above zero. This is a much shorter lag than is typically set for SRT gates that are intentionally held open for fish passage objectives.

3) The conductivity sensor that was mounted on the upstream side of Tube 3 (where the SRT is located) shows a very subtle increase immediately after the head difference rises above zero. This increase continues for three hours before spiking to levels similar to seawater at 8:00. While not shown on this plot, the conductivity data from all four tubes all showed similar timing of increases in conductivity following the rising tide. A likely explanation for this change in the rate conductivity values are increasing is that the lag between 5:00 and 8:00 reflects the time it takes for the volume of fresh water that is on the downstream side of the gates to be pushed upstream and through the gates. At 8:00 the freshwater volume has advanced to the upstream side of the gates and continues to push upstream further increasing the conductivity at the sensor until the tide drops at 12:10 and the gate opens, and fresh water passes downstream again.

4) The rate of conductivity change upstream of the gates does not change when the SRT closes. This indicates that the total volume of saltwater passing through to the upstream side of the gate is not dominated by the additional 20 minutes for which the SRT is open relative to the top hinged gates, but rather by the steady leaking of gates during the high tide cycle.

2.3 Phase 3 – Redeployed Conductivity Sensors and Modified SRT

Following an analysis of the Phase 2 data and receiving feedback from Dave Lohman from District 16, it was decided that an additional phase of monitoring would be performed. For this phase the gate position sensors and water-level loggers were left in-place and the SRT operation would be disabled (making it operate like a standard tidegate that closes immediately when the tide rises) to see if there was any effect on the system leakage. The conductivity sensors were also deployed in a different manner, initially in February 2021 with only two sensors available, one was placed upstream at the Edison Elementary bus access road and the other was attached to the upstream side of the Main Street (Edison gates) crossing. Later, a third conductivity sensor became available and was also deployed downstream near the west end of Doser Street on April 27 2021 (see Figure 2.6). Unfortunately, the sensor on the upstream side of the Main Street (Edison gates) crossing was lost before the first download attempt and the sensor at the Bus Access Road bridge ceased logging on May 2, 2021. Ultimately Phase 3 conductivity data was only available at the Bus Access Road bridge prior to May 2 and at Doser Street after April 27, which means that contemporaneous conductivity data was limited to the period April 27 through May 2, 2021.

Figure 2.6 Deployment of conductivity sensor at west end of Doser Street (left) on upstream side of Main Street (upper right), and at the Bus Access Road Bridge to Edison Elementary School

The data collected in Phase 3 was evaluated for evidence of changes in leakage with the SRT disabled and for information on the movement of salt water between Doser Road and the Bus Access Road bridge. Figure 2.7 provides a snapshot of a four-day period between April 2 and 6, 2021 when the SRT was disengaged and also the subsequent three-day period through April 7, 2021. It is difficult to directly compare these periods because the tides and rainfall before and after the SRT was disengaged differ somewhat from one another. However, the relative timing between the opening and closing of the SRT and of high conductivity at the Bus Access Bridge are similar both before and after (e.g. April 4 vs. April 7, 2021) the SRT was disengaged. Figure 2.8 provides a snapshot of April 27 through May 3, 2021 when the SRT was disengaged and both the Doser Road and Bus Access Road Bridge conductivity sensors were operating. The plot shows a similar sequence as Figure 2.7, the most noteworthy difference being that the duration for which the conductivity at the Buss Access Road Bridge is low is shorter than that at the beginning of April. This difference is believed to be the result of either higher high tides in May, less runoff in early May than early April, or a combination of both mechanisms. The SRT closes when the seaward water-levels exceeds approximately 2.5 to 3.0 feet NAVD, regardless of being engaged or disengaged.

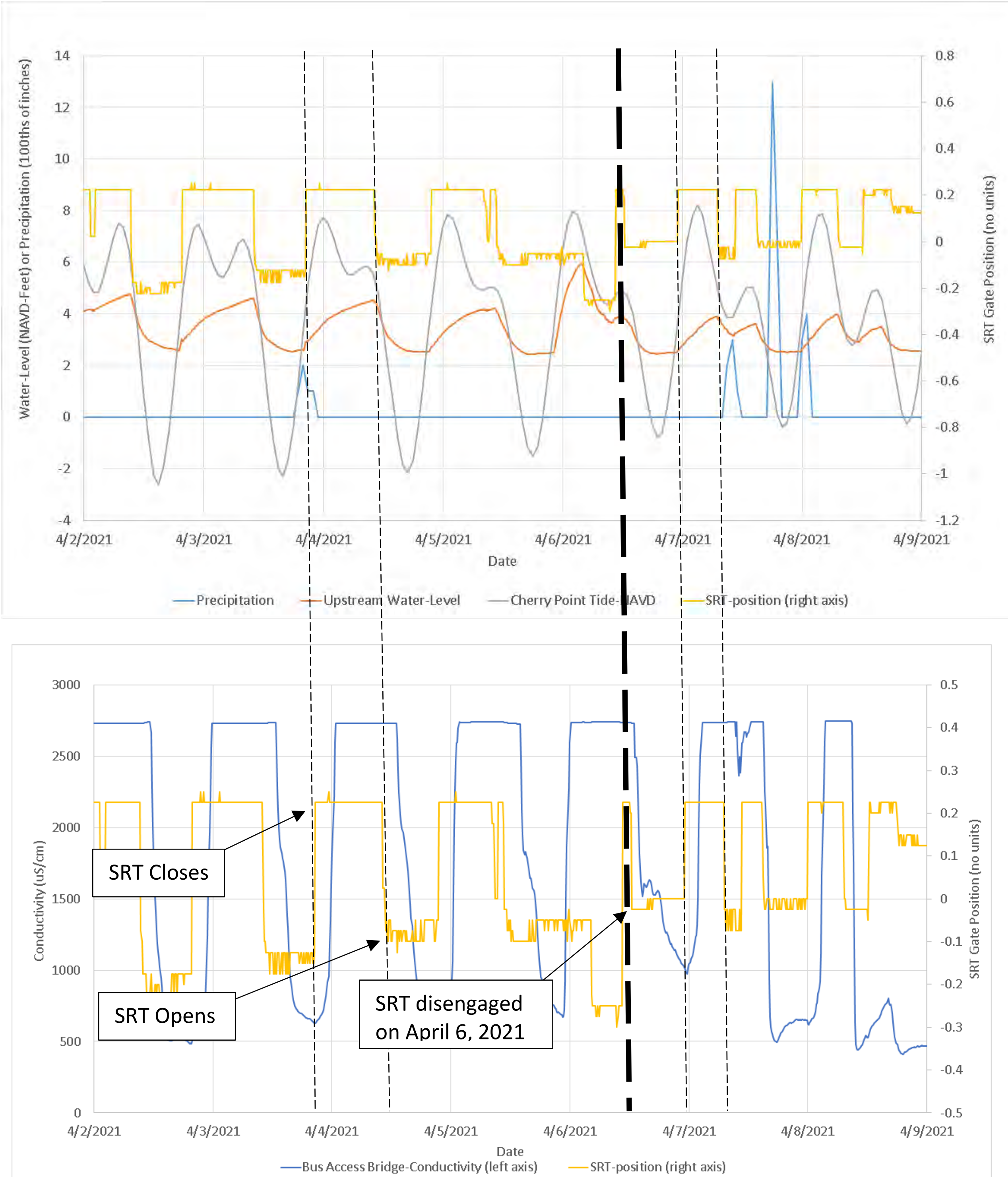


Figure 2.7 Example SRT Data Open-Close Timing (April 2 through April 12, 2021) – SRT disengaged on April 6, 2021

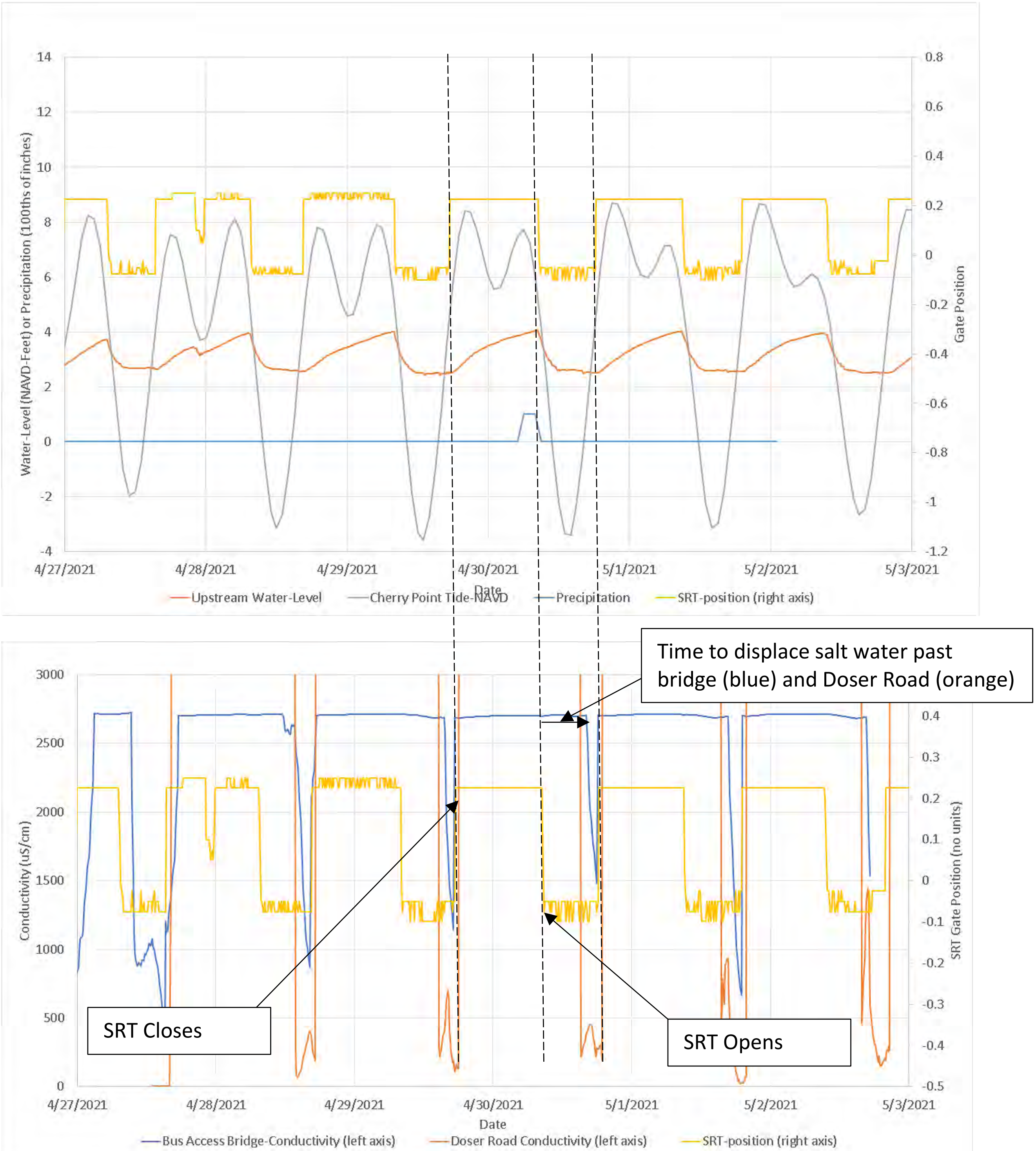


Figure 2.8 Example SRT Data Open-Close Timing (April 27 through May 3, 2021) – SRT disabled throughout

2.4 Phase 4 – Inspection of Interior of Gates

Review of the Phase 4 conductivity data did not offer any new evidence indicating that the SRT is the cause of upstream leakage through the gates at the Main Street crossing. This leaves the evidence from the Phase 1 observation on May 19, 2020 indicating that leakage from Tubes 1 and 4, both top hinged tide gates, and to a lesser extent from Tube 3, where the SRT is located, is the strongest indication of how salt water is passing upstream of the crossing. While NHC concluded that leakage from the outer two tubes was the biggest problem at the site, the mechanism by which water is entering the tubes was not known. Water could be entering by any number of pathways but the three[1] most likely include:

- Leaky gate doors
- Leaky connection in the grout joints between gate frames and tubes
- Water is passing through road embankment and entering tubes through cracks in the concrete. [1]

The recommended action to remedy the leakage will vary depending on the mechanism of leakage, so it was decided that an inspection of the interior of Tube 1, where the greatest amount of leakage had been observed, was needed. The inspection was scheduled for the afternoon of May 16, 2022 when the tide would be rising in a similar manner as it was on May 19, 2020, during the initial reconnaissance two years prior. During the low tide on May 16 the door on Gate 1 was opened to provide access to the interior of Tube 1. This initial inspection revealed ½ inch wide gaps in the grout lines connecting the Gate 1 and Gate 2 frames (or housings) to the concrete box forming Tube 1. Figure 2.9 highlights some of these gaps as well as barnacles that have been forming where water enters through the cracks. The cracks were visible on the top and sides of the gate frames but also likely exist on the bottom of the structure.

Based on the initial observation of the interior of Tube 1 it was decided that it would be informative to setup a trail camera inside of Tube 1, with the camera oriented toward Gate 2, so the rate of flow during the high tide could be observed. The camera was mounted on top of a 2x4 board where it would stay relatively dry and then deployed to collect photos on 5-minute intervals. The camera collected a photo every 5 minutes through of afternoon May 18, 2022. A movie file compiled from these images shows water pouring in through the grout lines whenever downstream tides are above the water level inside the structure.

[1] The amount of this type of subsurface leakage is difficult to quantify and will be driven largely by the permeability of the fill materials used to build the crossing.

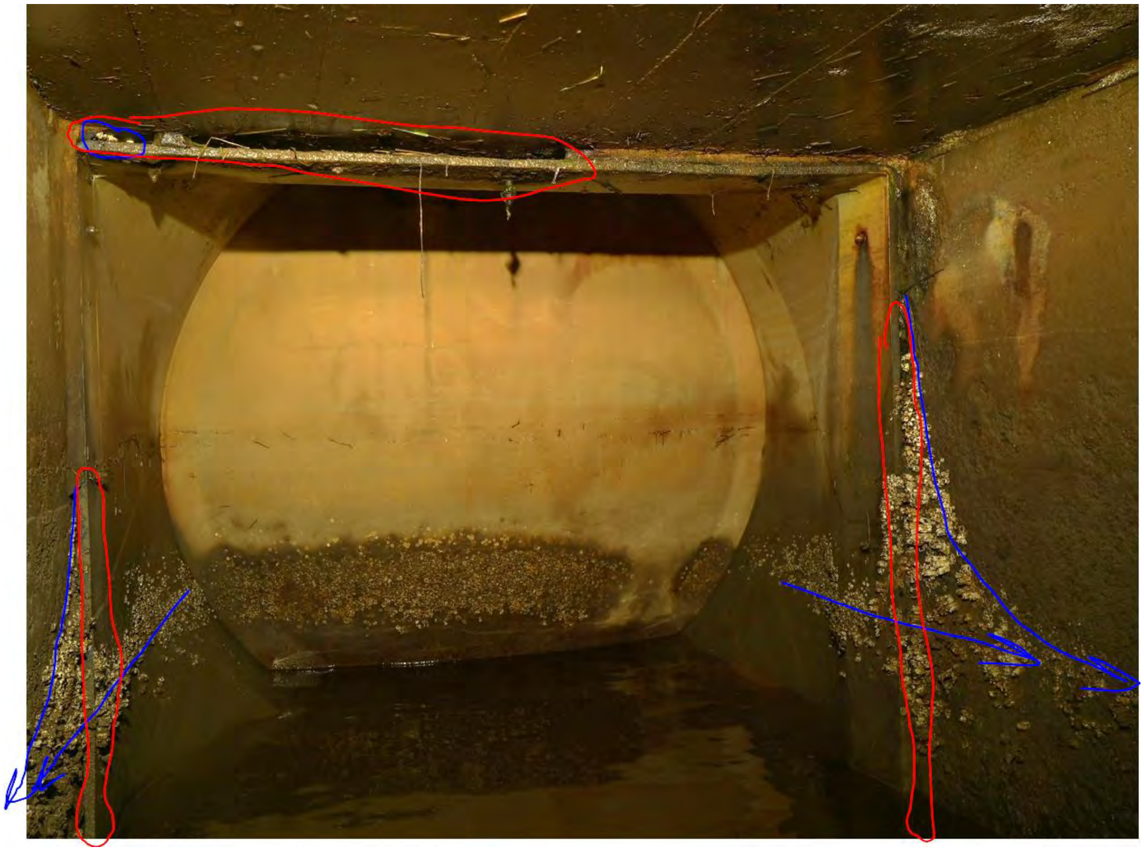


Figure 2.9 Photo of interior of Gate 2 taken on May 16, 2022 (gaps in grout lines are circled red and barnacle accumulation from salt water is identified in blue)

The gates for Tubes 3 and 4 are also leaking, but at a much lower rate than those for Tube 1. The leaking through Tube 3 (including the SRT) is coming through edges of the closed door. Figure 2.10 shows water entering from the top edge of Gate 7 in Tube 4. From a distance it appeared as though the leakage was coming through the door seal, but this tube was not opened and we were not able to readily walk completely through the tube to the back side of the gate to confirm if the leakage was coming through the door seal or the gate attachment to the concrete tube.

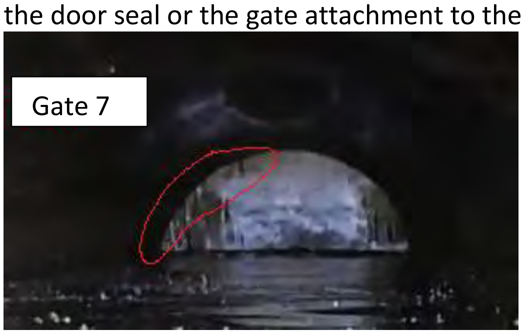


Figure 2.10 Leakage through top of Gate 7 (from video DSCI16004.MOV)

3 RECOMMENDATIONS

Based on the data collected in 2020 and 2021 and the inspection of the interior of the tubes performed on May 16, 2022, there is no evidence indicating that the timing of the SRT door closing is the primary source of salt water to the upstream side of the Edison Slough gates. Rather, leakage through the grout joints in Tube 1 and gate door leakage in Tubes 3 and 4 appear to be the primary sources of saltwater through the crossing during high tides. The most meaningful short-term action we recommend is to clean the interior and exterior of the Tube 1 grout lines and repack them with new grout or expanding urethane foam. This action was discussed with Jason from Skagit County Public Works when the problem was discussed during a site visit on May 16.

During the duration of our site observations, we noticed that Gate 1 door to Tube 1 was occasionally caught on a rock that could have prevented it from fully closing. We recommend that maintenance be performed to keep debris from blocking any of the gates at this site. Similarly, we also observed the Gate 1 door was partially buried by sediment in a manner that was preventing it from opening. This condition was corrected by Skagit County Public Works during the later half of 2021, but similar maintenance will be needed in the future.

Even if the grout joints on Tube 1 are corrected the gate doors to Tube 3 and 4 will still be leaking, though to a lesser degree. It is possible that improved seals to these gates can be sourced and installed. Some gate designs leak less than others as evidenced by the variable performance of the different types of gates at this site. Gates can also leak under low head conditions but seal under higher heads. District 16 may want to consider replacing the gate doors with new gates for each of the tubes or, the improvement that has been widely popular in the delta in recent years, the entire set of tubes could be replaced by a single structure with large Nehalem Marine style side hinged gate doors. These doors are reportedly hydraulically efficient while also minimizing leaking during high tide cycles.

NHC was not tasked with evaluating flooding within the downtown Edison, WA vicinity, but we understand that a high tide in January 2022 caused flooding. It is worth noting that flood control measures, including raising roadways, could be incorporated into a gate redesign effort.

While the potential benefits associated with additional monitoring are likely more limited, there would be additional information gained by redeploying conductivity sensors at the gates and the Bus Access Road bridge to get more contemporaneous data. This, combined with additional hydrologic and/or hydraulic modeling could be used to further evaluate the existing gate function but more importantly evaluate the performance of a new gate configuration.

Sincerely,

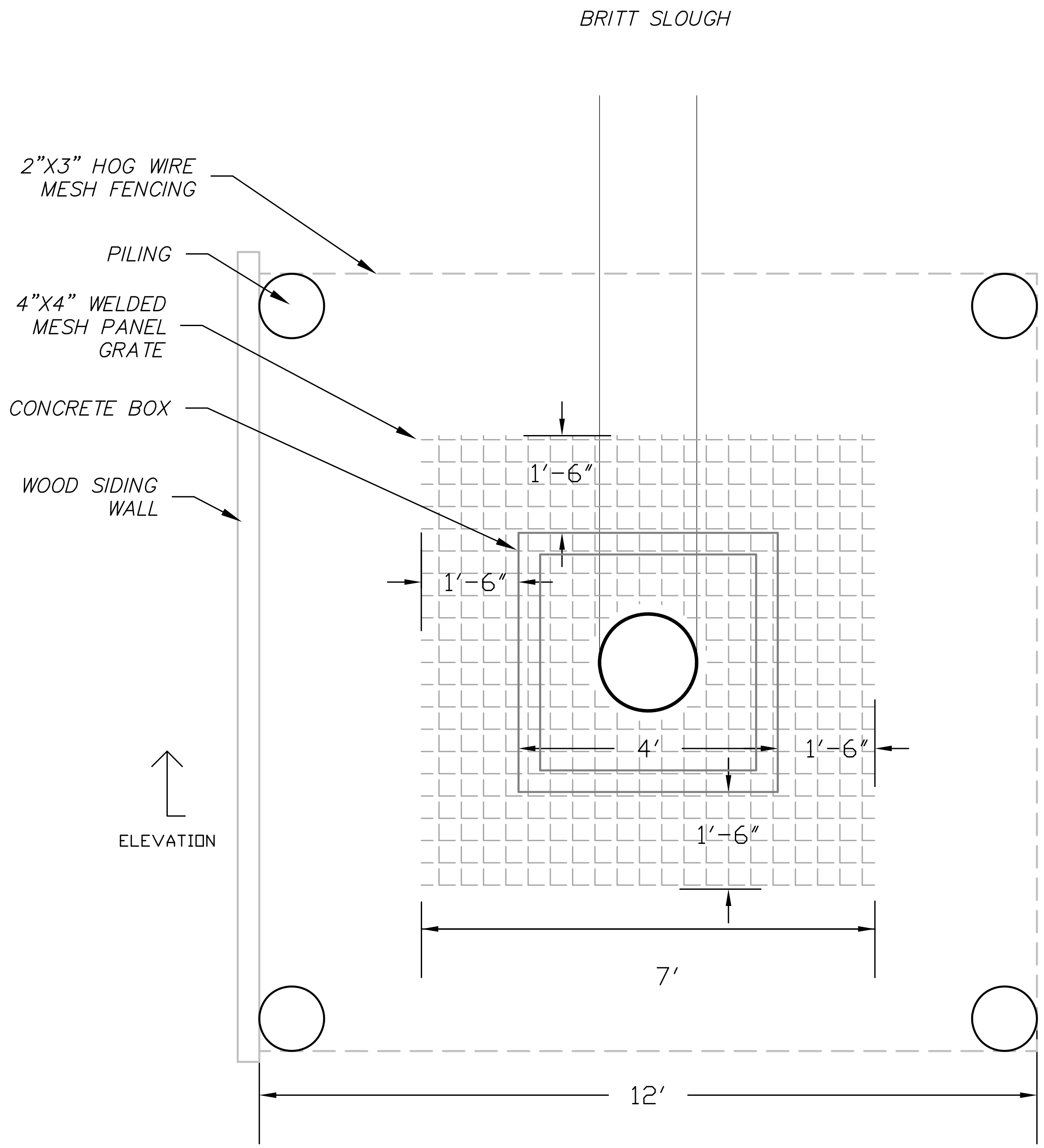
Northwest Hydraulic Consultants Inc.

Derek Stuart

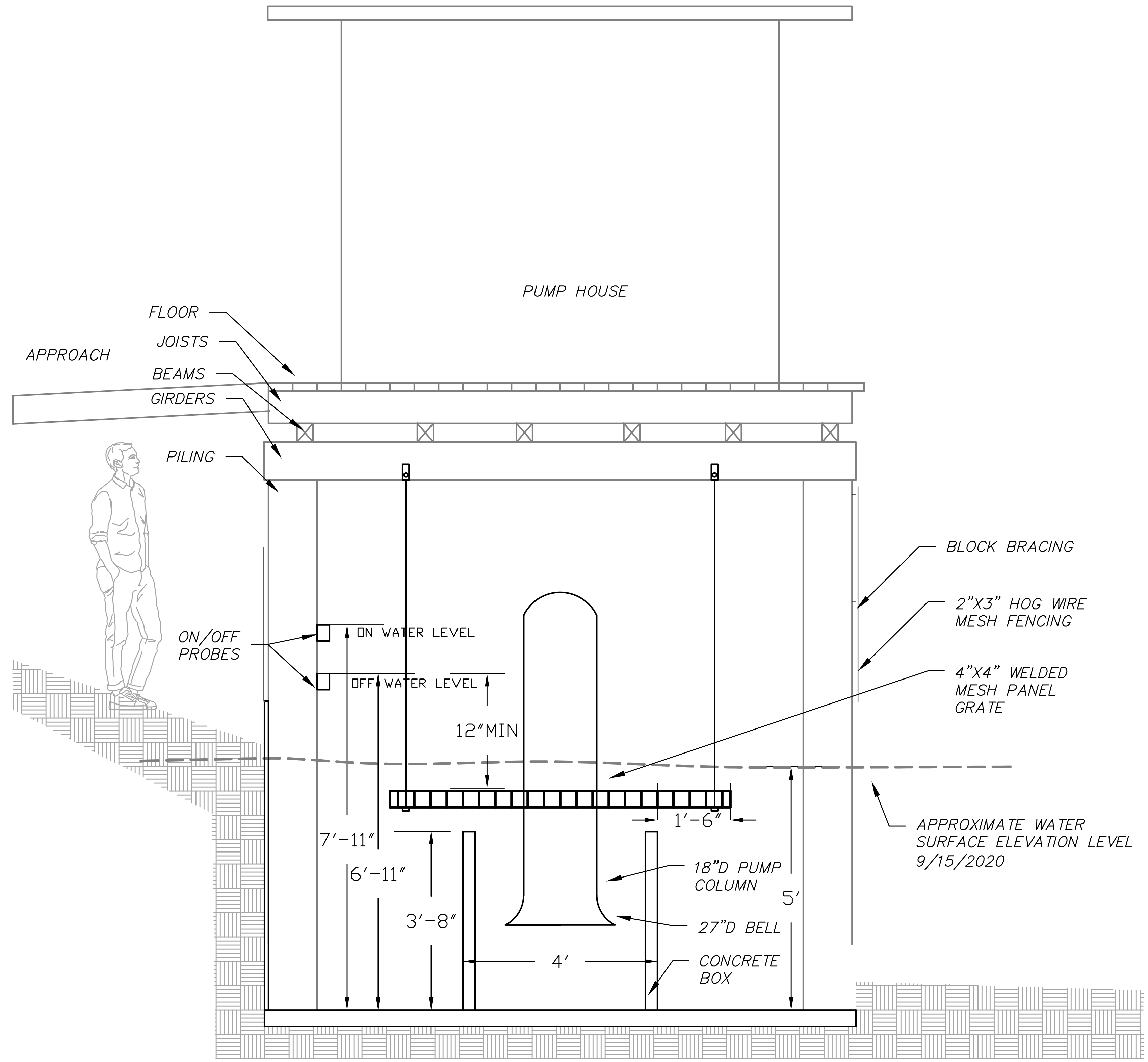
Derek Stuart, PE
Principal

APPENDIX H

BRITT SLOUGH PUMP STATION VORTEX BREAKER DESIGN



PUMP HOUSE PLAN VIEW
W/ PROPOSAL VORTEX BREAKER
3/8" = 1'



PUMPHOUSE ELEVATION VIEW
W PROPOSAL VORTEX BREAKER
3/8" = 1'

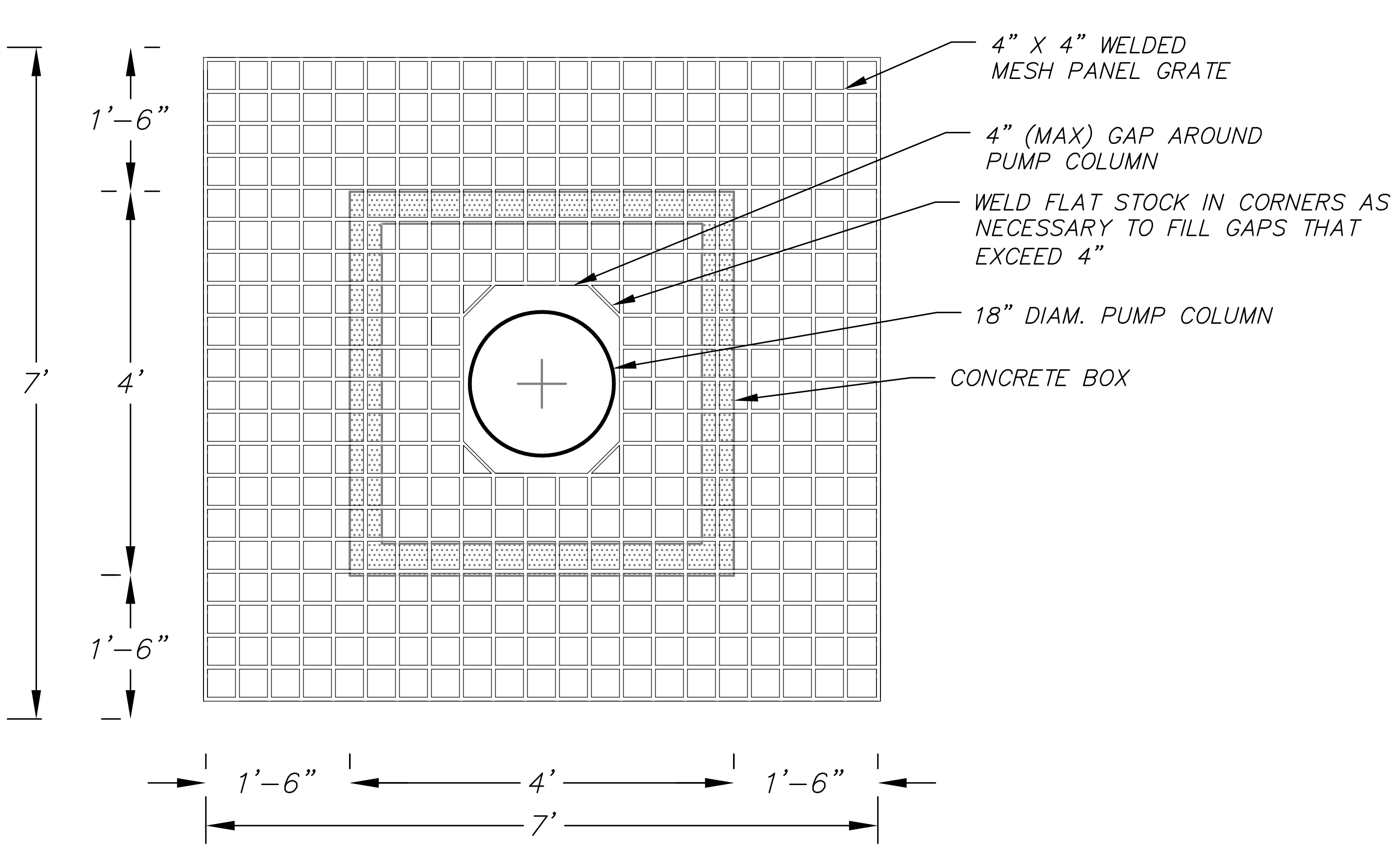
Skagit County Public Works
Natural Resources Division

northwest hydraulic consultants
12787 gateway drive south
tukwila, washington 98168–3308
phone: (206) 241–6000
fax: (206) 439–2420

Job:2006112
Rev: R1
Drft: BD
Chkd: JMB
Date: 06Nov20

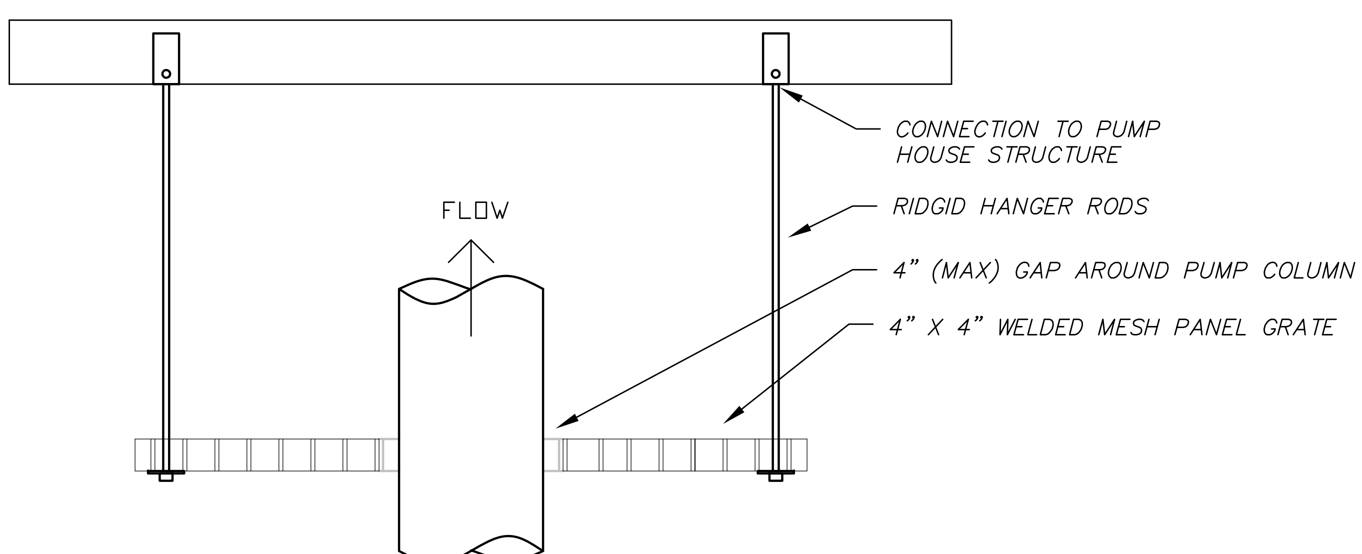
Britt Slough Pump Station Vortex Breaker

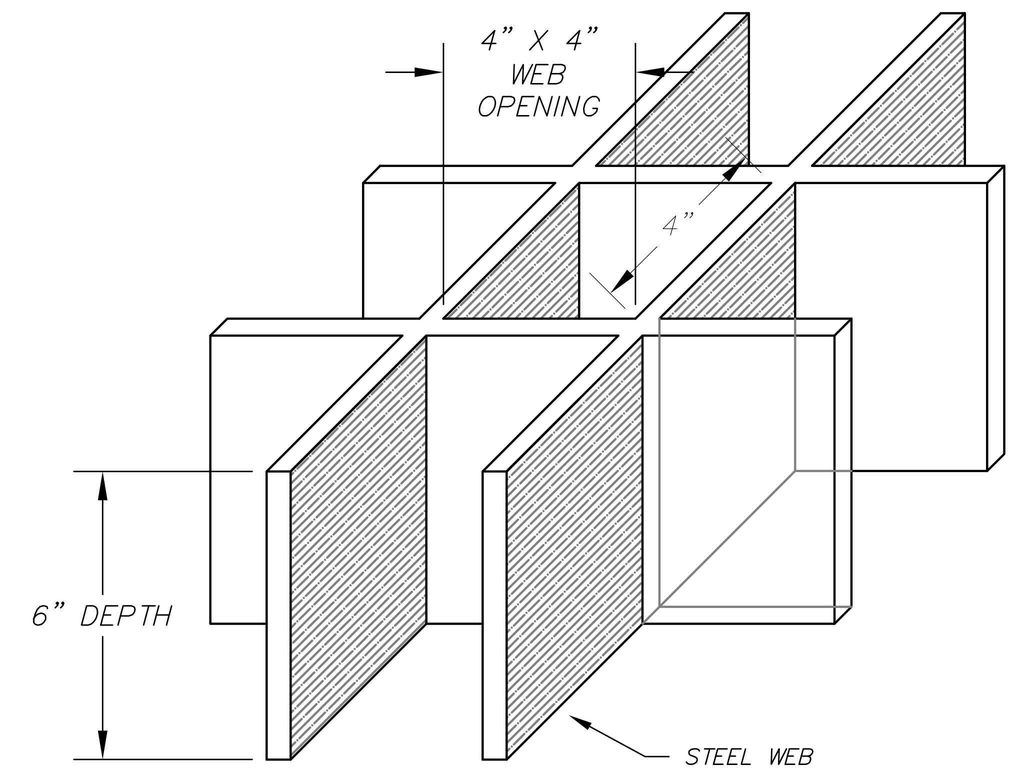
PLAN AND ELEVATION VIEW



PROPOSED VORTEX BREAKER
GRATE PLAN
1/2" = 1'

NOTES:
1. GRATING TO BE FABRICATED IN HALVES OR QUARTERS DEPENDING ON WEIGHT AND FEASIBILITY TO POSITION IT WITHOUT MACHINERY.
2. NO CORNERS OR SHARP EDGES SHALL REMAIN INSIDE CUT OUT FOR PUMP COLUMN.
3. SUGGESTED ATTACHMENT METHOD SHOWN, BUT OTHER OPTIONS INCLUDE ATTACHING THE GRATING DIRECTLY TO THE CONCRETE BOX SURROUNDING THE PUMP COLUMN OR HANGING THE GRATING USING WIRE ROPE OR CHAIN.





PROPOSED VORTEX BREAKER GRATE WEB DETAIL
3" = 1'

PROPOSED VORTEX BREAKER
GRATE SECTION
1/2" = 1'

Skagit County Public Works Natural Resources Division	nhc northwest hydraulic consultants 12787 gateway drive south tukwila, washington 98168–3308 phone: (206) 241–6000 fax: (206) 439–2420	JARON M. BROWN STATE OF WASHINGTON 49425 REGISTERED PROFESSIONAL ENGINEER	Job:2006112 Rev: R1 Drft: BD Chkd: JMB Date:06Nov20	Britt Slough Pump Station Vortex Breaker GRATING DETAIL 2/2

APPENDIX I

TIDE GATE TYPES AND PERFORMANCE SUMMARY

There are multiple types of tide gates that may influence upstream water quality, habitat connectivity, fish passage, required maintenance, and cost. However, it should be noted that the selection of an appropriate type depends on the specific habitat and hydrological characteristics of the site as well as project goals (Giannico and Souder 2005). Tide gate types vary in terms of ecological impact, maintenance, construction complexity, and cost characteristics. As a means to provide a qualitative comparison of the strengths and weaknesses of common gate types, a Low, Medium, and High impacts was assigned to each based on the relative performance, according to available studies (Giannico and Souder, 2005; Giannico et al., 2018; WWAA, NMFS, and WDFW, 2008) and field observations/monitoring.

A general definition was considered for “High”, and subsequently “Medium” and “Low” classes were defined relative to that. The broad definition of “High” impact for different parameters follows.

- High ecological impact: very short opening period; very narrow opening width; highly impacted upstream water quality; very limited access for fish passage.
- High maintenance: frequent checks are required due to significant debris collection and gate damage; short life span.
- High construction complexity and cost: difficult and complex installation/design; costly due to mechanism and/or material used.

Table I.1 summarizes various tide gate types and their general performance, with respect to the categories noted above.

A photo set is also provided showing different types of tide gates that exist within the study area vicinity now or are planned for construction soon.

Table I.1 Summary of tide gate types

Tide gate type	Typical Geometry and Material	Ecological Impact	Maintenance	Construction Complexity and Cost
Top-Hinged (Traditional)	Shapes: round and box Material: wood and metal	High (narrow opening over a short period of time)	Low (durable and long life span)	Low (easy and straightforward design and installation)
Side-Hinged	Shapes: round and box Material: aluminum and stainless steel	Medium (wide opening over a longer period)	Medium (angle of tilt should be checked to keep functionality)	Medium (complex set up for angle of tilt and support structure)
Self-regulating (SRT)	Shapes: round and box Material: aluminum	Low (longer and adjustable opening time)	High (collects debris)	High (not documented but expected to be higher due to site-specific adjustment and more complicated setup)
Muted Tide Regulator (MTR)	Shapes: round and box Material: aluminum	Low (longer and adjustable opening time)	High (expected to be similar to SRT)	High (expected to be higher due to site-specific adjustment and more complicated setup)

Photo Set 12 **Constructed tide gates in the studied area vicinity**

Photo I12.1 Joe Leary Slough Side Hinge Tide Gates, Installed in Summer 2019

Photo I12.2 Big Ditch Side Hinge Tide Gates

Photo I12.3 Alice Bay Top Hinge Tide Gates Proposed for Replacement (left) Alice Bay channel on seaward side of gates (right)

Photo I12.4 Farm to Market Replacement with Side Hinged Tide Gates (left)

Photo I12.5 Left: Top view of Edison Slough SRT gate. Right: Side view of traditional top-hinged gates (near) and SRT gate (far) at Edison Slough

Photo I12.6 Examples of MTR tide gates. Left: unknown location; Right: Fisher Slough (Pictures from http://www.nehalemmarine.com)

Photo I12.7 Top hinged tide gate at "Old Stilly Gate" structure near Stanwood, WA.