Seattle Department of Transportation

Fairview Avenue N Bridge Replacement Project

Appendix A

Contents

FAIRVIEW AVENUE NORTH BRIDGE REPLACEMENT PROJECT

Biological Assessment

Prepared for

City of Seattle
Department of Transportation

April 2014

EXECUTIVE SUMMARY

Project Description

The City of Seattle Department of Transportation (SDOT) proposes to replace two existing bridges (East and West Bridge) on Fairview Avenue North, with a single new bridge spanning a portion of the southeast shoreline of Lake Union, in Seattle Washington. The West Bridge and East Bridge were built in 1948 and1963, respectively. Based upon a December 2012 inspection report, both bridges are structurally deficient. These two structures are proposed to be replaced with a single bridge, measuring 540 feet long and 67 feet wide, and consisting of four 135-foot-long spans with the northern abutment located at the northern end of the existing bridges. The proposed action will receive federal funding through the Federal Highways Administration, which is the federal nexus for the proposed action requiring consultation under the Endangered Species Act.

The Fairview Bridge Replacement Project will involve the construction of four new bridge spans supported on bents of four foot diameter reinforced concrete bridge columns, constructed on eight foot diameter shafts that will be installed to an approximate depth of 120 feet. Drilled shaft construction will also require construction of two temporary work trestles, constructed on temporary piles. The project also includes reconstruction of the roadway approaches on the north and south side of the bridge and relocation of underground and underwater utilities. The proposed new roadway will not add capacity and will include three travel lanes, a cycle track, a sidewalk and a mixed use trail/walkway. The project will either replace or relocate the existing (west of the bridge) floating dock.

The project will result in an overall reduction (approximately 0.05 acre) of pollution generating impervious surface (PGIS). Furthermore, stormwater facilities will treat stormwater runoff from all PGIS within the project area for water quality prior to stormwater discharge into Lake Union. Currently, runoff from impervious surfaces in the project receives no stormwater treatment or detention.

The Action Area is located in Water Resources Inventory Area (WRIA) 8, the Lake Washington Basin, 6th Field Hydrologic Unit Code (HUC) 171100120400. Identified habitat areas for listed species within the Action Area are limited to the aquatic habitat of Lake Union. ESA-listed fish species addressed in the Biological Assessment include the Puget Sound Chinook salmon evolutionary significant unit, the Puget Sound distinct population segment (DPS) of steelhead trout, and Coastal-Puget Sound DPS of bull trout, which are all known to occur within Lake Union and Lake Washington. Additionally, critical habitat has been designated for Chinook salmon and bull trout in Lake Union (proposed critical habitat for the Puget Sound steelhead DPS does not include the action area). There are no known additional listed terrestrial/ marine wildlife or plant species identified in the project vicinity or Action Area.

Potential direct effects of the proposed project upon protected fish species include direct or indirect construction effects from extensive work within the ordinary high water mark of Lake Union. Direct injury or mortality could occur to individual fish from physical contact with machinery or entrainment from in-water project activities including installation of temporary piles, drilled shaft construction, removal of existing piles, and minor excavation within the wetted portions of the project area. Also, contaminated surface and near-surface sediments (including poly-cyclic aromatic hydrocarbons (PAHs), metals, and oil/fuel contaminants) are known to be present underneath the existing bridges. Resuspension of these materials during project construction could result in exposure by listed fish species. The project will utilize containment curtains, which will extend from the water surface to the lake bottom that completely isolates the project area from Lake Union in order to both 1) exclude fish from the work areas, and 2) minimize the spread of resuspended materials within Lake Union. Furthermore, all lake bottom areas where work will occur will be treated with the application of a one to two-foot-deep layer of sand prior to the initiation of ground disturbing action. This will serve to minimize the resuspension of potentially contaminated materials from construction activities.

No impact pile driving will occur, and vibratory pile installation or removal is not expected to cause take of listed species. Likewise, the pollutant loads from stormwater runoff are expected to decrease as a result of water quality treatment of all PGIS in the project area, where none currently exists.

The project will utilize appropriate best management practices (BMPs), including stormwater treatment facilities and sediment and erosion control measures, which would reduce potential impacts.

As summarized in Table ES-1, the project is "likely to adversely affect" Chinook salmon and steelhead, while the project "may affect, (but is) not likely to adversely affect bull trout. A "may affect, (but is) not likely to adversely affect effect" determination is also appropriate for designated Chinook salmon and bull trout critical habitat, which is present in the Action Area. As no designated critical habitat for Puget Sound steelhead is present within the Action Area, a "no effect" determination is appropriate for critical habitat. In addition, the project would *not adversely affect* Pacific salmon Essential Fish Habitat (EFH) (see Section 6).

Table ES-1-1. ESA Regulated Species Potentially Occurring in the Project Vicinity

Common Name	Scientific Name	ESA Status *	Jurisdiction	Designated Critical Habitat in Action Area	Effect Determination**
Puget Sound Distinct Population Segment (DPS) Steelhead	*Oncorhynchus mykiss*	Threatened	NMFS	No	LAA
Puget Sound Evolutionary Significant Unit (ESU)	*O. tshawytscha*	Threatened	NMFS	Yes	LAA
Coastal-Puget Sound DPS Bull Trout	*Salvelinus confluentus*	Threatened	USFWS	Yes	NLAA

* Threatened: Species are likely to become endangered within the foreseeable future.

** NLAA: Not Likely To Adversely Affect; LAA: Likely To Adversely Affect

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1 INTRODUCTION

Project Name:	Fairview Avenue North Bridge Replacement Project
Location:	Northwest Quarter, Section 19, Township 25 North, Range 04 East, WM.
Proposed timing or schedule:	Spring 2015 to Spring 2017
Project Proponent:	City of Seattle Department of Transportation

The City of Seattle (City) proposes to replace two existing bridges (East and West Bridge) on Fairview Avenue North, with a single new bridge spanning a portion of the southeast shoreline of Lake Union. The purpose of this Biological Assessment (BA) is to review the City of Seattle Fairview Avenue Bridge Replacement project (project) to determine if the proposed action may affect species or habitat protected under Section 7 of the Endangered Species Act (ESA) (United States Code, 19 USC 1536 (c)).

This biological assessment (BA) has been prepared by the City of Seattle Department of Transportation (City) on behalf of the Federal Highways Administration (FHWA) to evaluate the potential effects of the proposed action on species and habitats listed under the federal Endangered Species Act (ESA) by the US Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS), jointly referred to hereafter as the Services. The City has prepared this BA to facilitate coordination between the federal action agency (FHWA) and the Services.

This BA assesses the effects of the project on threaten and endangered species resources in the Action Area and documents appropriate minimization measures for the proposed action. Information on listed species and habitats occurring or potentially occurring in the project area was provided by state and federal agencies (Appendix A, Table 1-1). NMFS and USFWS lists of threatened, endangered, and proposed species were downloaded from agency web sites on December 16, 2013.

1.1 Consultation History

Two Pre-Biological Assessment/pre-application meetings were held for the proposed action. These meetings occurred on February 8, 2012 and December 11, 2013. No other correspondence with the USFWS or NMFS has been made to date concerning the proposed action or its potential effects to listed species under their jurisdiction.

Table 1-1. Data and Sources for Information on Listed Species in the Vicinity of Fairview Avenue North Bridge Replacement Project

Species and Habitats	Agency/Data Source	Data Provided
Endangered, threatened, rare, and sensitive plant species and high-quality plant communities	Washington State Department of Natural Resources (WDNR)	No such species or communities occur in the project vicinity.
Federally threatened and endangered plants, fish, and wildlife species	USFWS http://www.fws.gov/wafwo/speciesmap/KingCounty121510.pdf	One threatened species could occur in the project vicinity: (1) Coastal Puget Sound bull trout (*Salvelinus confluentus*) DPS
Federally threatened, endangered, and proposed fish species	NMFS http://www.nwr.noaa.gov/ESA-Salmon-Listings/Index.cfm	Two threatened species could occur in the project vicinity: (1) Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*) ESU (2) Puget Sound steelhead DPS (*O. mykiss*)
Critical habitat for federally threatened and endangered species	USFWS (2010) NMFS (2005)	The closest designated critical habitat for the Coastal Puget Sound bull trout DPS and Puget Sound Chinook salmon ESU occurs within Lake Union, within the Action Area of the project.
Priority Habitats and Species (PHS) (database search of May 2013a,b)	Washington State Department of Fish and Wildlife (WDFW)	No additional ESA listed or proposed species within the project vicinity

1.2 Federal Nexus

Section 7 of the ESA requires that, through consultation (or conferencing for proposed species) with the USFWS and NMFS, federal actions do not jeopardize the continued existence of any threatened, endangered, or proposed species or result in the destruction or adverse modification of critical habitat. The proposed action will receive discretionary funding from the Federal Highway Administration (FHWA) through the Washington State Department of Transportation (WSDOT), which is the federal nexus for the proposed action (Federal Aid Number: BRM-1613(005)).

In addition, this BA addresses the proposed action in compliance with the Magnuson-Stevens Fishery Conservation and Management Act (MSA), as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267), which requires Federal agencies to consult with NMFS on activities that may adversely affect Essential Fish Habitat (EFH). The objective of this EFH assessment is to determine whether or not the proposed action "may adversely affect" designated EFH for relevant commercially, federally-managed fisheries species within the Action Area. For the purpose of this assessment, the proposed action for the EFH assessment and BA incorporate the same project elements. The EFH Assessment is included in Section 6 of this document.

1.3 Project Setting and Background

The Fairview Bridge Replacement Project is located on the east side of Lake Union in Seattle, King County, Washington (Figure 1). The Fairview Avenue North Bridge consists of two bridges built in parallel, spanning a narrow embayment of Lake Union at the southeastern end of Waterway 8.

The West Bridge, built in 1948, carries one lane of southbound traffic and a bike lane (Figure 2). It has a concrete deck and is supported on creosote treated timber piles, many of which are deteriorated and in poor condition, or previously repaired. The West Bridge is rated as with a sufficiency rating of 23.98.

The East Bridge, built in 1963, has a pre-stressed concrete girder superstructure supported on pre-stressed concrete piles and carries two lanes of northbound traffic and one raised 8-foot-wide sidewalk for pedestrians (Figure 2). The East Bridge has a sufficiency rating of 40.98.

Historical research indicates the project corridor (Fairview Avenue and bridge) was originally constructed in the early 20th Century during a period of filling and development along the Lake Union shoreline (HWA, 2013). The project corridor was replaced and improved in the 1940’s and 1960’s. Development in the surrounding area has been of an urban and commercial nature since the late 19th Century and early 20th Century.

Locally, the project area consists of a re-graded and flattened lakefront area. To the east, the ground surface slopes up to I-5 and the Capitol Hill district. The topography of the site is flat at both ends of the bridge due to previous grading and filling of the area. The bridge straddles the east edge of Waterway 8 with water depths up to 26 feet near the center of the bridge and becoming shallower to the east. The mudline along the north end of the bridge inclines steeply to the north while the southern end has a more gentle increase in elevation to the south. The ordinary high water mark (OHWM) of the lake extends under the ZymoGenetics building, which is built on piles in this area.

The vast majority of the shoreline consists of rip-rap. Concrete rubble, wood waste, and other debris covers the shoreline under almost all of the East Bridge, and much of the West Bridge. Riparian vegetation does not exist at the bridge crossing and sparse vegetation within the project area occurs along the upland portion of the waterway edges. These plants are largely noxious species and landscape cultivars that provide no aerial cover and have no physical connection with the waterway.

In addition to over two hundred creosote-treated wooden piles and concrete piles that support the existing bridges, multiple wooden braces occur under the bridge. In addition, a metal walkway is located under the bridge (perpendicular to bridge) that provides pedestrian passage from the ZymoGenetics building to a floating walkway and kayak launch pad.

1.4 Project Purpose

The West Bridge, built in 1948, carries one lane of southbound traffic and one mixed use (bicycle and pedestrian) lane. It has a concrete deck and is supported on creosote treated timber piles, many of which are deteriorated and in poor condition, or previously repaired.

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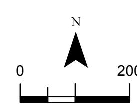
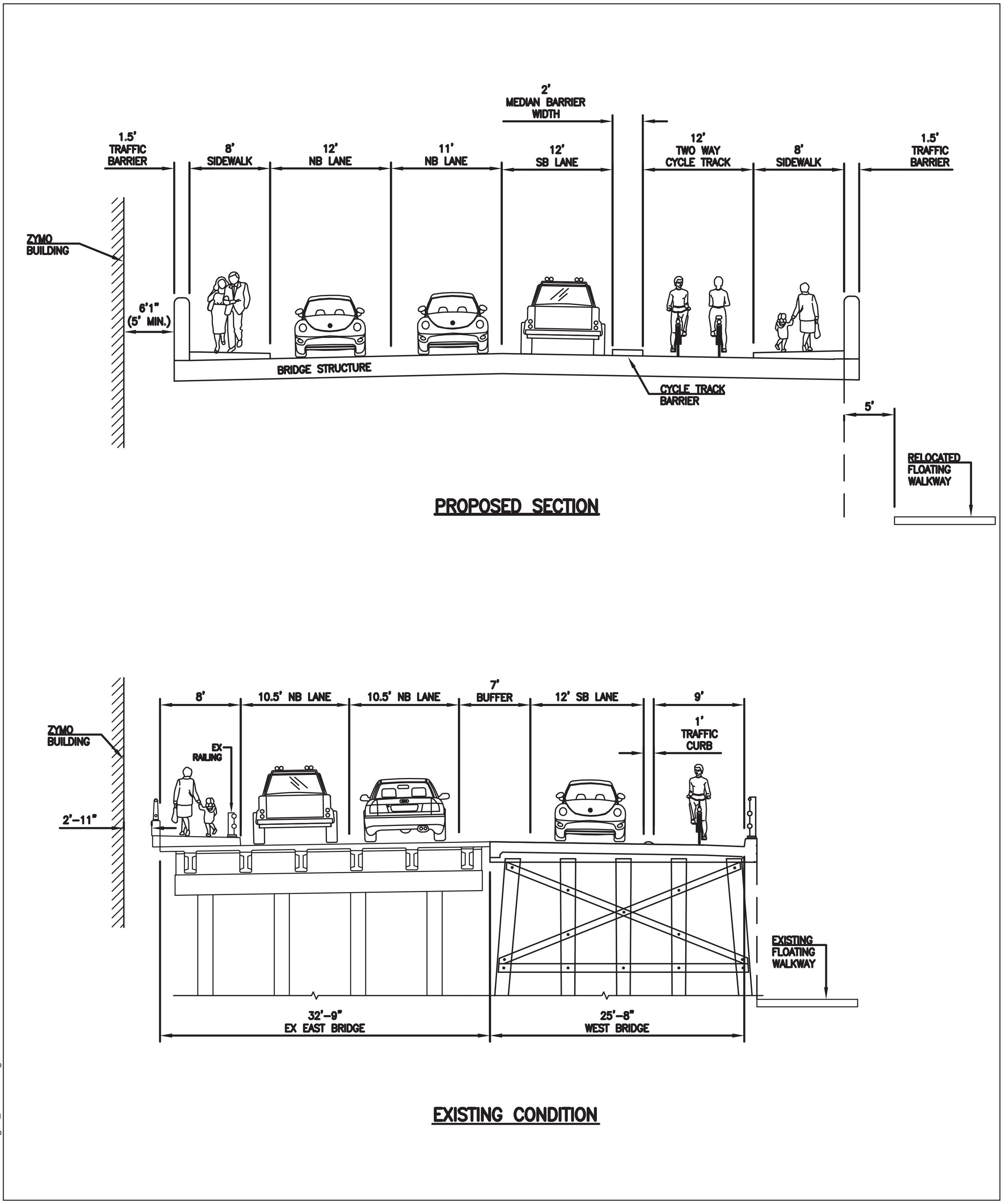
SOURCE: City of Seattle, 2009, 2010; WA Dept Ecology, 2009; WDFW, 2007; Microsoft Bing, 2010 (Aerial Photo).

Fairview Bridge. 210715

Figure 1

Project Vicinity Map





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SOURCE: Perteet

Fairview Bridge . 210715

Figure 2
Lane Configuration for Existing and Proposed Bridges
Seattle, Washington

The bridge is rated as structurally deficient, with a sufficiency rating of 23.98 (SDOT, 2012). The East Bridge has a sufficiency rating of 40.98 (SDOT, 2013). The sufficiency rating formula is used to evaluate a bridge's sufficiency to remain in service, based on a combination of several factors. A sufficiency rating of 100 represents a new bridge and zero represents a fully deficient bridge or a bridge that is near collapse. Bridges are often closed when their sufficiency rating reaches the mid to low teens. The rating helps determine which bridges may need repair or replacement, but does not reflect the ability of the structure to handle loads or its potential for collapse. Therefore, the City is proposing to replace the entire structure with a new bridge that meets current design standards.

A Type, Size, and Location study analyzed various project construction options and determined that replacement of both bridges was preferable to replacement of the West Bridge and rehabilitation of the East Bridge (HNTB and Perteet, 2013).

1.5 Project Description

The project will include bridge and roadway reconstruction, relocation of underground and underwater utilities, and the installation of stormwater treatment and conveyance, where none currently exists. The proposed new roadway will not add capacity and will include three travel lanes, a cycle track, a sidewalk and a mixed use trail/walkway (Figure 2). The project will temporarily relocate and slightly modify an existing floating walkway, presently connected to the existing West Bridge. The relocated floating walkway will be anchored to an estimated 16 steel pipe piles, up to 16-inches in diameter, which will be vibrated into place.

The proposed project will completely remove and replace the existing East and West Bridge structures with a new structure. Bridge removal includes removal of numerous creosote-treated wood piles supporting the existing West Bridge and cleanup of existing concrete rubble and waste under both existing bridges. The new four span bridge will be supported on bents of four foot diameter reinforced concrete bridge columns, constructed on eight foot diameter shafts that will be installed to an approximate depth of 140 feet. Drilled shaft construction will also require construction of two temporary trestles, constructed on temporary drilled shafts. The project also includes reconstruction of the roadway approaches on the north and south side of the bridge.

1.5.1 Description of Project Elements

1.5.1.1 Bridge Layout

The new bridge will be constructed as a four span structure approximately 540 feet in length, from the north pier to the south pier (Figure 3). It will be constructed on the same alignment as the existing bridge, although the new structure will be approximately seven (7) feet wider (60 feet existing versus 67 feet proposed), to accommodate a cycle track. No additional travel lanes will be added from the existing configuration. The existing bridge has an overwater footprint of approximately 23,200 square feet and proposed bridge has on overwater footprint of approximately 26,800 square feet. This will result in an increase in the overwater footprint (and a concurrent increase in overwater shading) of approximately 3,600 square feet.

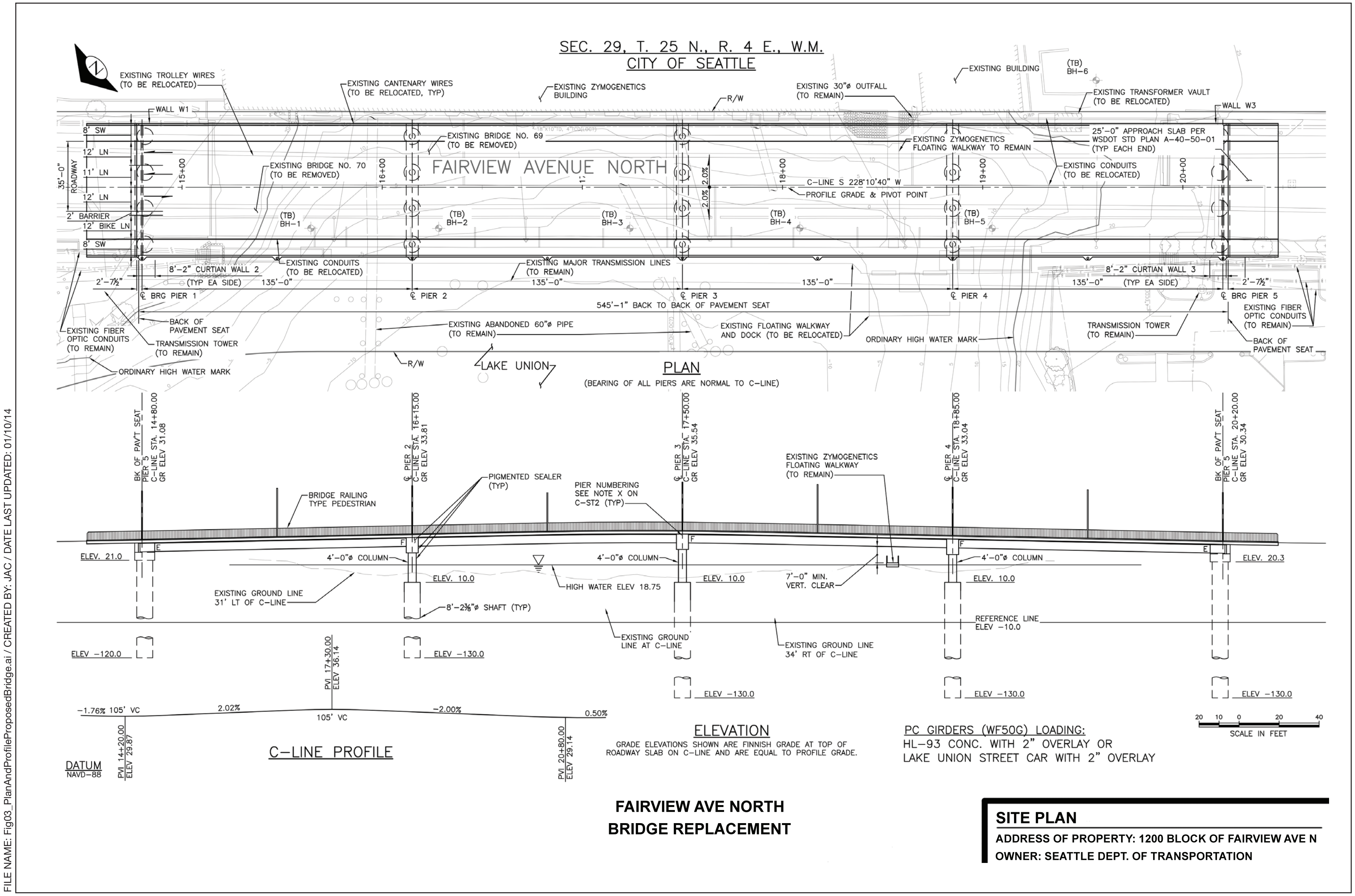


Figure 3
Plan and Profile of Proposed Fairview Avenue North Bridge
Seattle, Washington

In addition, the bridge will be approximately three (3) feet further away from the ZymoGenetics building on the east side of the existing bridge, so the new bridge will extend a total of 10 feet further to the west than the present location. Each of the four spans will be approximately 135 feet long. The five piers are numbered as Piers 1 through 5, from north to south. Piers 2, 3, and 4 will be constructed below the ordinary high water mark (OHWM) and thus require in-water work. Piers 1 and 5 will be constructed entirely in the dry within upland, and require no in-water work.

The substructure would consist of three (3) intermediate piers and two (2) abutment piers (Figure 3). Each of the five bridge piers will be supported by four drilled shafts, each consisting of re-bar supported concrete structures measuring approximately 8-feet, 2-inches in diameter. The intermediate piers have drilled shaft foundations supporting columns (4-foot diameter) extending to the superstructure. A total of 20 drilled shafts will be required (4 per pier x 5 piers). Twelve of these shafts (for piers 2, 3, and 4) will be located below the OHWM of Lake Union, while eight shafts will be constructed landward of the OHWM (for Piers 1 and 5). The shafts will be installed to a depth of more than -100 feet (NAVD-88). High water lake surface elevation is +18.75 feet and water depths in the project range from zero to approximately 26 feet.

The top of the drilled shafts would be set at a consistent elevation for all of the shafts within a pier. The top of the eastern most drilled shaft would be set approximately 3 feet below the existing mud line (NAVD-88). However, due to the fact the lake bottom slopes down to the west, the western most drilled shaft would extend up from the mud line on the order of 15 to 17 feet, at an elevation of +10 (NAVD-88) based on the preliminary design.

The superstructure would be constructed with WF58G precast pre-stressed concrete girders and a cast-in-place concrete deck with traffic barriers and sidewalks on each side. The superstructure would provide access for current utilities as well as block outs for future utilities to be installed on the bridge.

In the final configuration, the bridge deck will be to convey automobile, bicycle, and pedestrian traffic (Figure 2). From the east side to the west side the new bridge will be configured to support an 8-foot wide sidewalk, a 12-foot wide and an 11-foot wide northbound travel lanes, a single 12-foot wide southbound travel lane, a two-foot wide buffer with traffic barrier to separate traffic and cyclists, a 12-foot wide two way cycle track, and another 8-foot wide sidewalk.

Accommodation for the future extension of the South Lake Union Streetcar would be provided by designing the bridge to accommodate a future 2-inch-thick concrete overlay across the entire structure, including the sidewalks, and the live load associated with the streetcar. The 2-inch-thick concrete overlay is intended to accommodate the future installation of streetcar rails, using block rail, in a 3.5-inch-deep rail pocket. A depth of 1.5 inches will need to be ground out of the proposed bridge deck within the 2.5 inches of clearance provided to the top mat of reinforcing steel.

The bridge deck will be crowned in the center of the roadway with the high point of the profile being located on the middle of bridge, along Pier 3. Stormwater runoff will flow off the roadway surface, and then conveyed downward to the north and south via a system of curb and gutters. This will allow collection of stormwater runoff from the bridge at either end of the bridge, as opposed to stormwater discharging directly into Lake Union through scuppers, as occurs with the existing bridge.

1.5.1.2 Construction Timing Constraints

The project has several elements that constrain the timing of certain construction elements. These factors include: 1) the need to maintain traffic flow over the bridge during construction, 2) conflicts with overhead high voltage transmission power lines, and 3) the allowed in-water work window for the project area.

An analysis of existing traffic patterns and demand necessitate that a single travel lane in each direction be kept open during daytime hours during the entirely of project construction. This traffic requirement will require the two halves of the bridge to be built sequentially. The existing West Bridge will be demolished and one half of the new bridge constructed, while traffic remains on the East Bridge. Once the west side of the new bridge is constructed, traffic will be shifted to that side, and the existing East Bridge will be demolished and reconstructed.

Major overhead transmission lines, carrying 115kV, are located west of the West Bridge. These transmission lines, operating under the authority of Seattle City Light and Bonneville Power Administration (BPA), are supported by two large towers at either end of the bridge. There are a number of construction activities associated with the West Bridge that require high crane booms and drilling masts to extend into the safe zone of the energized power line. These activities include drilling permanent and temporary shafts, setting of temporary trestle, and the setting of the precast girders. Safety considerations will necessitate requiring these construction activities to be limited to times when the power lines are de-energized. However, BPA typically limits power outages to these lines to a 30 day power outage within the months of April 1 to October 1, upon approval.

In addition, the general in-water work window for fish protection for the Ship Canal and Lake Union is from October 1 to April 15. The overlap between the in-water fish work window and the allowable window for power line de-energizing is only two weeks each year (April 1 to April 15). Based on the required construction sequence and duration, and the limitations associated with overhead construction activities on the western half of the bridge, the project will require work outside of the general in-water fish work window. However, the application of construction BMPs (particularly the isolation of all inwater areas where sediment disturbance will result from project construction, through the use of an inwater containment curtain as discussed in Section 1.5.2.3) will minimize or eliminate effects to listed species during in-water work. Although in-water work could occur any time of the year during the 24-month construction schedule, only work that occurs within the established containment curtain will be allowed outside of October 1 to April 15 (e.g., installation and demobilization of the curtain will occur between October 1 to April 15). In all cases, all in-water work will occur during the approved terms and conditions, including timing requirements, as set forth in the Hydraulic Project Approval (HPA) yet to be issued for the proposed action by the Washington State Department of Fish and Wildlife (WDFW).

1.5.1.3 Primary Project Features

The primary features of the proposed action are likely to include the following project elements, in the approximate order of occurrence listed below. The specific sequence and methods used for construction will be determined by the selected contractor, based upon the limitations and requirements in the project bidding specifications. However, as the project description below represents a conservative assessment, the potential impacts from other construction methods would result in either equivalent or less severe impacts.

1. Mobilization and preconstruction activities, including installation of temporary erosion and sediment control BMPs;
2. Relocation of the existing floating walkway to temporary storage or mooring;
3. Install temporary drilled shafts for west bridge work trestle;
4. Westbound bridge deck removal and work trestle installation;
5. Construct west bridge substructure (drilled shafts) and vibrate in permanent steel pipe piles for floating walkway anchorage;
6. Construct west bridge superstructure;
7. Install existing floating walkway in new location adjacent to the new bridge;
8. Bridge deck improvements and switch traffic to new west bound deck;
9. Install temporary drilled shafts for east bridge work trestle;
10. Eastbound bridge removal and work trestle installation;
11. Construct east bridge substructure;
12. Construct east bridge superstructure;
13. Demobilization and post-construction actions.

Each key primary feature of the project is discussed in detail in the following sections.

1.5.2 Mobilization and preconstruction activities

Prior to initiation of demolishing the existing bridges and beginning construction of the new bridge, the project site will be prepared for construction, equipment and materials mobilized, and construction BMPs will be installed. Listed below are the primary mobilization and preconstruction activities, in the approximate order of implementation. More detail on some of these activities follows.

1. Install BMP's and TESC per approved Plan.
2. Secure staging and stockpile areas and set up on-site office.
3. De-energize and remove existing trolley lines on existing bridge.

4. Remove and store existing floating walkway.
5. Install primary in-water silt curtain.
6. In water debris clean up.
7. Prepare staging area for potential contaminated material handling.
8. Install traffic control and move traffic into one-lane each way on the existing East Bridge. Close West Bridge to traffic.
9. Pre-fabricate portions of the work trestle.

1.5.2.1 Staging and Stockpile Areas

Staging and stockpile areas are necessary to store equipment and construction materials, stockpile of fill materials (e.g., clean sand and gravel), for assembly of the rebar cages required for drilled shaft installation, and to serve as decanting facilities for potentially contaminated and clean soils (separate facilities). Although the exact siting of these areas has not yet been finalized, several likely stockpile and staging areas have been identified immediately adjacent to the work area (Figure 4). Staging and stockpile areas will be established in currently developed areas, outside of the OHWM of Lake Union and other sensitive areas. These areas will be delineated with construction fencing and TESC measures installed to contain all materials and runoff from entering project waters. In addition, a prefabricated temporary job office will be brought on-site and remain in place for the duration of construction activities.

1.5.2.2 Remove/ Store Existing Floating Walkway

An existing floating walkway is located immediately west (waterward) of the existing bridge. The walkway, consisting of concrete encased polystyrene floats with treated wood railings and connecting boards, measures approximately 8-feet wide and 336-feet long (4,930 square feet in total including an attached kayak launch pad and gangways). The walkway is located approximately 5 feet west of the existing edge of the bridge, and is attached to the existing bridge by metal supports. The walkway provides water access, and is currently used by pedestrians as part of the longer trail system. At either end of the walkway, which is part of the longer Cheshiahud trail, metal gangways and stairs connect the walkway to the paved trail along the west side of Fairview Avenue North. During construction of the proposed project, the walkway will need to be removed, in order to allow for construction access. The walkway and gangways will be disconnected from their anchorage and likely separated into smaller linear sections.

The walkway will then either be removed from the water and stored off-site during construction or will be towed away from the project site, and temporarily moored in Lake Union until bridge construction is complete. The metal ramps will be removed and stored during construction either on-site, off-site, or by placing on the floating walkway. Removal to temporary storage of the floating walkway is anticipated to take approximately 5 days. Once bridge replacement is complete, the existing floating walkway will be re-installed at a location approximately 10-feet west of its existing location (5-feet west of the new bridge). Following construction, pedestrian and bicycle facilities will be provided on the new bridge.

1.5.2.3 Install Primary In-water Containment Curtain

The project will implement containment BMPs consisting of a series of floating containment curtains in order to: 1) minimize entry of aquatic life, particularly juvenile Chinook salmon and steelhead in the immediate work area; and 2) contain suspended, and potentially contaminated, sediments to the immediate work area. The inner, secondary, portion of the containment system will be installed and removed around specific work elements, outlined in subsequent sections of the BA. However, the primary, outer portion of this containment system will be present during the entirety of all in-water work activities. The primary containment system will consist of a non-permeable barrier capable of trapping suspended solids containment curtain that will be supported on floats or booms. Although the exact material, specifications, and location of the primary will be determined by the contractor, the contractor will be required to ensure that the curtain: 1) encompasses the entire in-water work area; 2) extends horizontally the full extent of the water column, from the water surface to the lakebed (the bottom of the curtain may have attached weights ["lead-line"] to ensure it is fully deployed to the depth of the lakebed); and 3) extends vertically to connect to the locations where the OHWM crosses the west edge of the project on the north and south banks of Waterway 8. In addition the contractor will be required to ensure the curtain meets the dual performance standards of fish exclusion and sediment containment.

The curtain will be placed to extend offshore to an extent that the curtain will surround all wetted areas of Lake Union where in-water and overwater work activities associated with bridge demolition and construction will occur. It is anticipated the curtain will extend from the shoreline to a maximum depth of approximately 40-feet. The outer curtain will be installed during the approved in-water work window (general in-water work window is between October 1 and April 15), prior to the initiation of any additional in-water work. The curtain installation timeframe is intended to minimize the incidental trapping of aquatic life within the contained area, particularly juvenile Chinook salmon and steelhead. The curtain will be regularly inspected and maintained as necessary, and will remain in place during the entire in-water construction period (approximately 16 to 24 months). Due to the relatively deep-water habitat in the outer portions of the curtain, and the inaccessibility of the area under the bridge due to multiple pile structures, fish removal/salvage in the contained area is not considered to be effective or feasible. However, the sediment curtain will be consistently monitored to insure it is correctly installed and properly functioning. Installation of the primary sediment curtain is anticipated to take approximately 5 days.

1.5.2.4 In-water Debris Cleanup and Removal

The Lake Union shoreline, underneath the existing bridges, is littered with debris, wood waste, concrete rubble, garbage and other refuse (see Photo 5 in Appendix B). As part of bridge demolition activities, but after installation of the outer (primary) containment curtain, a majority of this debris and rubble will be cleaned up and removed.

SOURCE: King County, 2011; Microsoft Bing Maps, 2011 (Aerial)

210715 Fairview Bridge . 210715

Figure 4
Potential Staging and Stockpile Areas
Seattle, WA

As with all in-water work activities that disturb sediment (e.g., drilled shaft installation/temporary support removal, pile installation and removal), a secondary containment curtain or curtains will be placed prior to debris removal to further minimize the spread of re-suspended materials in Lake Union. This secondary curtain will be of similar construction to the primary curtain, although it will be sized much smaller to encapsulate the specific work area(s). The secondary curtains will remain in place until completion of the specific sediment-disturbing activity, and then removed.

The majority of debris removal will occur by hand methods, with pieces of debris loaded into large buckets and bins to be removed with heavy equipment to the upland, where the material will be sorted and undergo disposal. All materials that are potentially hazardous (e.g., pieces of creosote treated wood) will be hauled off-site and properly disposed of at an appropriately licensed facility. Extremely large pieces of debris, or those that extend greater than a few feet into the lake sediment, will be left in place in order to minimize re-suspension of potentially contaminated lake sediments.

1.5.2.5 Prepare Staging Area for Potential Contaminated Material Handling

The project requires the removal of potentially contaminated sediments from the lakebed of Lake Union, in order to construct the new bridge. The largest source of contaminated soil excavation for this project will be the drilled shaft excavations. Total excavation quantities for shaft construction are approximately 7,500 cubic yards over an approximate area of 1,600 square feet. Approximately 5,500 cubic yards (over 700 square feet) will be required for the permanent shafts and 2,000 cubic yards (over 900 square feet) for the temporary shafts.

Based on limited testing of sediments within the project area (see Section 3 for details), it is expected that approximately the upper 10 feet of sediments within Lake Union are likely to be contaminated. Contamination appears to decrease significantly in shallow native soils underlying sediment and fill. Based on this assumption, it is anticipated that approximately 400 cubic yards of contaminated soil will be removed from the drilled shaft casings during the bridge foundation installations. Some additional contaminated soil will be excavated for temporary shafts installed for the working platform.

Given the proposed depth of each drilled shaft and the fact that the soils within the shafts will be excavated with clam shell, or other similar type, excavation equipment, the bid contract will specify that the contractor separate the near surface contaminated soils from the deeper clean soils during excavation. Sediment testing will also likely be required to determine the extent of contamination. The existing analytical data may be sufficient to establish a disposal profile, although deeper native soils will likely need additional characterization for purposes of segregation and documentation for ‘clean’ soil receiving facilities.

The contractor will be required to prepare a stormwater pollution prevention plan (SWPPP) which includes Temporary Erosion and Sediment Control (TESC) and Spill Prevention Control and Countermeasure (SPCC) and to employ BMPs to ensure that neither excavated sediment nor excavation support materials contaminate Lake Union. Excavated contaminated soils will be disposed at a facility licensed to dispose, treat, or recycle contaminated soil.

In addition to separating soils during excavation activities, soils excavated from the drilled shafts will be saturated and will require decanting prior to removal from the project site. Therefore, as part of the excavation plan, the contractor will be required to isolate runoff from potentially contaminated soils. A likely construction methodology for meeting this requirement is the establishment of multiple decanting facilities in a staging area adjacent to the project site. One facility would be required for decanting of contaminated soils and the other facility would be required for decanting clean soils excavated from the shafts. During the decanting process, decanted water from potentially contaminated areas would be routed into a water quality treatment facility. Wastewater will be treated on-site to the greatest extent practicable. Decanted water from the potentially contaminated sediments may require testing to ensure it meets state and federal water quality standards. If water quality standards are not met, dilution or off-site disposal at an appropriate facility would be required. The primary means of treatment may include a vault system, sediment bag system, or Baker Tanks. In either case, no contaminated water or water with turbidity or pH outside of state water quality standards will be allowed to re-enter Lake Union.

1.5.3 Install Temporary Supports (Drilled Shafts of Piles) for West Bridge Work Trestle

Based on the need to maintain two way traffic and one sidewalk during construction, the removal of the existing West Bridge and construction of the west half of the new bridge structure will have to be completed prior to work on the east side of the project alignment.

The load limitations on the existing bridge do not allow for heavy equipment required to construct the drilled shafts. Safety considerations necessitate the construction of a temporary work trestle to operate the cranes and oscillator necessary for shaft installation. The temporary work trestle requires the installation of piles or shafts to support the trestle deck. Normally these temporary shafts would be driven pilings that are installed using a vibratory or impact hammer. However, noise and vibration concerns for adjacent buildings, businesses, and underlying soil necessitate that the shafts are installed as drilled shafts.

Prior to removal of the existing West Bridge deck, holes will be cut in the concrete deck at the shaft locations. A drill rig will then be used to install a 36-inch diameter steel casings to the depth necessary to develop capacity (minimum depth of 40 feet below the mudline), through each hole. Approximately 60 supports will be required to support the west work bridge, all of which will be installed within the OHWM of Lake Union.

A previous study (Parametrix, 1989) estimated that drilled shaft installation along the shoreline would not suspend sediment more than 0.5 meters above the lakebed, and water pressure and lack of other disturbances would likely prevent sediment migration. However, in order to minimize sediment suspension to the extent practicable, several minimization measures will be applied. The first includes surrounding the area to be disturbed with an inner, secondary silt curtain (the larger primary silt curtain described previously will remain in place during all in-water work activities). In addition, prior to installation of the steel casings, a one to two-foot deep layer of sand will be applied to the lake bed where the drilling will occur (see details on sand application in following section). This application will minimize the re-suspension of potentially contaminated materials on the lakebed during drilling operations. Over the entire project area, the application of the sand will require approximately 2,100 cubic yards of material and cover a total area of approximately 28,200 square feet.

There are several pieces of drilling equipment that could perform the work, but all will have tall masts or booms that will infringe upon the setback clearances for the high voltage power lines, requiring this activity to occur during the timeframe when the power lines are de-energized. Following completion of construction, the temporary supports will be removed to a minimum of two feet below the mud line of the lake.

1.5.4 Westbound Bridge Deck Removal and Work Trestle Installation

Construction activities associated with the removal of the bridge deck of the existing West Bridge will be conducted concurrently with construction of a work trestle upon temporary drilled shafts and the removal of piles supporting the existing bridge. This work operation will involve four basic activities, outlined and discussed further below. The activities will occur in the approximate order listed; however, it should be noted that construction of the work trestle and related activities would be sequenced in each span until the work trestle decking is installed, with the operation then moving forward to the next span. Work will begin at the north or south shoreline and will likely move in a north or south direction, until the work trestle is completed across the lake.

1. Concrete deck removal.
2. Apply sand layer around existing piles to be removed.
3. Remove existing bridge piles.
4. Install the steel girders and decking for the work trestle.

1.5.4.1 Concrete Bridge Deck Removal

This task involves saw cutting the deck into sections that can be easily lifted by a crane or large excavator and placed onto a truck for disposal at an appropriate facility. The majority of this work will require high mast equipment that will require de-energizing the power lines. However, it may be possible that some portions of the existing West Bridge deck can be removed without impact to the high voltage power lines. If this is the case, some sections of the existing West Bridge roadway can be removed prior to de-energizing the power lines. This would occur by sawing the deck into sections and lifting/removing the sections using excavators that are small enough to provide adequate clearances from the power lines.

The saw cutting should reduce or eliminate demolition debris from entering the water. In addition, the project will apply containment BMPs to ensure that no materials from demolition will fall into the water. The specific BMPs to be utilized will be determined by the contractor, but may include containment tarps below the bridge or small floating Styrofoam barges placed beneath the construction area.

A list of equipment likely to be required for this task includes a track hoe with thumb or/and demolition head attachment (hoe-ram), a crane to lift sections of the deck and place into trucks, dump trucks or tractor/trailer with demolition bed to receive and transport removed bridge decking, and a large concrete saw. It is anticipated that removal of the bridge deck would take approximately six weeks (assumes construction crew working two shifts per day).

1.5.4.2 Apply Sand Layer around Existing Piles to be Removed

A one to two-foot thick layer of sand will be placed immediately around each individual pile slated for removed. This clean fill is being placed to contain and minimize disruption of existing contaminated soils. The precise particle size and composition of the fill material will be determined based on slope conditions. The mixture will be fine grained enough to effectively cover and contain lakebed sediments, while containing enough larger-grained materials (e.g., larger grained sand or pea gravel) to ensure the treatment remains on the bottom and does not immediately shift downslope.

The sand layer will either be applied using uniform broadcast methods over the entire project area or the application will be targeted around each individual pile to be removed, with application subsequent to deck removal along each bridge span. The second scenario is more likely, due to access limitations associated with the large number of existing piles present under the existing bridge. The sand material may be placed with a track hoe or a crane with a skip box.

1.5.4.3 Remove Existing Bridge Piles

All of the existing piles supporting the West Bridge will require removal during demolition of the existing bridge and construction of the temporary west work trestle. An estimated 60 to 250, 16- to 20-inch diameter creosote-treated wooden piles will be removed for construction of the west bridge. There are an unknown number of relic wooden piles from previous bridges that may require removal. The existing piles are creosote-treated and many are severely degraded and structurally compromised.

Following application of a sand layer around each piling to be removed, the piles will be removed using the preferences for pile removal methods and other guidance presented in the Washington State Department of Natural Resources *Best Management Practices For Pile Removal and Disposal* (WDNR, 2011). The preference for pile removal as listed in the document is vibratory removal, followed by direct pull, clamshell removal, and cutting the pile off at the mud line. Although the priorities in this guidance will be followed to the extent possible, several project factors may preclude use of the highest priority methods.

Some of the buildings and businesses adjacent to the existing bridge are sensitive to noise and vibration due to both the condition of the building and the type of business operated within the building (e.g., biotechnical research performed by ZymoGenetics). Due to these potential noise and vibration impacts on surrounding infrastructure, vibratory pile removal methods, the preferred method in WDNR (2011), will likely not be feasible in some or all cases. Likewise, clamshell and direct pull may not be feasible due to the deteriorated conditions of the wooden piles. If the method of pile removal is cutting, the piles would be cut at 2 feet below the mud line, measured after the application of the sand mix. This would ensure that the potentially contaminated sediment located at and below the existing mud line would be only minimally disturbed.

Pile removal is likely to cause the most sediment disturbance. Parametrix (1989) evaluated potential effects of sediment disturbance due to pile removal by breaking or cutting. Worst-case conditions were estimated based on highest detected contaminant concentrations within a radius of 15 meters of a pile. Based on Parametrix' calculations, suspended sediments would likely exceed water quality criteria outside the selected dilution zone (15 meters) for metals, but not for organics (PAHs, etc.). Parametrix recommended mitigation methods to decrease or control sediment disturbance and migration including surrounding the work area with a silt curtain, and partial pile removal (cutting the pile at a sufficient height above the lakebed to avoid sediment disturbance).

Therefore, in order to minimize sediment suspension to the extent practicable, several minimization measures will be applied. As with the installation of the work trestle drilled shaft supports, the area to be disturbed with an inner, secondary silt curtain (the larger primary silt curtain described previously will remain in place during all in-water work activities). In addition, prior to removal of the existing piles, a one to two-foot deep layer of sand will be applied to the lake bed where the piles will be removed (see details on sand application in preceding section). This application will minimize the re-suspension of potentially contaminated materials on the lakebed during pile removal.

1.5.4.4 Construct West Temporary Work Trestle

Construction of the temporary work trestle will commence at one end of the bridge following application of sand, installation of trestle support steel casings, and removal of the existing bridge deck. Steel cap beams and stringers will be installed for structural members and prefabricated deck sections will then be set in place. Installation of stringers and deck will follow the existing concrete deck removal operation and will set from the completed portions of the Work Bridge. This operation will require cranes to handle the steel members and deck panels. The deck sections will be constructed to be removable for access during construction of the new piers 2, 3, 4 (in-water piers). The work trestle for the west side of the bridge, when completed, will measure approximately 450- feet long by 32-feet wide, for a total area of 14,400 square feet.

The construction equipment needed for temporary work trestle installation has tall masts or booms that will infringe upon the setback clearances for the power lines, requiring this activity to occur during the timeframe when the power lines are de-energized. Pre-fabricated or a panelized decking system may be employed to help expedite construction.

Equipment that will be needed for construction of the temporary work trestle will likely include a track hoe with drill mast for piles; crane(s) for handling of steel members and decking; a welder for steel frame system; and a forklift for handling materials. This task is estimated to take 4 weeks (assumes construction crew working two shifts per day). The completion of the work trestle is estimated to lag behind the deck removal about 2 weeks.

1.5.5 Construct West Side Bridge Substructure

The primary tasks associated with constructing the new substructure along the western half of the new bridge are the following, which are discussed in further detail below.

- Construct new drilled shafts
- Construct new pier columns
- Construct bridge abutments

1.5.5.1 Construct New Drilled Shafts

The pier construction will start with setting equipment and materials in place. This operation will be accomplished from the work bridge and will require the high voltage overhead power lines to be de-energized during this work phase. The pier shafts are estimated to be approximately 140 feet and will require high mast equipment and crane work, requiring this activity to occur during the timeframe when the power lines are de-energized. The drilled shafts will be installed from the temporary work trestle utilizing the oscillating casing method of shaft installation. This method utilizes a full depth temporary casing that is advanced through a slow oscillating motion which minimizes vibration to surrounding structures.

Prior to commencement of drilling for the shafts, BMPs will be applied to minimize re-suspension of potentially contaminated sediments. These BMPs will be identical to those described for temporary work trestle shaft construction (see above) and will consist of an inner, secondary silt curtain around each pier and the application of a one to two-foot deep layer of sand will be applied to the lake bed where the drilling will occur.

As the casing is advanced, the soils inside the casing are excavated with a clam shell and placed in lined dump trucks for transfer to the on-site decanting facility (in the case of wet soil) or to an off-site disposal site (for dry, uncontaminated soil). Excavated materials that are potentially contaminated will be kept separate, tested for contaminants, and decanted or disposed at a licensed facility (see earlier text for details on soil separation and decanting).

Each section will be rotated or oscillated into the ground and as the casing is installed additional sections will be bolted onto the top of the installed section until the desired depth is achieved. Once the termination depth of the shaft is achieved (elevation -120 to -130 NAVD-88) and the base of the shaft is cleaned out, a full-length rebar cage will be lowered fully into the excavated shaft. Concrete is then pumped to the base of the excavation with a concrete pump truck and tremie, through which concrete is placed below water level. All fresh and curing concrete will be fully contained within the shaft during construction. As the concrete is placed, the temporary casing is slowly removed to the specified elevation of the permanent casing. During this process water inside the casing will be pumped out, captured and treated as appropriate, based on the results of water quality monitoring. No turbid or contaminated water will be released into Lake Union.

This method of rotating or oscillating shaft casings produces minimal vibration and is completed entirely inside a casing, minimizing propagation of sound waves into the surrounding lake water. It is estimated that each shaft will take 3 to 4 days to complete excavation, setting the rebar cage, and concrete pouring.

When the casing is set to designed grade, the drill operation will commence with the next pier casing while the rebar cage is set and concrete is placed in the first casing. This general sequence will continue until all piers are completed. The tops of the drilled shafts are estimated to be constructed at an elevation of +10 NAVD-88. Due to the sloping nature of the lakeshore, some of the drilled shafts furthest from the shoreline will extend in the water column up to 20 feet.

The estimated effort for completing drilling and construction of the 20 drilled shafts (four shafts each for five piers) is approximately five weeks (a two shift operation may be required to complete this task during the period the high voltage power line is de-energized). Construction equipment that will be utilized in constructing the drilled shafts includes a large crane, mounted with a drilling attachment, a second large crane for handling of casings and rebar cage, concrete trucks/concrete pump for concrete placement, a forklift for material handling, and a welder for joining casings.

1.5.5.2 Construct New Pier Columns

Once the drilled shafts are completed for the in-water piers (at Piers 2, 3, and 4), a pier column will be constructed on top of each drilled shaft, for a total of twelve bridge columns. The pier columns consist of 4-foot diameter concrete columns, reinforced with rebar. The columns will be cast-in-place. Forms will contain all curing concrete during column construction. Column construction will require high mast equipment and crane work, requiring this activity to occur during the timeframe when the power lines are de-energized.

Construction duration for construction of the pier columns is approximately four weeks (assumes construction crew working two shifts per day). Construction equipment required for this task includes a small crane for setting forms and handling rebar, a forklift to get materials to the crane, a welder (if using steel forms), a concrete pump for placement of concrete, and concrete trucks for delivery of concrete.

1.5.5.3 Construct Crossbeams

Following installation of the pier columns at Piers 2, 3, and 4, concrete crossbeams will be constructed across each pier to support the precast girders and bridge deck. Each of the three crossbeams will measure approximately 6 by 10 by 70 feet and be constructed of reinforced concrete. The crossbeams will be cast-in-place. The forms will contain all curing concrete during column construction and containment tarps or other BMPs will be installed, if necessary, to ensure that no wet or curing concrete enters the waters of Lake Union.

Construction duration for construction of the crossbeams is approximately four weeks (assumes construction crew working two shifts per day). Construction equipment required for this task includes a small crane for setting forms and handling rebar, a forklift to get materials to crane, a concrete pump for placement of concrete, and concrete trucks for delivery of concrete.

1.5.5.4 Construct Bridge Abutments

Once the drilled shafts are completed for the upland piers (at Piers 1 and 5), bridge abutments will be constructed behind the drilled shafts. The bridge abutments will be constructed of reinforced concrete and cast-in-place. Each of the two bridge abutments will measure approximately 10 by 10 by 70 feet. orms will contain all curing concrete during column construction. As bridge abutment construction will require high mast equipment and crane work, this activity would ideally occur when the power lines are de-energized. Once the abutments are constructed, pre-cast girders will be set on top of the abutment wall.

Construction equipment required for this task includes a small crane for setting forms and handling rebar, a forklift to get materials to crane, a welder (if using steel forms), a concrete pump for placement of concrete, and concrete trucks for delivery of concrete.

1.5.6 Construct West Side Bridge Superstructure

Following construction of all substructure components, the west portion of the new bridge superstructure will constructed. The primary construction elements are listed as follows and described below:

1. Remove work bridge superstructure
2. Set bridge girders
3. Construct roadway deck

1.5.6.1 Remove Work Bridge Superstructure

Several spans of the work trestle superstructure will be removed to clear the span needed for precast girder erection. The west side work bridge would be removed in sections immediately prior to setting precast girders. Once the area between two adjacent permanent bridge piers is cleared of all work bridge superstructure (bridge decking), the precast girders for that span will be set in place. Only the portions of the work trestle requiring removal for setting girders will be initially removed. Once the girders are set in place (see below), the remaining portions of the work bridge superstructure will be removed.

The work bridge drilled shafts would be removed at a later date, during the general in-water work window for Lake Union (October 1 to April 15). The supports will be removed using the preferences for pile removal methods and other guidance presented in the Washington State Department of Natural Resources *Best Management Practices For Pile Removal and Disposal* (WDNR2011). Because the piles are hollow steel piles, in good structural condition, it is likely they will either be vibrated out or pulled directly, provided vibration limits are met. If either of these methods are not possible, the piles will be cut at the mud-line.

1.5.6.2 Set Bridge Girders

A total of 20 (five (5) per span for four spans) pre-cast girders will be installed to serve as the roadbed foundation. Prior to setting girders, the East Bridge would be strengthened or a load distribution system installed, as required, to support a crane capable lifting and setting one end of a girder. This operation will require a full traffic closure most likely during night time shifts. Setting of precast girders will require high mast equipment and crane work, requiring this activity to occur during the timeframe when the power lines are de-energized. In addition, Fairview Avenue North will be closed to traffic during this night time operation so that the existing East Bridge can be used for crane deployment. One crane will be positioned on the work trestle during the girder erection and a second crane will be positioned on the existing, strengthened East Bridge.

Removal of the west work trestle and installation of bridge girders is estimated to take approximately three weeks (assumes construction crew working two shifts per day). Construction equipment required for this task include two large cranes (or one very large crane) to handle girders, semi-tractor/trailer for delivery of girders, semi-tractor/trailer for removal of work bridge materials, and a forklift for material handling.

1.5.6.3 Construct Roadway Deck and Barriers

After the girders are set, the roadway deck work will commence. A plywood containment deck will be placed on the bottom flange of the precast girders to contain any material that may be dropped as well as collect any concrete leakage. Concrete deck formwork will be placed on the underside of the top flange of the girders to support the deck reinforcing steel, imbeds, and concrete during placement. This work will proceed span to span until completed. Preparing the deck requires approximately six weeks, and construction equipment needed includes a crane to handle rebar and form materials and a forklift for material handling.

After completion of roadway deck forming, rebar is placed and embeds are installed, the roadway deck concrete will be placed. The deck may be formed in sections; however, this will depend on the specific layout of the expansion joints. Placement of concrete is estimated to take approximately one week, with an additional four to six weeks to place closure pours and allow for concrete curing time. Construction equipment required includes a concrete pump or line pump, concrete trucks, and a concrete finishing machine.

1.5.7 Bridge Deck Improvements and Switch Traffic to New Deck

Once the west side of the new bridge is constructed and the bridge deck finished, the bridge approaches will be completed, as will the expansion joints. Bridge approach slabs will be constructed. The new bridge approaches will be finished with hot mix asphalt (HMA). Other activities include the installation of bridge rails, light poles and wiring, and conduit on the underside of the deck. Temporary barriers for traffic will also be installed. All of this work will be conducted above the roadway deck and is necessary to prepare the west side of the new bridge for receiving traffic from the existing East Bridge, which will then be closed in order to finish construction of the new bridge.

The bridge deck improvement activities described above are estimated to take approximately five weeks. Anticipated equipment needs include concrete trucks, forklifts, a small crane for barriers and light pole installation, an ACP paving machine, and asphalt delivery trucks.

1.5.8 Construct Eastern Portion of Bridge

Following completion of the western portion of the new bridge, traffic will be shifted from the existing East Bridge to the newly constructed west half of the new bridge. This will allow for construction of the east half of the new bridge, which will essentially follow the same construction sequence that was outlined above for the west portion of the new bridge.

However, there are several small differences for the construction sequence of the eastern portion of the new bridge. The existing East Bridge is not directly adjacent to the high voltage overhead power lines so de-energizing these lines is not necessary to address safety concerns as it was for removal and construction at the West Bridge. This removes the overhead lines as a project timing restraint for this portion of the bridge construction. In addition, the existing East Bridge is supported by concrete, not wooden piles and these piles are substantially closer to noise and vibration sensitive building and businesses (e.g., ZymoGenetics). Therefore, removal of the concrete piles by direct pull, clamshell, or vibratory method will likely not be feasible. The likely method of concrete pile removal will be saw cutting by divers at the existing mud line (which will be two feet below the 2-foot layer of clean sand placed for sediment containment purposes). General guidance, as presented in the Washington State Department of Natural Resources *Best Management Practices For Pile Removal and Disposal* (WDNR, 2011), will be followed for removal of existing concrete piles. A total of approximately 58, 18-inch diameter concrete piles will be permanently removed for construction of the east temporary trestle. Some unknown number of relic wooden pile stubs from previous bridges may also require removal.

The temporary work trestle for the east side of the bridge, when completed, will measure approximately 450-feet long by 32-feet wide, for a total area of 14,400 square feet. This structure will require the installation of 60, 24 to 36-inch diameter temporary supports, likely hollow steel piles or drilled shafts, to support the structure.

The large, non-permeable primary sediment curtain will be left in place during construction of the eastern portion of the bridge. Also, identical to what was described for the western work trestle, all in-water work activities will utilize both: 1) the use of secondary sediment curtains around localized lake sediment disturbing activities (e.g., pile installation or pile removal); and 2) the application of a sand layer. Both of these elements will assist in minimizing the suspension and spread of lake bed sediments, which may be potentially contaminated by various toxic compounds.

1.5.9 Install Walkway Supports

Lastly, since the floating walkway will no longer be attached to the bridge using supports, vertical pile elements will be required along the relocated floating walkway to anchor the structure into its new location. Approximately 15 vertical supports would be required to anchor the floating walkway. These supports will be installed during the project when it is convenient for the contractor’s operations provided it complies with all permit requirements. The vertical supports would consist of small diameter hollow steel pipe piles (approximately 16-inches in diameter) that would be either drilled in place or vibrated into place with a vibratory hammer. This activity has a relatively low potential to suspend sediment due to the installation method and small size of the piles and the activity would occur within the confines of the primary containment curtain, installed prior to all in-water work.

1.5.10 Demobilization and Post-Construction Activities

Once construction is completed for the entire new bridge and the structure is fully open to traffic, the construction site will be demobilized. Activities associated with demobilization include:

- Demobilize staging areas and on-site office
- Remove silt fencing and all floating silt curtains
- Reinstall floating walkway on new vertical piles
- Remove remaining construction BMP’s and TESC measures

1.5.10.1 Secondary Project Features

Barge Activity

Barges may be used for construction of the project. Disturbance from near-shore barge operations are likely limited, and may result from anchoring, or barge travel in shallow water. The water depth in the vicinity of the work area is approximately 16 feet, although the water depth decreases towards shoreline. The typical draft (hull depth below waterline) of a heavy construction barge is 6 to 10 feet. Placement and movement of barges will be required to avoid grounding in shallow waters, in order to minimize sediment disturbance and associated turbidity. The use of barges, as with all other in-water work, will be within the primary sediment curtain and will be required to comply with state water quality standards, and this activity would be included in the establishment of an approved water quality monitoring plan.

1.5.11 Stormwater

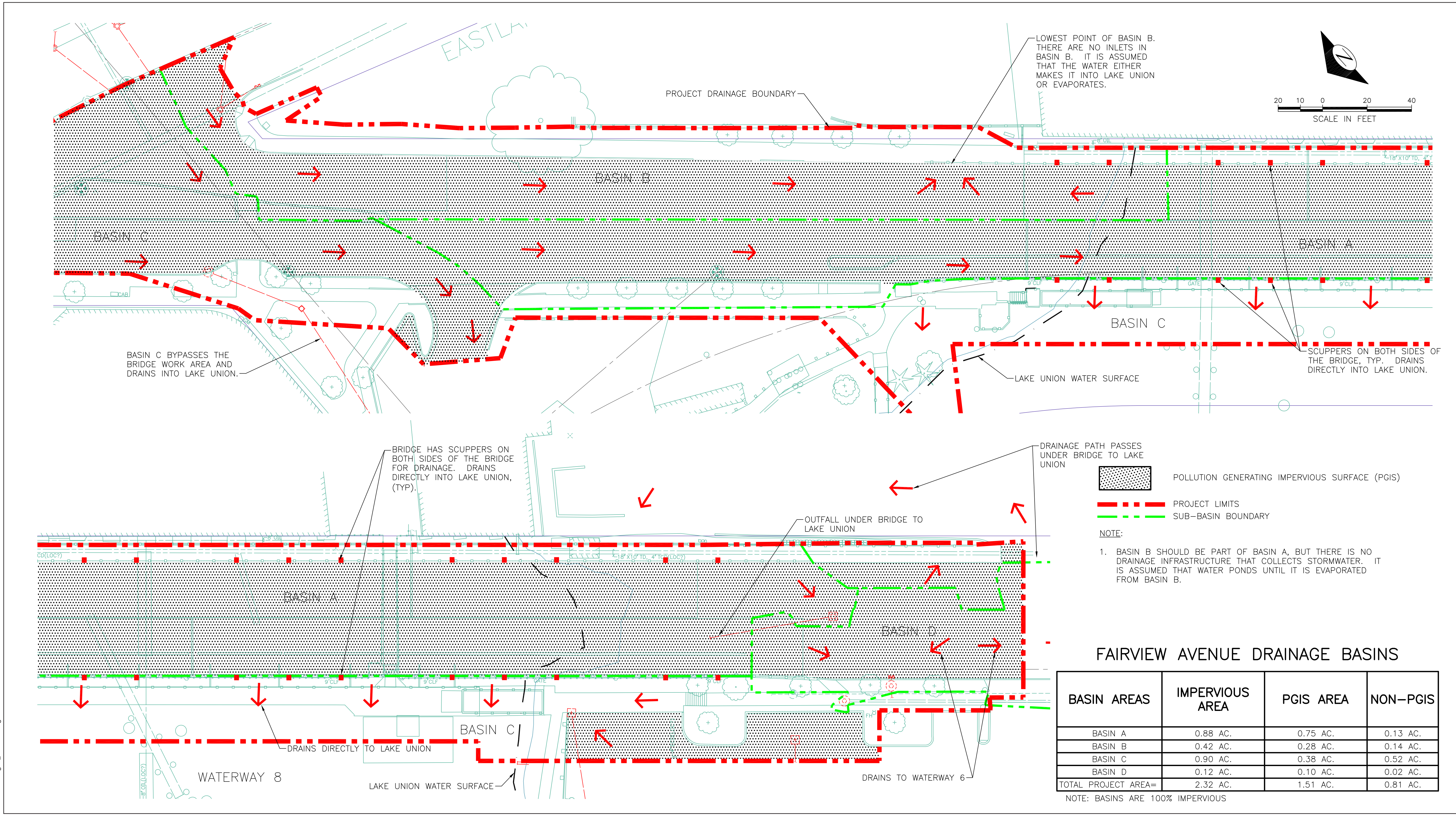
1.5.11.1 Existing Conditions

Four separate threshold discharge areas (TDAs) are present within the project area, which cumulatively contain approximately 2.32 acres of impervious surface area. Of the total impervious surface, approximately 1.51 acres is pollution generating impervious surface (PGIS) (Table 1-2; Figures 5 and 6). None of the runoff from existing impervious area within the project area is treated for stormwater quality, or receives flow regulation.

The existing stormwater system consists of scuppers on the West Bridge and bridge drains on the East Bridge. There is no conveyance on the existing bridge and the existing runoff does not receive any treatment. Runoff discharges directly into Lake Union at Waterway 8, along the edges of the existing bridge.

Table 1-2. Pre-Project (Existing) and Post Project (Proposed) Impervious Surface Areas within the Fairview Avenue North Bridge Replacement Project Area.

Threshold Discharge Area (TDA)	Acres of Pre-Project Total Impervious Area	Acres of Post-Project Total Impervious Area	Change (acres) in Total Impervious Surface	Acres of Pre-Project Pollution Generating Impervious Surface (PGIS)	Acres of Post-Project Pollution Generating Impervious Surface (PGIS)	Change (acres) in Pollution Generating Impervious Surface (PGIS)
A	0.88	0.64	-0.24	0.75	0.47	-0.28
B	0.42	1.05	0.63	0.28	0.75	0.47
C	0.90	0.63	-0.90	0.38	0.24	-0.14
D	0.12	0.00	0.51	0.10	0.00	-0.10
Totals	**2.32**	**2.32**	**0.00**	**1.51**	**1.46**	**-0.05**



FAIRVIEW AVENUE DRAINAGE BASINS

BASIN AREAS	IMPERVIOUS AREA	PGIS AREA	NON-PGIS
BASIN A	0.88 AC.	0.75 AC.	0.13 AC.
BASIN B	0.42 AC.	0.28 AC.	0.14 AC.
BASIN C	0.90 AC.	0.38 AC.	0.52 AC.
BASIN D	0.12 AC.	0.10 AC.	0.02 AC.
TOTAL PROJECT AREA=	2.32 AC.	1.51 AC.	0.81 AC.

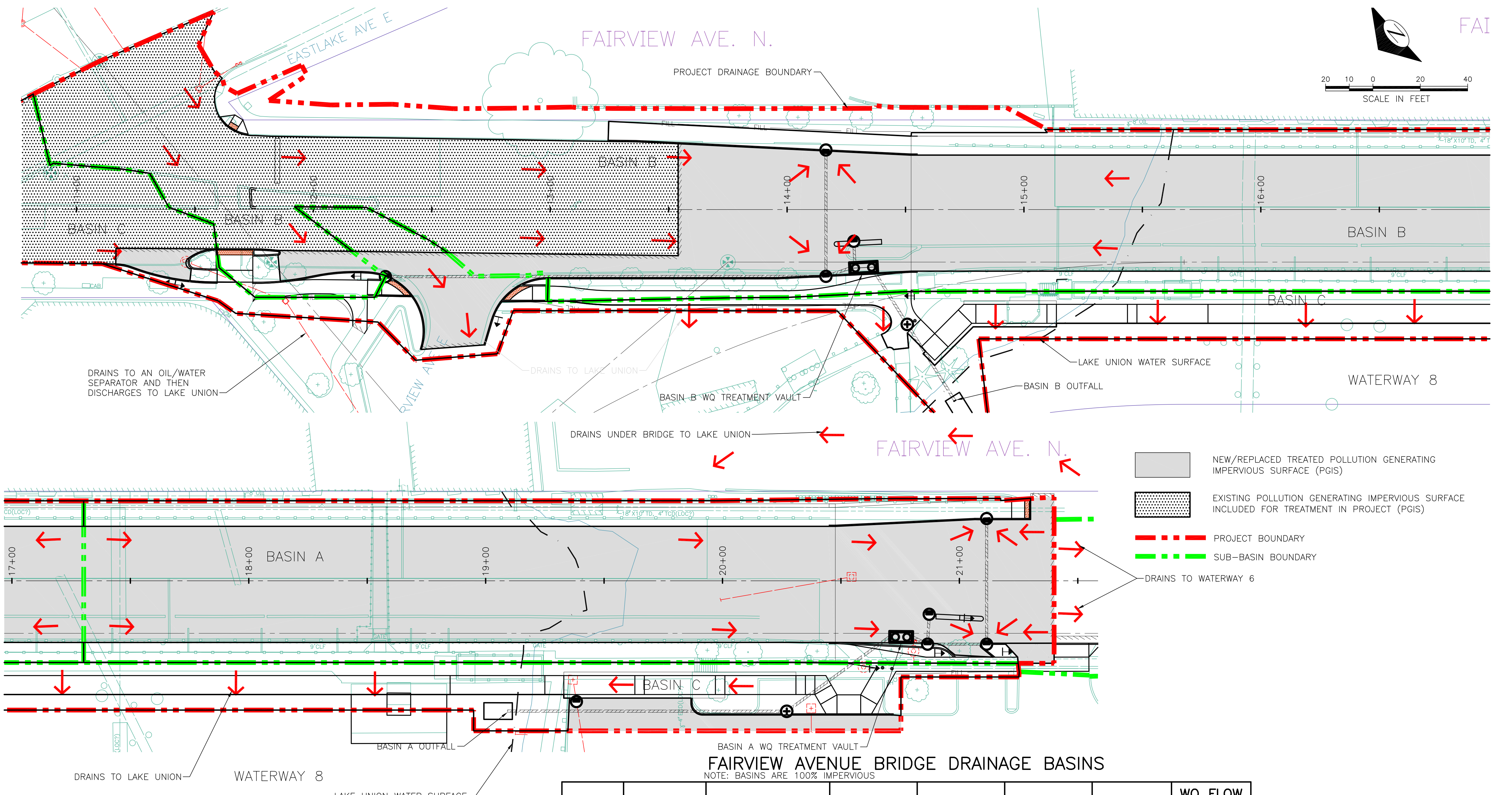
NOTE: BASINS ARE 100% IMPERVIOUS

FILE NAME: Fig05_ExistDrainageCond.ai / CREATED BY: DLD / DATE LAST UPDATED: 01/13/2014

SOURCE: CITY OF SEATTLE, SPU, 2014.

Fairview Bridge . 210715

Figure 5
Existing Drainage Conditions Fairview Avenue North Bridge
Seattle, Washington



FAIRVIEW AVENUE BRIDGE DRAINAGE BASINS

NOTE: BASINS ARE 100% IMPERVIOUS

BASIN AREAS	TOTAL AREA	NEW/REPLACED PGIS AREA	EXISTING PGIS	EXISTING NON-PGIS	NEW/REPL. NON-PGIS	WQ FLOW REQ (CFS)	WQ FLOW TREATED (CFS)
BASIN A	0.64 AC.	0.47 AC.	0.00 AC.	0.00 AC.	0.17 AC.	0.066	0.066
BASIN B	1.05 AC.	0.46 AC.	0.29 AC.	0.09 AC.	0.20 AC.	0.065	0.106
BASIN C	0.63 AC.	0.07 AC.	0.17 AC.	0.15 AC.	0.25 AC.	0.010	0.000
TOTAL=	2.32 AC.	1.00 AC.	0.46 AC.	0.24 AC.	0.62 AC.	0.141	0.172

30% SUBMITTAL

PROPOSED DRAINAGE CONDITIONS

FILE NAME: Fig05_ExistDrainageCond.ai / CREATED BY: DLD / DATE LAST UPDATED: 01/13/2014

SOURCE: CITY OF SEATTLE, SPU, 2014.

Fairview Bridge . 210715

Figure 6

Proposed Drainage Conditions Fairview Avenue North Bridge
Seattle, Washington

Roadway drainage runoff south of the bridge flows away from the bridge deck. Two systems collect runoff from the roadway at the south bridge approach. The first system is a catch basin located at the center of the roadway. The catch basin discharges to Lake Union via an 8-inch outfall running underneath the bridge. The second system involves a series of catch basins located along the west side of the road. These catch basins connect to a 12-inch trunk line that runs underneath the existing sidewalk. Stormwater from this trunk line runs south to connect to a 72-inch outfall located at the intersection of Ward Street and Fairview Avenue North. This outfall discharges into Lake Union via Waterway Number 6.

Roadway drainage runoff north of the bridge flows south down from Eastlake Avenue East toward the Fairview Avenue North/Fairview Avenue East intersection. The water then runs down either toward Fairview Avenue East or ponds at the intersection. It is assumed the runoff eventually drains to Lake Union.

1.5.11.2 Stormwater Design Parameters

All stormwater design and analysis will conform to the 2009 Stormwater Municipal Code (SMC 22.800-22.808) and the 2009 City of Seattle Stormwater Manual Volume 3, Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual (Manual). According to the US Army Corps of Engineers, the water level at Lake Union is controlled by the Hiram M. Chittendan Locks and is at 20 to 22 feet above sea level, which translates to NAVD-88 elevation of 16.75 to 18.75 feet.

All stormwater from the project area discharges into Lake Union, under both existing and proposed conditions. Lake Union has been identified as a Designated Receiving Water by the City of Seattle, the Department of Ecology, NMFS, and USFWS. Therefore, flow control is not required.

1.5.11.3 Developed (Post-Project) Conditions

As part of the proposed design, the bridge profile is to be slightly raised to allow for positive drainage; hence, collection and treatment systems will not be required on the bridge structure proper, but will be located in the roadway section adjacent to each bridge approach. The stormwater runoff will be treated at each end of the bridge and discharged to Lake Union via 12-inch diameter outfalls, with one outfall each at the north and south ends of the walkway (on west side of walkway). To meet the requirements of City of Seattle's shoreline code, all outfalls will not be visible above the low lower water and therefore be located beneath the low (winter) OHWM elevation of Lake Union (16.75 NAVD-88) and designed to prevent fish entry. No outlet protection or energy dispersion devices are therefore necessary.

Due to space constraints, it is likely that this project will require use of emerging technologies as defined in Manual Section 5.12. The project will provide basic water quality treatment using General Use Level Designation (GULD) approved water quality treatment vault.

The project area will remain unchanged in the final condition. There will be a slight decrease of PGIS by 0.05 acre (see Table 1-2).

1.5.12 Description of Project Sequencing and Timeline

The proposed action is anticipated to occur over a 24 month period between Spring 2015 and Spring 2017. The general in-water work window for Lake Union is October 1 through April 15, although several project constraints (see above for discussion of constraints) will likely necessitate some in-water work outside of the general window.

The general sequence of construction activities is described above. It should be noted that the project schedule is only a likely representation of what the actual schedule may be and that variations in work timing and possible phasing may occur due to permitting considerations, funding issues, contractor delays, or adverse weather conditions.

1.6 Impact Avoidance and Minimization Measures

Conservation Measures and Best Management Practices (BMPs) have been incorporated into the proposed project to avoid and minimize short-term and long-term impacts to listed species and their habitats in the project vicinity. Significant short-term effects to water quality are expected to be minimized if sediment containment measures, erosion control and spill containment BMPs are properly implemented, monitored, and maintained during construction. Long-term water quality impacts are not expected. Contractor will be required to prepare a Stormwater Pollution Prevention Plan (SWPP) which includes a TESC and the SPCC plan and will implemented to minimize sedimentation into the lake and prevent erosion. The following includes BMPs and conservation measures designed to avoid and minimize impacts to listed species.

1.6.1 Erosion and Sediment Control

- Implementing construction phasing that minimizes the amount of earthwork that exposes the ground surface to erosion;
- Implementing a Temporary Erosion and Sediment Control (TESC) plan including sediment-control BMPs such as silt fences, check dams, sediment traps, sedimentation basins, and flocculation methods;
- Using erosion-control practices (seeding, mulching, soil conditioning with polymers, use of geo-synthetics, sod stabilization, erosion-control blankets, vegetative buffer strips, and preservation of trees with construction fences);
- Using construction entrances, wheel wash stations, and parking areas that reduce tracking sediment onto public roads;
- Performing routine inspections of erosion-control and sediment-control BMPs and subsequent BMP maintenance;
- Implement construction BMPs to control dust and limit impacts to air quality, including the following:
    - Wet down fill material and dust on site;
    - Minimize ground disturbances;
    - Cover loads and ensure adequate freeboard to prevent soil particles from blowing away during transport;

- Remove excess dirt, dust, and debris; and
- Cover disturbed soil with seeding, sod, mulch, geosynthetics, matting, etc. as soon as practicable.

1.6.2 Contaminated Materials Handling

- All contaminated or potentially contaminated project excavation spoils and waste material (e.g., removed creosote-treated piles) will be isolated from the lake once removed, at which time the materials will be tested/characterized in accordance with applicable guidelines to determine proper storage, transportation and disposal options; all such spoils and waste materials will be stored, transported and disposed of by a duly licensed transportation, storage, and disposal contractor(s) at an appropriately licensed waste facility or other appropriate site pursuant to applicable regulations.
- Excavated material from the drilled shafts will be tested/characterized on-site, and the potentially contaminated top layer (approximately top 10 feet, to be determined by testing at time of excavation) of material will be both stockpiled and decanted separately.

1.6.3 In-Water Work

- No in-water work will occur until a primary, containment curtain is installed around the entire project area.
- Prior to activities that involve physical disturbance of the lake bed (e.g., shaft installation or pile removal), the work area will be further isolated with a smaller, secondary sediment curtain, installed as close to the work area as feasible.
- Prior to activities that involve physical disturbance of the lake bed (e.g., shaft installation or pile removal), one to two feet of clean sand will be placed around the work area to minimize re-suspension of potentially contaminated materials.
- A debris containment system will be installed prior to demolition of the existing bridge structures, in order to minimize or eliminate debris falling into Lake Union.
- The project will not use impact pile driving, in order to minimize in-water noise and vibration.
- Work within Lake Union will require a Hydraulic Project Approval (HPA) from the Washington Department of Fish and Wildlife (WDFW). The project will comply with all permit conditions to minimize impacts on aquatic resources.

1.6.4 Clearing/Vegetation Removal

- Exposed slopes and disturbed areas around the construction area will be restored to original condition, with currently vegetated areas being replanted.

- Installation of high visibility construction fencing around the work area will define the work area and protect sensitive areas such as wetlands and streams from construction related impacts.
- Areas where vegetation is removed will be stabilized using sediment and erosion control BMPs during construction

1.6.5 Stormwater Pollution/Spill Prevention

- A Spill Prevention Control and Countermeasure (SPCC) plan will be implemented. Elements of this plan will satisfy all pertinent requirements set forth by federal, state, and local laws and regulations.
- All vehicles operated within the project area will be inspected daily for fluid leaks before leaving the vehicle staging area. Any leaks detected will be repaired before the vehicle resumes operation. When not in use, all vehicles will be stored in the staging areas or stored with spill containment pans or pads.
- All mechanical equipment will be fueled at least 50 feet from the Lake Union. All equipment will be inspected daily for fluid leaks. Spill response equipment will be on-site for potential fluid leakage.
- During construction, the contractor will provide on-site temporary BMPs to comply with water quality requirements and NPDES permit limitations.
- The project is providing necessary treatment of stormwater runoff for the project, where none is currently provided. All stormwater from PGIS in the project area will receive basic stormwater treatment.

1.6.6 Staging Areas

- All staging and stockpile areas will be located outside of lakes, streams, wetlands, and vegetated buffers. Staging and stockpile areas will be limited to paved or gravel right-of-way.
- Staging areas will be located in areas that will prevent the potential of contamination of Lake Union. Servicing and refueling of vehicles will not occur in areas that reduce potential spills of petroleum and hydraulic fluids in sensitive areas. Additionally, drip pans will be fitted with absorbent pads and placed under all equipment being fueled.
- Erosion of stockpiled materials will be controlled as per Standard Specifications for Erosion Control.

1.6.7 Construction Activities

- Any use of wet concrete will include provisions for allowing adequate time and protection of material to allowing adequate curing before coming into contact with water. No wet or curing concrete will be allowed to come in contact with the waters of Lake Union.

1.7 Action Area

The Endangered Species Act requires that potential effects to listed and proposed endangered and threatened species be evaluated in relation to the complete range of area influenced by the proposed action (the Action Area) (50 CFR Part 402.02). The Action Area encompasses the complete extent where measurable direct and indirect effects resulting from the proposed action are foreseeable and are reasonably certain to occur (USFWS, 1998).

For the purpose of this assessment, the Action Area generally includes both a terrestrial zone of effect and an aquatic zone of effect. The terrestrial zone of effect includes the entire construction footprint along and adjacent to Fairview Avenue North, including all areas of operation for construction equipment, including barges.

1.7.1 Action Area Terrestrial Component

The primary driver of the terrestrial zone of effect is construction noise. The project area is located within an urban setting and will require the use of heavy machinery including graders, excavators, dump trucks, auger rigs, rollers, pavers, dozers and cranes, and the potential use of a vibratory pile driver (for installation or removal of piles).

Using the rules for decibel addition, the combined noise level of all construction equipment operating together was calculated. The three loudest pieces of equipment have noise levels of 101 (vibratory pile driver), 90 (concrete saw), and 90 (hoe-ram) A-weighted decibels (dBA) at a distance of 50 feet from the source. Combined, the equipment will generate noise at 102 dBA at 50 feet from the source.

The standard reduction for point source noise, such as that generated from construction activities is 6 dB per doubling of distance from the source at “hard sites”. The areas adjacent to the project have “hard site” conditions in the form of Lake Union to the east of the project area and developed land uses (roads, buildings, etc.) to the north, east, and south of the project site. Therefore, the reduction in construction noise is 6.0 dBA per doubling of distance from the source.

The project is located on has an Average Daily Traffic (ADT) of approximately 12,500 vehicles (HNTB and Perteet, 2013) with a posted speed limit of 30 miles per hour (mph). The traffic volume in vehicles per hour is typically 10 percent of the ADT, which in this case would be 1,250 vehicles per hour. Traffic noise for this type of roadway, at the given volume and speed would generate noise levels of 76.2dBA at 50 feet from the source (WSDOT, 2012). Line source noise, such as that generated by roadways, attenuates at a rate of 3 db per doubling of distance. Based on “hard site” conditions as described above, the reduction in traffic noise is 3.0 dBA per doubling of distance from the source.

Based on measured noise levels the existing environmental background (ambient) noise levels would be approximately 70 dBA (Greenbusch Group, 2013). It is anticipated that construction noise would attenuate to traffic noise at 15,100 feet, but would attenuate to ambient noise at 1,774 feet pending no other noise attenuating circumstances. Therefore, the project Action Area will include a terrestrial zone of effect related to construction noise extending in all directions from the project area for a distance of 1,800 feet (Figure 7). This is a conservative estimate of the action area, as an elevated portion of Interstate 5 runs parallel to the project site. Interstate 5, which produces high amounts of traffic noise, is located only 300 to 400 feet away from the roadway and bridge. Furthermore, the site is located directly adjacent to a commercial seaplane base and within close proximity to numerous industrial maritime businesses. Lastly, Lake Union has high maritime use, both pleasure craft and commercial boats.

The terrestrial zones potentially affected by construction projects generally include those areas affected by an increase in noise and human activity. For this project, there are no listed terrestrial species anticipated within several miles of the action that could be affected by increased noise or human disturbance; therefore, a terrestrial zone of effect related to noise was not established. No highly intensive noise activities such as blasting or impact pile driving are anticipated.

1.7.2 Action Area Aquatic Component

The Action Area also includes an aquatic zone of effect, primarily related to potential in-water work activities and resulting water quality impacts. Substantial in-water work, including the installation of drilled shafts, installation of temporary piles, and removal of existing piles will occur within Lake Union. The in-water work will result in sediment disturbance and localized increases in turbidity. In addition, at least some of the Lake Union sediments that will be disturbed are likely contaminated with a variety of compounds. The project will employ a non-permeable sediment curtain around the entire in-water work area prior to in-water work that will remain in place the duration of in-water construction. In addition, the project will adhere to all state and federal water quality regulations.

The lateral extent of the aquatic zone of effect was determined by using the regulatory mixing zone as established in the *Water Quality Standards for Surface Waters of the State of Washington; Chapter 173-201A Washington Administrative Code (WAC)*, which indicates that for non-flowing waters, the point of compliance shall be 150 feet away from the activity causing the turbidity disturbance (Ecology, 2012a). Therefore, the aquatic zone of the Action Area includes the wetted portions of the project site and the portion of Lake Union within 150 feet of any sediment disturbing construction activities (Figure 7).

The other project elements that could potentially affect the aquatic portion of the Action Area are in-water noise and effects from stormwater generated pollutants. However, no impact pile driving will occur as part of the project, and all in-water piles will be installed through drilling or by vibratory methods. The underwater noise generated by these construction methods are typically significantly lower than for impact hammers, and have a lower rise time (time for the noise wave form to raise from 10 to 90% of its highest peak). As a result, the pile driving energy is spread out over a longer time period, thereby minimizing the potential to harm aquatic organisms. Therefore, underwater noise will not increase the size of aquatic component of the Action Area from that presented above for sediment disturbing actions.

SOURCE: King County, 2011; Microsoft Bing Maps, 2011 (Aerial)

210715 Fairview Bridge . 210715

Figure 7
Project Action Area
Seattle, WA

Likewise, the project will result in an overall decrease in PGIS. Based on High-Run modeling results, post-project loading of copper and zinc from the roadway have less than a 35 percent chance of increasing in Lake Union. Therefore, any changes in copper or zinc loading or concentrations from post-project stormwater runoff would be minimal or nonexistent, and would not increase the size of aquatic component of the Action Area from that presented above for sediment disturbing actions.

In summary, the components of the Action Area includes the extent of all potential direct and indirect effects of noise, soil disturbing activities, and stormwater upon water quality and quantity at both project site and associated mitigation site (Figure 7).

2 STATUS / PRESENCE OF LISTED SPECIES AND DESIGNATED CRITICAL HABITAT IN THE ACTION AREA

2.1 Species and Critical Habitat List(s) and Listing Status

NMFS (2013) and the USFWS (2013) indicate that the project will occur within the range of several federally-listed species and designated critical habitats (Table 2-1, Appendix A). In addition, the Washington State Department of Natural Resources (WDNR) Natural Heritage Database (WDNR, 2013) was reviewed for the potential presence of federally-listed plant species in the project area.

Table 2-1. Occurrence of Listed Species and Critical Habitat within the Project Area.

Common Name	Scientific Name	ESA Status	Jurisdiction	Critical Habitat
Coastal-Puget Sound DPS Bull Trout	*Salvelinus confluentus*	Threatened	USFWS	Yes
Puget Sound Chinook Salmon Evolutionarily Significant Unit (ESU)	*Oncorhynchus tshawytscha*	Threatened	NMFS	Yes
Puget Sound Steelhead Distinct Population Segment (DPS)	*O. mykiss*	Threatened	NMFS	No

The USFWS is no longer providing site-specific species lists due to current workload and budget constraints. Therefore, the species list provided for this project is a county-wide species list that includes species that would not normally be included on a site-specific list due to their limited range or specific habitat requirements.

For the majority of the species identified for King County, either the species was not historically distributed within the Action Area and/or the Action Area does not contain suitable habitat features to support the species. These species include the listed species Canada lynx (*Lynx Canadensis*), gray wolf (*Canis lupus*), grizzly bear (*Ursus arctos*), northern spotted owl (*Strix occidentalis*), and golden paintbrush (*Castilleja levisecta*) and the proposed species North American wolverine (*Gulo gulo luteus*), Oregon spotted frog (*Rana pretiosa*), and yellow-billed cuckoo (*Coccyzus americanus*).

The Canada lynx, gray wolf, and grizzly bear are wide-ranging species that are found in critically small numbers in Washington; most reliable observations are from the North Cascades (Almack and Fitkin, 1998). They generally require remote, dense, and mature forests free from human activity. The northern spotted owl nests and roosts in mature/old growth coniferous forests with high canopy closure, a multi-layered, multi-species canopy dominated by large (>30 inches diameter at breast height) trees, tree deformities such as cavities and broken tops, large snags, woody debris, and space for flying below the canopy (USFWS, 1990). No forested habitats that provide trees of sufficient size or structure occur within the Action Area. No prairie habitats are present to support golden paintbrush and their occurrence in King County is identified as historic.

In summary, Canada lynx, gray wolf, grizzly bear, northern spotted owl, golden paintbrush, North American wolverine, Oregon spotted frog, and yellow-billed cuckoo are not likely to occur on the site due to a lack of suitable habitat for these species. Therefore, these species or their designated critical habitats (where applicable) will not be affected by the project and these species are not addressed further in this BA.

For similar reasons, other marine or anadromous fish species under the jurisdiction of NMFS, such as the southern distinct population segment (DPS) of Pacific eulachon (*Thaleichthys pacificus*) or the listed species of rockfish (*Sebastes* spp.) are not located within the Action Area. Likewise, marine mammals including Southern Resident killer whales (*Orcinus orca*), will not be addressed in this report as the project does not have the potential to affect these species or their habitats.

Information on threatened and endangered plant species and plant communities from the Washington State Department of Natural Resources (WDNR) Plant Natural Heritage Database indicated that no threatened or endangered plants are known to occur within the project vicinity.

2.2 Presence of Federally Listed and Proposed Species in the Project Action Area

2.2.1 Puget Sound ESU Chinook Salmon

NMFS issued a ruling in May 1999 listing the Puget Sound ESU Chinook Salmon as threatened (NMFS, 1999). Primary factors contributing to declines in Chinook salmon in the Puget Sound ESU include habitat blockages, hatchery introgression, urbanization, logging, hydropower development, harvests, and flood control (NMFS, 1998).

2.2.2 Life History

The life history of Puget Sound Chinook salmon is described in detail in *NOAA Technical Memorandum NMFS-NWFSC-35 Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California* (Myers et al., 1998) and is included herein by reference. This information has been summarized to assist in the discussion of effects related to the proposed action, and is included in Appendix C.

2.2.3 Status and Abundance in the Action Area

Two natural Chinook salmon spawning populations (the north Lake Washington population and the Cedar River population) occur in the Action Area and use Lake Washington for rearing and migration. A third population, the Issaquah stock, is a nonnative stock from the Issaquah Hatchery, which has been in operation since the 1930s (WDFW, 2004; Ruckelshaus et al., 2006). Lake Washington populations have shown some of the steepest declines of the 22 extant populations of the Puget Sound Chinook ESU, greater than 5 percent per year since the peak returns during the mid-1980s (Myers et al., 1998; Weitkamp and Ruggerone, 2000).

The status of the Lake Washington populations is based on their abundance, productivity, diversity, and spatial structure, but substantial development in the basin has degraded their spawning and rearing habitat.

The status of Chinook stocks in the 2002 Salmonid Stock Inventory was reported as depressed for the Cedar population and healthy for the Sammamish population components (WDFF, 2006). During recent years, the Cedar River Chinook salmon run has declined about 10 percent per year, while the Issaquah Creek (hatchery) run has declined about 8 percent per year and the north Lake Washington run has declined about 17 percent per year (Weitkamp and Ruggerone 2000). The recent (1994 to 2007) average Chinook salmon escapement level to Lake Washington is estimated at 824 fish (Exhibit 2-2) (City of Seattle and USACE 2008).

Table 2-2. Escapement of Naturally Spawning Chinook Salmon into the Lake Washington Basin

Return Year	North Lake Washington and Issaquah Creek	Cedar River	Total
1994	436	452	888
1995	249	681	930
1996	33	303	336
1997	67	227	294
1998	265	432	697
1999	537	241	778
2000	227	120	347
2001	459	810	1,269
2002	268	369	637
2003	212	562	774
2004	143	587	730
2005	215	525	740
2006	129	1,090	1,219
2007	161	1,729	1,890
Average	**243**	**581**	**824**

2.2.4 Distribution in the Action Area

The Action Area contains Chinook salmon juvenile and adults in Lake Union (WDFW, 2011a, b). This potentially includes outmigrating fry that enter from the Sammamish and Cedar Rivers (Fresh, 2000; Tabor et al., 2004; Tabor et al., 2006). Adult Chinook salmon may also be present in the Action Area, as they typically return to Lake Washington in August and September, sometimes within days of returning to their natal rivers (City of Seattle and USACE, 2008).

Chinook salmon smolts typically pass through the Ship Canal in May and June as age-0 fish. However, some Chinook leave the basin as 2-year olds. The outmigration timing of juvenile Chinook through the Ship Canal and Locks appears to be later than that in any other stock in the Puget Sound basin. Detailed tracking studies found that some Chinook smolts spend several days in Portage Bay before moving on to Lake Union (Celedonia et al., 2008a). Chinook salmon smolts appear to briefly reside (1-4 days) in Lake Union during their outmigration. Smolts use the entire lake, with 25% to 50% of tagged smolts using the southern portion of Lake Union.

During this residence, Chinook move around the northern and southern parts of the Lake. Chinook smolts are active during the day, but exhibit variable behavior at night.

Juvenile salmonids appear to avoid overwater structures in Lake Union based on both juvenile Chinook salmon acoustic tagging studies period (Celedonia et al., 2008ab) and above water and snorkel observational studies (Pentec, 2010). Fine-scale acoustic tracking between 2005 and 2007 in the Ship Canal at Portage Bay and north Lake Union showed little evidence of shoreline affinity. Instead, juvenile Chinook salmon smolts were observed fanning out and mixing within Portage Bay and north Lake Union (Celedonia et al., 2008a). In north Lake Union most activity occurred at depths greater than 33 feet. Pentec (2010) noted that only 1 of 97 observations events conducted between late-April and early-July revealed the presence of juvenile Chinook salmon proximal to floating homes. Juvenile salmonids largely selected against nearshore habitats in South Lake Union and Gas Works Park.

Returning adult Chinook salmon pass through the Ship Canal and Lake Union from the end of July through the beginning of September. Very little is known about adult salmon migration through the Ship Canal and Lake Union. There are some data on Chinook and sockeye salmon from tagging studies (Fresh et al., 1999, 2000; Newell and Quinn, 2005). In general, adult salmon do not appear to spend substantial time in the Ship Canal, including Lake Union. Typically, Chinook pass through the Ship Canal in 2 or fewer days (Fresh et al., 1999, 2000). Habitats used by adult salmon migrating through the Ship Canal are unknown. Only one report shows that Chinook salmon are generally found near depths of 20 feet in the Ship Canal (Fresh et al., 1999).

Adult salmon passage through the Ship Canal and Lake Union is thought to be influenced by warm water temperatures in the Ship Canal, among other things. Both sockeye and Chinook salmon may be impacted by these high temperatures. Sockeye tend to spend longer in the Ship Canal, but also keep to a tighter temperature range than Chinook. Chinook enter the Ship Canal later in the season when temperatures are higher, however.

Summer water temperatures in the Ship Canal and Lake Union consistently exceed values that a physiologically stressful to adult salmon (> 68ºF or >20ºC). The Ship Canal and Lake Union are relatively homogenous in water temperature. Summer DO levels in Lake Union may also be a problem for adult salmon. The lake is generally under low-DO conditions from June to October. The low DO concentrations in the lake may prevent salmon from using the water column below a 33-foot depth, while warmer surface temperatures later in July may limit use of the upper water column (City of Seattle and USACE, 2008).

2.3 Puget Sound DPS Steelhead

On May 7, 2007, NMFS announced the listing of the Puget Sound DPS of steelhead as a threatened species under the Endangered Species Act (NMFS, 1997; 72 Federal Register 91). Possible factors influencing the depletion of Puget Sound steelhead populations include habitat destruction and fragmentation, inadequate regulatory mechanisms of hatchery practices and land use activities, and potential genetic introgression between hatchery - and natural-origin steelhead.

2.3.1 Life History

The life history of Puget Sound Steelhead is described in the *Proposed Endangered Status for Five ESUs of Steelhead and Proposed Threatened Status for Five ESUs of Steelhead in Washington, Oregon, Idaho, and California* (NMFS, 1999; 61 Federal Register 155) and is included herein by reference. This information has been summarized to assist in the discussion of effects related to the proposed action, and is included in Appendix C.

2.3.2 Status and Abundance in the Action Area

There are two steelhead populations in the Lake Washington watershed: the natural-origin Cedar River population and the introduced north Lake Washington population (WDFW, 2006). There is insufficient information to evaluate whether this resident form contributes to the viability of the anadromous steelhead population over the long-term (NMFS, 2007).

Both the Cedar River and the north Lake Washington populations of winter-run steelhead have undergone steep declines in recent decades (Busby et al., 1996). WDFW (2004) identified the Lake Washington population of winter steelhead as depressed in 1992 and as critical by 2002 (WDFW, 2004). These assessments were based on the chronically low escapement and short-term severe decline in escapements. WDFW (2006) still considers the stock to be depressed because recent escapement estimates of this stock have been consistently low; escapement rates were 20 to 48 fish between 2000 and 2004 (Table 2-3 (WDFW, 2006). Based on these numbers, the relative risk of extinction for the Lake Washington winter steelhead population is considered very high.

Table 2-3. Escapement of Steelhead into the Lake Washington Basin

Year	Total Escapement
1986	1,816
1987	1,172
1988	858
1989	686
1990	714
1991	621
1992	599
1993	184
1994	70

Year	Total Escapement
1995	126
1996	234
1997	620
1998	584
1999	220
2000	48
2001	42
2002	38
2003	20

2.3.3 Occurrence of Species in the Action Area

Juvenile steelhead migrating through Lake Washington watershed will pass through the Action Area using the general area as a migratory corridor. Although limited information is available on steelhead passage through the Ship Canal, peak passage of steelhead smolts at the Ballard Locks is believed to occur in May (City of Seattle and USACE, 2008). The large steelhead smolts likely migrate relatively quickly through Lake Washington and the Ship Canal during late spring utilizing a wide range of habitats. Their large size also likely reduces predation risks during their migration through the action area and other portions of the migration route. There is no available information that identifies the Action Area as a location specifically used by juvenile steelhead for rearing.

WDFW concludes that there is little overlap in spawning of natural and hatchery winter steelhead based on assumed run timing. Historically, adult steelhead enter Lake Washington through the Ballard Locks between December and early May, with peak numbers in February and March (WDFW et al., 2004). Their subsequent movements in the Ship Canal and Lake Washington have not been described in available documents. It is likely the steelhead move directly into Lake Washington because the water temperatures are relatively cool during their migration period, avoiding any temperature impedance to migration.

2.4 Coastal-Puget Sound DPS Bull Trout

The Coastal-Puget Sound bull trout (*Salvelinus confluentus*) distinct population segment (DPS) is composed of 34 subpopulations (USFWS, 1998b; USFWS, 1999). In 1998, USFWS completed a status review of bull trout, identifying five DPSs in the continental U.S. (USFWS, 1998a). USFWS listed bull trout in the Coastal-Puget Sound DPS as threatened under the ESA on November 1, 1999 (USFWS, 1999).

Similarly, Dolly Varden (*Salvelinus malma*) was proposed for listing as threatened by the USFWS in 2001 (66 Federal Register 6) due to similarity of appearance with bull trout and because they occur together only within the area occupied by the Coastal-Puget Sound bull trout DPS. A designation of threatened or endangered under the similarity of appearance provisions of the ESA extends the take prohibitions of Section 9 to cover the species. However, under section 4(e) of the ESA, a designation of threatened or endangered due to similarity of appearance, does not extend other protections of the ESA, such as the consultation requirements for federal agencies under section 7 of the ESA. Although not formally discussed in this document, the effects of the action upon Dolly Varden are anticipated to be similar to that of bull trout.

2.4.1 Life History

The life history of the Coastal-Puget Sound DPS Bull Trout is described in the *Endangered and Threatened Wildlife and Plants: Determination of Threatened Status for Bull Trout in the Coterminous U.S.; Final Rule* (USFWS, 1999) and the *Draft Recovery Plan for the Coastal-Puget Sound Distinct Population Segment of Bull Trout* (USFWS, 2004) and is included herein by reference. This information has been summarized to assist in the discussion of effects related to the proposed action, and is included in Appendix C.

2.4.2 Status and Abundance in the Action Area

Bull trout population status and use of the Lake Washington FMO habitat are currently unknown. Adult and subadult bull trout have been infrequently observed in the lower Cedar River, in Carey Creek (a tributary of upper Issaquah Creek), in Lake Washington, and at the Ballard Locks. However, no spawning activity or juvenile rearing has been observed, and no distinct spawning populations are known to exist in Lake Washington outside of the upper Cedar River upstream from Chester Morse Lake (not accessible to bull trout within Lake Washington) (USFWS, 2004). The potential for bull trout spawning in the Lake Washington watershed is believed to be low because most of the accessible habitat is at a low elevation; therefore, it is not expected to have suitable water temperatures for successful bull trout spawning.

2.4.3 Distribution in the Action Area

Although bull trout may occasionally occur within the Action Area, there is no known regular occurrence of bull trout in the lake. Little is known about the historical distribution and abundance of bull trout in the Lake Washington system. A one-year survey in the Lake Sammamish basin in 1982 to 1983 reported no char (WDFW, 1998). Although bull trout occasionally occur in Lake Washington, there are no indications of an adfluvial population in the lake, and bull trout are not expected to occur in the surface waters of Lake Washington during the summer, when water temperatures typically exceed 59 degrees Fahrenheit (ºF) (15 degrees Celsius [ºC]) for several months. Therefore, the apparent remnant amphidromous population likely uses the lake primarily as a migration route to marine waters for foraging and rearing. Amphidromous adult and subadult bull trout could occur in the Action Area in the non-summer months, when Lake Washington water temperatures are below 15^{o}C.

2.5 Presence of Federally Designated and Proposed Critical Habitat in the Project Action Area

2.5.1 Puget Sound ESU Chinook Salmon

NMFS published the final rule designating critical habitat for Puget Sound Chinook salmon in September 2005 (70 FR 52630). The rule identifies the entirety of Lake Union, including the Action Area, as designated critical habitat for Chinook salmon. The designation identified the Ship Canal and Lake Washington as habitat of high conservation value because of its connectivity with the high-value Cedar River watershed and its support of rearing and migration habitat for fish from all four watersheds in the subbasin. However, the rule excludes all tributaries of Lake Washington and the entire Lake Sammamish and Sammamish River watersheds from the final critical habitat designations. Within the Action Area, Chinook salmon critical habitat is present within the nearshore habitats of Lake Union. Critical habitat designations are based on the presence of primary constituent elements (PCEs) that are essential to supporting one or more life stages of the species and that contain physical or biological features essential to the conservation of the species.

The PCEs that apply to freshwater systems in the Action Area include the following:

- **PCE 2** – Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions that support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, logjams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.

- **PCE 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.

The critical habitat throughout Lake Union has been substantially modified by long-term anthropogenic activities. Freshwater rearing habitat along much of the shoreline of Lake Union is more supportive of some introduced species (i.e., black crappie, carp, smallmouth and largemouth bass, goldfish, and yellow perch) than of native Chinook salmon. Some of these species are also known to prey on juvenile Chinook salmon, further degrading the rearing conditions. Various forms of native and nonnative riparian vegetation grow along portions of the shoreline and substantial portions of the shoreline are hardened, producing relatively deeper habitat than that preferred by juvenile Chinook salmon. In general, the habitat conditions in much of the Action Area are unsuitable for Chinook salmon rearing.

2.6 Puget Sound DPS Steelhead

NMFS proposed critical habitat for Puget Sound steelhead January 14, 2013 (78 Federal Register 9). Critical habitat, as proposed, does not include Lake Union, the Lake Washington Ship Canal, or Lake Washington. The closest proposed freshwater critical habitat in WRIA 8 is the Cedar River, over 10 miles upstream of the Action Area.

2.7 Coastal-Puget Sound DPS Bull Trout

USFWS published the final rule designating critical habitat for Coastal-Puget Sound bull trout in September 2005 (70 FR 56212) and redesignated it in September 2010 (75 FR 63898). The final rule identifies Lake Washington as designated critical habitat for Coastal-Puget Sound bull trout. The agency identified nine PCEs for Coastal-Puget Sound bull trout critical habitat.

Three of these PCEs (PCEs 1, 6, and 7) are associated with in-stream spawning and rearing habitat and do not occur in the Action Area. The other six PCEs are present in various portions of the Action Area:

- **PCE 2** – Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

- **PCE 3** – An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

- **PCE 4** – Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks and unembedded substrates, to provide a variety of depths, gradients, velocities, and structure.

- **PCE 5** – Water temperatures ranging from 2°C to 15°C (36°F to 59°F), with adequate thermal refugia available for temperatures that exceed the upper end of this range. Specific temperatures within this range will depend on bull trout life-history stage and form; geography; elevation; diurnal and seasonal variation; shading, such as that provided by riparian habitat; streamflow; and local groundwater influence.
- **PCE 8** – Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.
- **PCE 9** – Sufficiently low levels of nonnative predatory species (e.g., lake trout, walleye, northern pike, smallmouth bass); interbreeding species (e.g., brook trout [*Salvelinus fontinalis*]); or competing (e.g., brown trout [*Salmo trutta*]) species that, if present, are adequately temporally and spatially isolated from bull trout.

Any bull trout usage of Lake Union is extremely limited, and would be limited to use as a migration corridor (PCE 2). There are no physical impediments to bull trout migration in the Action Area. However, temperature-related impediments may also be present in Lake Union (PCE 5). Surface water temperatures of these water bodies typically exceed 20°C for substantial portions of the summer.

As stated above, bull trout may forage in the Lake Union, Lake Washington, and the Ship Canal as they migrate to and from the marine environment. Availability of food in Lake Union is generally good and considered properly functioning (PCE 3). The benthic habitat of Lake Union likely provides adequate aquatic macroinvertebrates that support an abundant food base. The food base in Lake Union is more abundant now than it was in the middle of the twentieth century; however, it is likely less productive than it was under historical conditions. As piscivorous fish, bull trout are expected to forage on juvenile salmonids. Despite the introduction of artificially propagated salmonids, like Chinook salmon, into the Lake Washington watershed, the abundance and availability of juvenile salmonids are likely reduced relative to historical conditions.

The vast majority of the Lake Union shorelines are modified, so these areas are of extremely limited habitat complexity. The processes that establish and maintain these aquatic environments (including those that result in variety of depths and structures that support bull trout foraging and rearing phases) are generally degraded. Despite the high summer water temperatures in the surface waters of these freshwater bodies, they continue to provide sufficient water quality and quantity to support normal growth and survival of bull trout (PCE 8). However, the substantial populations of nonnative predator species (e.g., smallmouth bass) do not adequately support healthy bull trout populations.

3 ENVIRONMENTAL SETTING

3.1 Project Setting and Terrestrial Habitat Conditions

The proposed project would replace two existing bridges over Waterway 8 in Lake Union with a single new bridge improving approximately 540 linear feet of Fairview Avenue North within the City of Seattle. The project is located within the northwest quarter of Section 19, Township 25 North, Range 04 East, in 6th Field Hydrologic Unit Code (HUC) 171100120400, defined as the Lake Washington-Sammamish River subbasin.

Fairview Avenue North is a major arterial street that runs along the eastern shoreline of Lake Union. To the north, Fairview Avenue connects with Eastlake Avenue East and to the south it intersects other major city arterials including Mercer Street and Denny Way (see Figure 1). This roadway supports north-south traffic between downtown Seattle and the University District.

The land use in the project area is already developed as commercial/industrial, with industrial, office, and business zoning. Vegetation within the project corridor is limited to some shrubs and individual scattered small landscape-type coniferous and deciduous trees located along the west (waterward) side of the existing north and south bridge approaches. In addition, some narrow strips of grass and other herbaceous vegetation are located along the edges of Fairview Avenue North, on either side of the bridge.

Within the project area, the proposed project is located within and above Lake Union. No other surface water features are present on-site and no wetlands occur on or adjacent to the project site.

3.2 Basin Conditions and Aquatic Resources

3.2.1 Lake Union

Lake Union is a portion of the Lake Washington watershed, which in turn comprises 13 major drainage sub-basins and numerous smaller drainages, totaling about 656 miles (1,050 kilometers) of streams, two major lakes, and numerous smaller lakes. Lake Washington is located within the watersheds drained by Issaquah Creek, the Sammamish River, and the Cedar River, referred to as the Cedar-Sammamish Watershed Basin, or WRIA 8. The majority of the immediate watershed is highly developed, with 63 percent of the watershed fully developed, which gives Lake Washington the highest human population of any WRIA in Washington State (NMFS, 2008).

The Lake Union/Lake Washington Ship Canal system is comprised of the Montlake Cut, Portage Bay, Lake Union, the Fremont Cut, and the Salmon Bay Waterway. The Montlake Cut is an approximately 100-foot wide channel with concrete bulkheads extending along the length of the channel. Portage Bay is located west of the Montlake Cut and has a natural surface connection to Lake Union. Lake Union is linked to the Salmon Bay Waterway through the Fremont Cut, a steel, rip-rapped channel.

Lake Union has glacial origins. The basin of the lake was dug 12,000 years ago by the Vashon glacier, which also created Lake Washington. Lake Union covers an approximately 581-acre area with an average depth of 32 feet. Current land use along the shores of the Lake Union system still consists primarily of water dependent commercial and industrial uses including marinas, commercial shipyards, and drydocks. Other commercial development and single and multi-family residences also border the shoreline. Habitat in the Ship Canal and Lake Union is much more modified than that in Lake Washington. The shoreline is heavily armored and the presence of bulkheads, docks, and over-water structures provides virtually no natural shoreline within the system (Weitkamp and Ruggerone, 2000). Lake Union and the Lake Washington Ship Canal still support a large live-aboard and houseboat community. The south end of Lake Union is the only area of the lake that has retained any natural shoreline characteristics (Weitkamp and Ruggerone, 2000).

The U.S. Army Corps of Engineers (USACE) is mandated by Congress (Public Law 74-409, August 30, 1935) to maintain the level of Lake Washington, Lake Union, and the Ship Canal between 20 and 22 feet (USACE datum) as measured at the Government Locks. The USACE operates this facility to systematically manage the water level in Lake Washington, over four distinct management periods, using various forecasts of water availability and use.

The four management periods are:

- Spring refill - lake level increases between February 15 and May 1 to 22 feet (USACE datum);
- Summer conservation - lake level maintained at about 22 feet for as long as possible, with involuntary drawdown typically beginning in late June or early July;
- Fall drawdown - lake level decreasing to about 20 feet from the onset of the fall rains until December 1; and
- Winter holding - lake level maintained at 20 feet between December 1 and February 15.

Operation of the Government Locks and other habitat changes throughout the Lake Washington Basin have substantially altered the frequency and magnitude of flood events in Lake Washington and its tributary rivers and streams.

3.2.1.1 Predation within Lake Union

Predominant predators in the Ship Canal are northern pikeminnow, small- and largemouth bass, cutthroat trout, and piscivorous birds. Yellow perch and rock bass are potential predators in the Ship Canal. Predation rates in the Ship Canal most likely reflect outmigration timing, run size of each species and water temperature (Tabor et al., 2006). Fish size likely affects predation rates because larger fish have fewer predators.

Most of the nearshore habitats of Lake Union are dominated by overwater structures. Recent snorkel studies within these areas (Pentec, 2010) indicate that the most abundant species was the small forage species threespine stickleback. Several other warm water resident species were also present in low to moderate numbers including smallmouth bass, yellow perch, prickly sculpin and sunfish. However, most warm water residents were juveniles that would not pose a predatory risk to juvenile salmon. No large adult smallmouth bass, northern pikeminnow, or other predatory fish were observed during observation events near or beneath the structures of floating home complexes. The study concluded that the prevalent offshore behavior of juvenile salmon in Lake Union is likely influenced by a number of physical and biotic factors including prey abundance, predator avoidance, and the high level of nearshore development already present in the lake.

3.3 Sediment Quality within the Project Area

Lake Union contains Category 5 sediments (from sediment bioassay); however they were not identified in the immediate project area (Ecology, 2013b). Parametrix (1989) prepared a report containing sediment evaluations conducted as part of a Seattle City Light power line project. The work included sediment sampling at several locations throughout the waterway west of the bridge, including shallow sediments at eight locations in the vicinity of the Steam Plant (see Appendix D for sampling locations and data). Polychlorinated biphenyls (PCBs) and the metals mercury, lead, copper, and zinc were detected above screening levels at the time (Draft Puget Sound marine quality standards, 1989) at one or more locations in sediment west of the Steam Plant. Concentrations of heavy metals, PCBs, and PAHs generally exceeded criteria for offshore open water sediment disposal under the Puget Sound Dredged Material Management Program. One sample exceeded Dangerous Waste criteria for PAHs.

Prior studies of lake sediments also identified elevated metals, PAHs, and PCBs in the vicinity of the Steam Plant (Moshenberd, 2004), with generally similar results to the Parametrix study.

Aspect Consulting (2009) conducted a geotechnical investigation as part of a bridge rehabilitation study. Aspect completed two borings, one each at the north and south approach to the bridge deck. The borings encountered approximately 18 to 25 feet of fill soils over lacustrine and glacial recessional deposits. Field screening identified potential contamination impacts in Boring B1, completed at the south approach. Aspect collected composite soil samples from soil cuttings at each boring and analyzed them for petroleum hydrocarbons, PAHs, PCBs, and metals. Results were below criteria for offshore open water sediment disposal, although not all analytes required for offshore disposal were tested.

However, because these samples were collected as composite samples of soils throughout the borings, there is the potential for discrete soils within the soil column to contain higher concentrations of individual contaminants.

HWA (2013) collected environmental soil samples from the upper 0 to 7.5 feet of boreholes BH-3, BH-4, BH-5, and BH-6 for chemical laboratory analyses. Boring BH-3 through BH-5 were drilled below the bridge deck into lake sediments and underlying soils. Boring BH-6 was an upland boring adjacent east of the south approach. Samples were collected from fill soils overlying native lake deposits and alluvial soils with the exception of BH-3, where the sample was collected from shallow alluvial deposits. Gasoline, diesel and/or oil-range petroleum hydrocarbons, as well as carcinogenic PAHs were detected in three of the four soil samples (BH-4, -5 and -6), at concentrations above upland soil cleanup levels (Washington Department of Ecology Model Toxics Control Act (MTCA) Method A and Method B soil cleanup levels as defined in WAC 173-340). These criteria generally apply to upland soils, not to lake sediments, and are provided as a screening level indication of the environmental quality of the site only, and for handling and disposal purposes. Volatile organic compounds (VOCs) were detected in all soil samples, but at concentrations below the soil cleanup levels. None of the VOCs detected were halogenated solvents. The metals arsenic, cadmium, and/or lead were detected above soil cleanup levels in two samples (BH-4 and BH-6). Lead exceeded the total metals screening level for Dangerous Waste characterization of 100 mg/kg in three samples. Further testing by the Toxicity Characteristic Leaching Procedure (TCLP) method during design or construction would be required to establish Dangerous Waste characterization status.

The HWA testing results generally fell within ranges for open water disposal criteria that would require additional (e.g., bioassay) testing. Impacted soils were primarily detected in the fill layer. Undisturbed native soils below the fill sampled at BH-3 contained low concentrations of VOCs, PAHs, and chromium. Based on this, contamination does not appear to persist into the underlying native soils and deeper native soils are not likely to be impacted.

3.4 Water Quality within the Project Area

Significant sediment contamination (heavy metals and organics) has been documented in Lake Union, primarily from historic industrial sources. Current sources include point source discharges directly from stormwater and combined sewer overflow (CSO) outfalls; nonpoint discharges resulting from storage, handling, and processing of materials at lakeside industries and from other predominantly auto-related sources; recreational and commercial boat sewage and bilge waste discharges; and precipitation. Lake Union is included on the Washington Department of Ecology's 2008 list of impaired and threatened water bodies, pursuant to Clean Water Act 303(d). Lake Union/Lake Washington Ship Canal is 303(d) listed for total phosphorus, fecal coliform bacteria, lead, and aldrin in the water column and for sediment bioassay (Ecology, 2013b). Lake Union experiences periods of anaerobic conditions that typically begin in June and can last until October.

3.5 Environmental Baseline

Properly functioning conditions (PFCs) are the sustained presence of natural habitat-forming processes necessary for the long-term survival of the species through the full range of environmental variation (NMFS, 1996). Indicators of PFCs vary between different landscapes based on unique physiographic and geologic features. Since aquatic habitats are inherently dynamic, PFCs are defined by the persistence of natural processes that maintain habitat productivity at a level sufficient to ensure long-term survival (NMFS, 1996). NMFS (1996) identifies that PFCs commonly include the following elements: water quality, habitat accessibility, the suitability of various habitat elements, channel condition and dynamics, and overall watershed conditions. The vast majority of PFCs are currently not properly functioning, with the remainder of the PFCs being at risk (Appendix E). The project would not degrade any of the PFCs and would maintain existing PFC conditions (Appendix E).

4 EFFECTS OF THE ACTION

Under the ESA, when a discretionary federal action may adversely affect listed species or critical habitat, federal agencies must analyze the direct and indirect effects of the action, as well as effects of future state or private actions reasonably certain to occur related to the action (50 CFR 402.02. 402.03, 402.14). Direct effects include the action's immediate effects on a species or habitat (50 CFR 402.02; USFWS and NMFS, 1998). Indirect effects are defined as those that are caused by the proposed action and occur later in time, but are reasonably certain to occur (40 CFR 1508.8; 50 CFR 402.02). These are discussed in the following sections.

4.1 Direct Effects

Activities necessary to construct the proposed action will result in direct effects to the action area that may affect listed species. Substantive in-water work (below OHWM) will occur in wetted portions of Lake Union. This will include the installation of a sediment curtain to contain suspended sediment, which will intentionally preclude fish access into the project area during a large portion of the construction period. The curtain will be monitored, and adjusted if necessary, during construction to ensure maximum effectiveness. Once the curtain is installed, in-water work activities will occur within Lake Union, at the project site. These activities have the potential to directly affect a small number of ESA-listed fish, which may be present within the project area during curtain installation. These effects include direct physical disturbance, noise, vibration, and habitat alteration. They include the installation of both temporary and permanent drilled shafts, the removal of creosote-treated and concrete piles, the removal of the existing bridge over Waterway 8, the application of sand prior to minimize the re-suspension of potentially contaminated sediments, and excavation of upland soils adjacent to Lake Union. Each potential type of direct effect from project activities is discussed in detail below.

4.1.1 Installation and Operation of Sediment Curtains

The installation of a primary sediment curtain around the entire in-water work area in Lake Union, and the installation of smaller secondary curtains around individual in-water work areas, may result in harm or mortality to fish, if present. This project element may affect fish in several ways:

- Some individual fish will become trapped within the isolated work area by installation of the sediment curtain(s).
- Fish in the isolated area may be exposed to higher levels of noise, vibration, turbidity, and re-suspended contaminants.
- Fish will be excluded from entering habitats within the isolated portion of Lake Union.

Fish removal from within the primary sediment curtain is not feasible due to water depths and numerous existing in-water piles and structures within the wetted portions of the project site under the existing bridge.

Therefore, there is a potential for harm because of work area isolation and entrainment. This is related to the level of use by bull trout and juvenile Chinook and steelhead within Lake Union, during curtain installation and throughout the duration of in-water work activities, as well as other environmental factors. Direct effects of the proposed action on listed fish species will be minimized by installing the primary sediment curtain prior to April 1 and within the approved in-water work window as specified in the HPA (yet to be issued for the proposed action), which typically corresponds to a timeframe when juveniles and adults are least likely to occur in the project area.

As discussed in Section 3.3, bull trout are not anticipated to be in the project Action Area during construction. The direct effects of sediment curtain installation in Lake Union is anticipated to have little to no effect on bull trout due to the rarity of adult of sub-adult bull trout within Lake Union, which indicates a discountable chance of entrapping an individual bull trout within the sediment curtain.

Small numbers of juvenile steelhead are anticipated to be present within the area to be isolated and may be harmed or injured by the construction activities that will occur within the sediment curtain (see below). The anticipated densities of juvenile Chinook and steelhead within the area to be isolated are expected to be small, based upon the timing of curtain installation and the poor quality habitat within the area to be isolated (including shallow nearshore habitats with overwater structure, armored shorelines, and no natural shoreline vegetation).

4.1.2 Direct Injury or Mortality from In-water Equipment

The project will involve the placement of twelve, seven-foot diameter drilled shafts as well as a number of smaller drilled shafts and piles for temporary construction trestle construction. During the installation process, the shafts will be lowered vertically onto the lake bed. This process could injure, kill, or entrain individual juvenile Chinook salmon or steelhead located within the primary turbidity curtain (there is a discountable chance of bull trout being present in the Action Area). However, the number of such fish affected would be extremely low, likely on the order of a few individuals.

4.1.3 Turbidity and Sedimentation

Construction activity related to construction of a new bridge and deconstruction of the existing bridge could potentially lead to the suspension or entrainment of sediment, some of it potentially contaminated, into the water column (impacts from potentially contaminated sediment are discussed below in Section 4.1.4. In-water construction activities that could result in short-term water quality degradation include the application of a sand barrier layer prior to drilled shaft installation, installation and removal of temporary piles, installation of permanent piles, and removal of existing piles. These activities may result in the re-suspension of existing sediments. Sedimentation is a concern since it can degrade spawning habitat, increase scour potential, degrade rearing habitat, and alter riparian vegetative structure. Sediment in streams can also alter the amount and diversity of aquatic invertebrates, a primary prey species for both juvenile salmonids and juvenile bull trout. Suspended sediment has been shown to change salmon behavior and can cause mortality if turbidity concentrations are high. The sub-lethal effects of turbidity generally include salmon avoidance and redistribution, reduced feeding and growth, respiratory impairment, reduced tolerance to disease and toxicants, and physiological stress.

Suspension of sediments in the water would be minimized through the use of drilled shafts to construct the bridge piers, where excavation of all sediment is completely contained within the shaft casing. Also, a sediment curtain would be used to isolate the general project area from Lake Union and smaller sediment curtains will be erected around individual work areas prior to pile installation or removal work. The suspension of some sediment into Lake Union is an unavoidable adverse impact of the project. The amount of sediments suspended in the water as a result of construction is likely to be small relative to the background levels, and will meet applicable Washington State Water Quality standards, although a portion of these sediments may be contaminated.

Small numbers of juvenile Chinook and steelhead are anticipated to be present within the primary sediment curtain during construction. It is anticipated that increased turbidity will temporarily affect water quality extending from the site of each lake bed disturbing activity to a maximum distance of up to 150 feet from the activity. However, due to the use of primary and secondary turbidity curtains, increased turbidity will likely be confined to a much smaller area. Furthermore, there is no suitable spawning habitat for Chinook salmon, steelhead, or bull trout in Lake Washington/Union/Ship canal for listed salmonids. The direct effects related to sedimentation and turbidity are considered insignificant due to the fact that they will be short-term and episodic and are and will not persist following construction.

4.1.4 Contaminated Sediments and Bridge Construction

In-water construction activities that could result in the short-term re-suspension of potentially contaminated sediments includes the installation of a sand barrier layer prior to in-water work activities, drilled shaft installation, installation and removal of temporary piles, installation of permanent piles, and removal of existing piles.

It is possible that the re-suspension of sediments could lead to chemical concentrations greater than the toxicity reference values for listed salmonid species and that both individual chemical concentrations and those for mixtures could contribute additional exposure to chemicals and potentially adversely affect these species.

Furthermore, the specific exposure conditions resulting from the methods employed in driving piles will reduce the level of adverse effects but not eliminate them. These include a very small specific exposure area around and drilled shaft or pile being installed or removed. The application sand layer should reduce resuspension of sediments, but its effect cannot be quantified without field monitoring and verification. Overall, individual salmon could be adversely affected by chemical desorption from sediments resuspended by vibratory pile driving in a very small section of the action area.

Spill control measures would be used to minimize the release of petroleum, paint, concrete, and other potentially toxic materials during the construction and demolition over and near the water. Removal of all of the existing wooden creosote-treated piles composing the pier protection system for the existing bridge will remove a source of contaminants from Lake Union and would therefore result in an improvement in the water quality of the lake.

4.1.5 In-water Noise and Vibration

In-water construction activities will occur, but are not expected to exceed ambient aquatic noise levels. No impact pile driving will occur during the project. The in-water construction element that would likely produce the highest in-water noise levels is vibratory pile installation and/or removal. However, vibratory installation of steel piles in a river in California resulted in sound pressure levels that were not measurable above the background noise created by the current (Reyff, 2006). Carlson (2001) studied acoustic date and salmonid response during construction of a new pier on the Oregon Coast, and found that the use of vibratory hammers for pile installation are not likely to have a significant impact on migrating salmon behavior, because infrasound produced by vibratory pile driving is short in duration and because the relatively short range of the component of the total sound field to which salmon show an avoidance response.

Other noise sources from the project would include that from standard construction equipment such as dump trucks, cranes, backhoes, graders, and pavers although these sources will not cause in-water noise of a level capable of affecting aquatic species.

4.2 Indirect Effects

Potential indirect effects from the project include changes to water quality and water quantity from stormwater runoff, degradation of shoreline habitat from project clearing and grading, long-term sedimentation from ground disturbance, overwater shading impacts from a slightly wider bridge footprint, and potential alterations to predation patterns resulting from changes in the area and number of in-water vertical structures.

4.2.1 Stormwater Runoff and Water Quality

The proposed action includes the removal of two existing structurally deficient bridges on Fairview Avenue North and replacement of the structures with a single new bridge. Although the configuration of travel lanes will not change, the bridge will be seven feet wider to accommodate a cycle track. As discussed in Section 1.2.3.4 of this document, stormwater from the existing bridges and approaches is not currently treated.

The primary constituents of concern in stormwater generated by roadways, with respect to salmonids, include dissolved copper and zinc. Research has shown that copper can adversely affect olfactory sensory responsiveness and behavioral changes including decreased predator avoidance at relatively low concentrations (2.0 micrograms per liter (μg/L) above background concentrations of 3.0 μg/L or less (Baldwin et al., 2003; Sandahl et al., 2007).

The proposed action will result in a 0.05 acre decrease in PGIS within the project area. The stormwater runoff discharges into Lake Union under both existing and proposed condition. The project will provide basic stormwater treatment for runoff from all new and existing PGIS in the project area, where no such treatment currently exists.

Post-project stormwater pollutant loads and concentrations for pollutants of concern (TSS, total copper, dissolved copper, total zinc, and dissolved zinc) were assessed using the HI-RUN model (WSDOT, 2012). The HI-RUN model uses Monte Carlo methods to create a probability distribution for stormwater concentrations based on observed water quality monitoring data. Within the model are a set of mean pollutant concentrations and the standard deviation around those means for pollutants of concern. The model's end-of-pipe loading subroutine was run using dissolved zinc as the parameter of interest to determine whether the proposed project will result in a significant increase in pollutant loading over baseline conditions. Dissolved zinc was chosen for this initial screening step because monitoring data compiled by WSDOT for this parameter have generally shown it to be a good indicator of stormwater treatment system performance (WSDOT, 2012).

Based on output of the HI-RUN model, the pollutant loading project is expected to remain essentially unchanged, with only a minimal chance of increasing. The post-project-wide P(exceed) value for end of pipe dissolved zinc in Lake Washington values for dissolved zinc loading in Lake Union was 0.31 (Appendix F). According to the HI-RUN Model User's Guide, P(exceed) values greater than 0.35 represent conditions under which runoff quality may be degraded (WSDOT, 2012), while P(exceed) values less than 0.35 represent conditions under which runoff quality is unlikely to be degraded.

The HI-RUN results indicate that the potential project-wide water quality impacts would likely be either positive or insignificant. The project-wide maximum, 75^{th} percentile, median, and 25^{th} percentile dissolved zinc loads would all decrease from existing conditions (Appendix F). Furthermore, dissolved zinc end of pipe concentrations would likely decrease under proposed conditions for all TDAs with P(exceed) values of 0.32 for TDA 1 and 0.31 for TDAs 2, 3, and 4.

Based on the results of the HI-RUN model, the potential for exposure of steelhead, Chinook salmon, and bull trout to dissolved zinc and copper concentrations above that of the biological threshold is extremely low. The conservative analysis approach of HI-RUN indicates that the occurrence of exposure of these species to harmful levels of stormwater constituents is discountable.

4.2.2 Effects on Water Quantity and Flow Regime

Lake Union classified as a Designated Receiving Waterbody according to Ecology and the City of Seattle; therefore, no flow control is required. At the project site, the lake levels are controlled and maintained at the Ballard Locks. For these reasons, no effects to flow regime will result from discharge of stormwater to the lake.

4.2.3 Clearing and Grading

Clearing of shoreline vegetation can result in an indirect effect to fish species as a result of decreased habitat suitability and riparian complexity. However, the vegetative community on the heavily developed project site is severely altered from pre-settlement conditions. Vegetation on the project site is limited to some herbaceous and shrub vegetation, with a few scattered trees. These vegetation elements were planted for landscaping value, as opposed to being naturally recruited, and the habitat value provided is limited to non-existent. Although some amount of existing shoreline vegetation may require clearing or removal for bridge construction, all trees removed would be replaced at a minimum 1:1 ratio. Furthermore, all temporarily cleared vegetation will be replanted with native species following construction.

Based on the poor existing fish habitat quality in the shoreline portions of the action area, any changes in habitat value to fish in these areas would be insignificant. Therefore, the long-term and indirect effects of tree and vegetation removal are anticipated to have an insignificant effect on steelhead within the Action Area and no effect on bull trout due to their lack of distribution into the Action Area.

4.2.4 Sedimentation

Indirect effects to Chinook, bull trout and steelhead habitat may occur from excessive sedimentation if the potential for sedimentation is not properly managed. Soils disturbed during construction could provide a chronic source of erosion and sedimentation if not properly stabilized following construction. The project area is heavily developed, with little exposed soil in current conditions. Furthermore, the HPA for the proposed action is anticipated to require that within seven days of project completion, all disturbed areas are protected from erosion using vegetation or other means and that all revegetation be completed within one year. These measures will reduce indirect effects from increased erosion and sedimentation to discountable levels for Chinook salmon and steelhead. Indirect effects related to sedimentation are not anticipated for bull trout due to the fact that their distribution into the Action Area is discountable.

4.2.5 Shading and Habitat Complexity

Studies suggest that the primary potential behavioral response of juvenile salmonids to in-water and over-water structures is the alteration of their migration rates and/or migration routes, particularly for Chinook salmon (Celedonia et al., 2008a, 2008b, 2009). The alteration of migratory behavior may (1) cause fish to occupy areas or migrate through areas that are more or less productive than the habitats they would otherwise occupy, (2) require different levels of energy expenditure, and (3) subject the fish to more or less viable survival conditions such as changes in predation potential and/or water quality.

Salmonid responses to changes in over-water shading and in-water structural complexity are discussed collectively because there appears to be a synergistic effect of the two habitat alterations in combination. The data suggest that migration behavior could be affected by two primary mechanisms related to changed habitat conditions: alteration or disruption of physical structures (structural complexity) within the water column and increased or altered shading patterns of new over-water structures.

Overall, any effects on associated predator-prey distributions due to changes in habitat complexity are expected to apply primarily to juvenile salmon outmigration. Any such effects will likely be much reduced for older age classes and larger fish (residual Chinook salmon and steelhead), which do not generally exhibit a shoreline affinity during outmigration as do smaller migrants such as 0-age Chinook salmon. The fewer and more-widely-spaced in-water columns of the proposed permanent bridge structures are expected to reduce the habitat complexity in the immediate area of the bridge (Table 4-1). This alteration is expected to diminish the quality of smallmouth habitat and reduce both predator and prey habitat provided by the permanent bridge structures. Furthermore, previous studies indicate that the juvenile salmonids do not generally utilize shoreline habitat where overwater structures are present (see Section 2). Also, although habitat complexity will be affected during bridge construction due to the presence of temporary work trestle piles, fish will be excluded from this area by a sediment curtain. Therefore, no effects from these structures on ESA-listed fish species would occur.

Table 4-1. Changes to In-water Habitat Complexity Under Existing Permanent Bridge Sub-structure

Bridge Structure	Number of In-water Piers/Piles	Number of Creosote-Treated Piles	Approximate Total Area of In-water Piers (Square Feet)
Existing West Bridge	162	162	286
Existing East Bridge	58	0	102
Total Existing	*220*	*162*	*388*
Proposed New Bridge	12	0	629
Walkway Supports	15	0	21
Total New	*27*	*0*	*650*
Change from Existing to New	**-193**	**-162**	**262**

Factors that influence the extent of in-water shade include the width of the new bridge decks, the over-water height of the new bridge decks, light diffraction around the structure, light refraction in water, and the spatial alignment of the structures in relation to the path of the sun. Findings from Southard et al. (2006) suggest that the contrast of the light to dark boundary may be the primary factor in affecting juvenile salmonid movement into shaded areas while Simenstad et al. (1999) have indicated that the progression of changes that a fish eye must undergo to adapt to changing light conditions is correlated to light intensity. The indirect effects of changes in in-water shading on fish behavior and migration could include altered distribution and density of aquatic macrophytes, which in turn may affect migration behaviors.

However, significant effects on the migration of juvenile Chinook salmon and steelhead are not expected to result from this project for several reasons; 1) the amount of additional shading from the new bridge is relatively small, 2) the bridge is immediately adjacent to the shoreline of Lake Union and is therefore not located on a primary salmonid outmigration route, and 3) habitat conditions under the existing bridge are poor and studies have indicated that Chinook do not generally utilize shoreline overwater habitats of Lake Union.

The amount of existing overwater structure from the existing bridge structures is 23,200 square feet. The new bridge will provide 26,800 square feet of permanent overwater shading, an increase of 3,600 square foot (approximately 15 percent of existing overwater area). However, the new bridge will be crowned in the center to allow stormwater runoff, thus allowing a similar amount of light penetration under the bridge. In addition, the light/dark boundary will be relocated approximately 10 feet waterward (west) of the existing shade line.

The project site is on the southeast shoreline of Lake Union. Although juvenile Chinook salmon and steelhead may be present in the Action Area, outmigrating salmon generally avoid overwater structures and shallow water habitat in Lake Union (see Section 3.2 for Lake Union habitat usage discussion). Furthermore, the project area is not within the core of the primary migration route of juvenile salmonids, which includes the Montlake Cut and the Fremont Cut.

Lastly, habitat conditions under the bridge are poor, with concrete waste and riprap making up the majority of the substrate, several hundred vertical piles, no native aquatic macrophytic vegetation, and likely degraded water quality from untreated stormwater input and the presence creosote-treated piles. These degraded habitat conditions do not provide the functions to support rearing or migrating Chinook salmon or steelhead. Although post-project conditions will be improved from this baseline, with fewer piles, better quality substrate, and improved water quality, the conditions to adequately support migrating or rearing salmonids will not be present.

Given the understanding of how overwater and in-water structures may affect fish behavior, for the reasons above it is likely that any residual effects on ESA-listed salmonids during long-term operation of the proposed replacement bridge would be insignificant. Although temporary shading will be present during bridge construction due to the presence of temporary work trestles, fish will be excluded from this area by a sediment curtain. Therefore, no effects from these structures on ESA-listed fish species would occur.

4.2.6 Land Use Changes Related to Transportation Projects

The proposed action includes the widening of an existing roadway and installation of sidewalks to improve both pedestrian and traffic safety along the road corridor. No additional lanes or facilities are being added. Following completion of the project, the roadway will maintain the current level of service. Therefore, the proposed action is not anticipated to contribute to land use change within the project Action Area and indirect effects to listed species associated with that land use change are not anticipated.

4.3 Effects from Interrelated and Interdependent Actions

Interrelated activities are actions that are part of a larger action and that depend upon that action for their justification (50 CFR 402.02). Interdependent activities have no independent utility apart from the proposed action (50 CFR 402.02). Interrelated and interdependent activities that could result in direct or indirect effects are those that would not occur "but for" the proposed action. No interrelated or interdependent effects on ESA-listed species are expected from the proposed project, because the project is not linked, directly or indirectly, to any other projects in the area.

4.4 Cumulative Effects

Cumulative effects are those effects of future state or private activities, not involving federal funding or approvals, that are reasonably certain to occur within the action area of the federal action subject to consultation (50 CFR § 402.02). No significant non-federal actions within the project's action area that could contribute to cumulative effects are known to be planned or are reasonably certain to occur.

4.5 Critical Habitat

4.5.1 Puget Sound Chinook Critical Habitat

The Action Area includes designated critical habitat for Puget Sound Chinook salmon. The applicable PCEs present in the Action Area for Chinook salmon are listed below, followed by a discussion of potential effects to each PCE.

- *PCE #2: Freshwater rearing sites with: (i) Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; (ii) Water quality and forage supporting juvenile development; and (iii) 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.*

  The Action Area contains designated Chinook critical habitat, and low numbers of rearing Chinook salmon could be present within the Action Area during the spring-early summer following the winter spawning season. The project will employ a containment curtain system to both contain turbidity in Lake Union and to exclude migrating and rearing fish from under the bridge site during in-water construction. This will result the temporary loss of use by rearing Chinook salmon. However, the quality of the rearing habitat in Lake Union under the bridge is poor, with numerous vertical pile structures, poor sediment and water quality, a large amount of concrete debris and rubble, and essentially no plant community along the shoreline.

  Therefore, the effects of excluding Chinook salmon from this area would be insignificant. Furthermore, the long-term quality and quantity of rearing habitat in this reach will be maintained or improved, due to the removal of numerous vertical in-water structures, better water quality resulting from treatment of stormwater, and removal of creosote treated piles.

- *PCE #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.*

  The Action Area contains designated Chinook critical habitat, and low numbers of rearing Chinook salmon could be present within the Action Area during the spring-early summer outmigration following the winter spawning season. The project site is not on the direct migration corridor, and studies have shown that shoreline use of Lake Union by Chinook juveniles is minimal, particularly in those areas with overwater structures, such as the Fairview Avenue North Bridge. The project will employ a containment curtain system to both contain turbidity in Lake Union and to exclude migrating and rearing fish from under the bridge site during in-water construction. This will result the temporary loss of use by rearing Chinook salmon. However, the quality of the rearing habitat in Lake Union under the bridge is poor, with numerous vertical pile structures, poor sediment and water quality, a large amount of concrete debris and rubble, and essentially no plant community along the shoreline.

  Therefore, the effects of temporarily excluding Chinook salmon from this area would be insignificant. The project will not hinder the upstream and downstream movement of juvenile and adult Chinook salmon and no permanent or long-term degradation of freshwater migration corridors will occur. Furthermore, the long-term accessibility of the site will be improved, due to the removal of numerous vertical in-water structures, and replacement with many fewer (but larger) structures.

4.5.2 Bull Trout Critical Habitat

The Action Area includes designated critical habitat for the Coastal-Puget Sound DPS bull trout. The applicable PCEs present in the Action Area for bull trout are listed below, followed by a discussion of potential effects to each PCE.

- *PCE 2: Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.*

  The project will employ a containment curtain system to both contain turbidity in Lake Union and to exclude migrating and rearing fish from under the bridge site during in-water construction. This will result the temporary loss of use by rearing or migrating bull trout. However, the quality of the rearing and migration habitat in Lake Union under the bridge is poor, with numerous vertical pile structures, poor sediment and water quality, a large amount of concrete debris and rubble, and essentially no plant community along the shoreline.

  Therefore, the effects of temporarily excluding bull trout from this area would be minimal. The project will not hinder the upstream and downstream movement of sub-adult and adult bull trout and no permanent or long-term degradation of freshwater migration corridors will occur. Furthermore, the long-term accessibility of the site will be improved, due to the removal of numerous vertical in-water structures, and replacement with many fewer (but larger) structures. Although the project will place fill material in Lake Union (in the form of sand application and minor increase), only an extremely minor reduction (approximately 262 square feet) of open water lake area will result. Any effects on bull trout migration are expected to be insignificant.

- *PCE 3: An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.*

  The habitat quality in Lake Union under the bridge is poor, with numerous vertical pile structures, poor sediment and water quality, a large amount of concrete debris and rubble, and essentially no plant community along the shoreline. No communities of aquatic macrophytes are located under the bridge and the existing bridge structure results in shading under the bridge, likely limiting growth of both macroinvertebrates and plant species.

  No changes in shoreline or aquatic plan communities will result from the project, however the project will improve water quality in Lake Union, in the under the bridge through stormwater improvements and removal of creosote treated piles. In addition, project area substrate will be improved with the removal of concrete debris and rubble. These improvements should maintain or slightly improve the limited food base of bull trout within the action area, including other salmonids.

- *PCE 4: Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks and unembedded substrates, to provide a variety of depths, gradients, velocities, and structure.*

  The shoreline of Lake Union within the Action Area does not contain complex aquatic environments, and the processes that establish and maintain such environments are impaired. Human development along the lake shoreline has resulted in simplified habitat conditions, with armored and bulk-headed shorelines and a predominance of overwater structure. The project will not reduce the existing low-diversity environment, as no habitat features will be lost due to the project. The project would not affect the habitat complexity PCE.

- *PCE 5: Water temperatures ranging from 2°C to 15°C (36°F to 59°F), with adequate thermal refugia available for temperatures that exceed the upper end of this range. Specific temperatures within this range will depend on bull trout life-history stage and form; geography; elevation; diurnal and seasonal variation; shading, such as that provided by riparian habitat; streamflow; and local groundwater influence.*

  Summer temperatures in Lake Union and the Ship Canal frequently exceed those adequate to support bull trout. The proposed project will not result in decreased shading or loss of mature riparian vegetation within the action area and will therefore have no effect on the temperature PCE.

- *PCE 8: Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.*

  Short-term water quality will be periodically affected by construction activities in the action area, although long-term reductions in the rate of pollutant loading from stormwater will result due to the implementation of stormwater quality treatment, where none currently exists. All process water (from dewatering and other related activities) will be fully treated before re-entry to Lake Union, so no effects on this PCE are expected to occur from this activity. Water quantity in Lake Union (lake elevation) is controlled by the Locks and therefore does not have the potential to be affected by project activities.

- *PCE 9: Sufficiently low levels of nonnative predatory species (e.g., lake trout, walleye, northern pike, smallmouth bass); interbreeding species (e.g., brook trout [Salvelinus fontinalis]); or competing (e.g., brown trout [Salmo trutta]) species that, if present, are adequately temporally and spatially isolated from bull trout.*

  The presence of bull trout predators near the Lake Union shoreline, including smallmouth bass, is related to the presence and extent of overwater structures, shoreline condition, and habitat complexity. In the short-term, the project will essentially maintain habitat complexity (vertical structure) during construction, with piles for the temporary work trestles replacing piles removed from the existing bridges. In the long-term, habitat complexity supporting predatory species will decrease, which will likely result in a slight decrease in preferential predator habitat quality. Therefore, the project is not expected to have an effect on this PCE.

5 CONCLUSIONS

Provided that the construction techniques and conservation measures summarized herein and discussed in detail in the construction drawings prepared for the project are properly implemented, this project is anticipated to have the following effects on ESA regulated species:

5.1 Threatened Species

5.1.1 Puget Sound ESU Chinook Salmon

The proposed project **may affect, likely to adversely affect** Puget Sound ESU Chinook salmon.

Considering the information referenced above, the project information provided in the construction plans, and based upon the minimization measures provided, a **may affect** determination for Puget Sound ESU Chinook salmon is warranted based on the following rationale:

- Multiple sources document juvenile Chinook salmon usage of Lake Union, including within the Action Area.
- The proposed action will include substantial in-water work, including installation of drilled shafts and piles and removal of both existing and temporarily installed piles.
- Some of the lakebed sediments within the project area (particularly the top 10 feet of sediment) have been shown to be contaminated with a variety of hazardous materials, and other areas are likely contaminated. Construction activities will result in disturbances of these sediments, including potential sediment re-suspension.
- Because some in-water work activities within the isolation curtain will be required to occur throughout the period outside of the general in-water work window (October 1 to April 14), there is the potential for outmigrating juvenile Chinook salmon to be present within the Action Area.
- The project will result in an increase of over-water structure as compared to the existing structure.
- The project will result in changes in impervious surface area within the project boundaries.
- The project will require excavation within and adjacent to Lake Union.

A **likely to adversely affect** determination for Puget Sound ESU Chinook salmon is warranted because:

- In order to minimize the direct effects from suspended sediment material to Chinook during construction, the general in-water construction area along the shoreline will be isolated from the rest of Lake Union for the duration of in-water work activities (approximately 24 months). Although the isolation curtain will be placed between October 1 and April 15, the project would still likely trap some individual juvenile Chinook salmon within the work area, and fish removal within this area is not feasible.

Therefore, a limited number of individual Chinook salmon may be injured or killed from direct physical contact with construction equipment, entrainment within a drilled shaft casing, or sedimentation from construction activities including sand layer installation.

The determination that the project will not appreciably reduce the survival and recovery of Puget Sound ESU Chinook salmon is based on the following rationale:

- The project will meet all local, state, and federal water quality regulations.
- In order to minimize the exposure of juvenile Chinook salmon to turbidity and potential toxicants present in suspended sediment, the entire project area will be screened off by a floating sediment curtain prior to the juvenile outmigration period (April 15), to both: 1) contain sediment and turbidity within a confined area of Lake Union; and 2) preclude juvenile outmigrants from entering the project area during in-water work activities. The primary sediment curtain will remain in place for the duration of in-water work activities.
- When feasible, smaller secondary turbidity curtains will be temporarily installed around specific project elements (e.g., drilled shaft bents) to further contain turbidity.
- Prior to drilled shaft installation, pile installation, and pile removal, an application of one to two feet of sand will be applied over the work area to minimize re-suspension of contaminated or potentially contaminated sediment.
- The project will result in a decrease in the amount of PGIS within the Action Area and all PGIS within the project area will undergo treatment, where none currently exists. The HI-RUN dilution modeling subroutine indicates that concentrations of dissolved copper and zinc would likely decrease, and would have a discountable possibility of exceeding biological thresholds for these contaminants at the point of interest or where stormwater generated from the site may enter Lake Union.
- The project will not include impact pile driving, blasting, or other construction activity that would cause levels in-water noise levels high enough to harm or kill fish.
- Habitat conditions under the bridge will generally improve post-project, also likely reducing potential predation of Chinook salmon. The number of in-water vertical structures will be reduced by 193, including 162 creosote treated piles. A substantial amount of in-water concrete rubble and garbage will also be removed.
- The project proponent will employ a Temporary Erosion and Sediment Control (TESC) plan during construction that will include BMPs such as silt fencing, straw bales, straw wattles, and check dams to minimize the potential for increased turbidity and sedimentation within Lake Union.
- The project proponent will adhere to a Spill Prevention Control and Countermeasure (SPCC) plan developed specifically for this project.
- The project will be restricted to meet NPDES requirements for water quality throughout the duration of the project. After construction, the permanent stormwater treatment facilities shall be completely operational before removing temporary BMPs used during construction.

5.1.2 Puget Sound DPS Steelhead

The proposed project **may affect, likely to adversely affect** Puget Sound DPS steelhead.

Considering the information referenced above, the project information provided in the construction plans, and based upon the minimization measures provided, a **may affect** determination for Puget Sound DPS steelhead is warranted based on the following rationale:

- Multiple sources document juvenile steelhead usage of Lake Union, including within the Action Area.
- The proposed action will include substantial in-water work, including installation of drilled shafts and piles and removal of both existing and temporarily installed piles.
- Some of the lakebed sediments within the project area (particularly the top 10 feet of sediment) have been shown to be contaminated with a variety of hazardous materials, and other areas are likely contaminated. Construction activities will result in disturbances of these sediments, including potential sediment re-suspension.
- Because some in-water work activities within the isolation curtain will be required to occur throughout the period outside the general in-water work window (October 1 to April 14), there is the potential for outmigrating juvenile steelhead to be present within the Action Area.
- The project will result in an increase of over-water structure as compared to the existing structure.
- The project will result in changes in impervious surface area within the project boundaries.
- The project will require excavation within and adjacent to Lake Union.

A **likely to adversely affect** determination for Puget Sound ESU steelhead is warranted because:

- In order to minimize the direct effects from suspended sediment material to steelhead during construction, the general in-water construction area along the shoreline will be isolated from the rest of Lake Union for the duration of in-water work activities (approximately 24 months). Although the isolation curtain will be placed between October 1 and April 15, the project would still likely trap some individual juvenile steelhead within the work area, and fish removal within this area is not feasible. Therefore, a limited number of individual steelhead may be injured or killed from direct physical contact with construction equipment, entrainment within a drilled shaft casing, or sedimentation from construction activities including sand layer installation.

The determination that the project will not appreciably reduce the survival and recovery of Puget Sound ESU steelhead is based on the following rationale:

- Studies have indicated that juvenile salmonids shown very limited use of the Lake Union shorelines that have overwater structures.
- The project will meet all local, state, and federal water quality regulations.

- In order to minimize the exposure of juvenile steelhead to turbidity and potential toxicants present in suspended sediment, the entire project area will be screened off by a floating sediment curtain prior to the juvenile outmigration period (April 15), to both: 1) contain sediment and turbidity within a confined area of Lake Union; and 2) preclude juvenile outmigrants from entering the project area during in-water work activities. The primary sediment curtain will remain in place for the duration of in-water work activities.
- When feasible, smaller secondary turbidity curtains will be temporarily installed around specific project elements (e.g., drilled shaft bents) to further contain turbidity.
- Prior to drilled shaft installation, pile installation, and pile removal, an application of one to two feet of sand will be applied over the work area to minimize re-suspension of contaminated or potentially contaminated sediment.
- All PGIS within the project area will undergo treatment, where none currently exists. The HI-RUN dilution modeling subroutine indicates that concentrations of dissolved copper and zinc would likely decrease, and would have a discountable possibility of exceeding biological thresholds for these contaminants at the point of interest or where stormwater generated from the site may enter Lake Union.
- The project will not include impact pile driving, blasting, or other construction activity that would cause levels in-water noise levels high enough to harm or kill fish.
- Habitat conditions under the bridge will generally improve post-project, also likely reducing potential predation of steelhead. The number of in-water vertical structures will be reduced by 193, including 162 creosote treated piles. A substantial amount of in-water concrete rubble and garbage will also be removed.
- The project proponent will employ a Temporary Erosion and Sediment Control (TESC) plan during construction that will include BMPs such as silt fencing, straw bales, straw wattles, and check dams to minimize the potential for increased turbidity and sedimentation within Lake Union.
- The project proponent will adhere to a Spill Prevention Control and Countermeasure (SPCC) plan developed specifically for this project.

5.1.3 Coastal-Puget Sound DPS Bull Trout

The proposed project **may affect, but is not likely to adversely affect** Coastal-Puget Sound DPS bull trout.

A **may affect** determination for Coastal-Puget Sound DPS bull trout is warranted based on the following rationale:

- Individual bull trout have been historically observed within the Lake Washington/Ship Canal, and no physical barriers exist downstream to preclude bull trout presence in the Action Area.
- The proposed action will include substantial in-water work, including installation of drilled shafts and piles and removal of both existing and temporarily installed piles.

- Some of the lakebed sediments within the project area (particularly the top 10 feet of sediment) have been shown to be contaminated with a variety of hazardous materials, and other areas are likely contaminated. Construction activities will result in disturbances of these sediments, including potential sediment re-suspension.
- The project will result in an increase of over-water structure as compared to the existing structure.
- The project will result in changes in impervious surface area within the project boundaries.
- The project will require excavation within and adjacent to Lake Union.

A **not likely to adversely affect** determination for Coastal-Puget Sound DPS bull trout is warranted based on the following rationale:

- Bull trout are generally not known to occur within Lake Union in the project vicinity (documented presence is extremely rare). Observations are likely anadromous foraging fish, originating from other basins and no spawning occurs within Lake Union, Lake Washington, or tributary streams. The potential for bull trout to be within the action area is discountable.
- The project will meet all local, state, and federal water quality regulations.
- In order to minimize the exposure of bull trout to turbidity and potential toxicants present in suspended sediment, the entire project area will be screened off by a floating sediment curtain prior to the juvenile outmigration period (April 15), to both: 1) contain sediment and turbidity within a confined area of Lake Union; and 2) preclude adult or sub-adult bull trout from entering the project area during in-water work activities. The primary sediment curtain will remain in place for the duration of in-water work activities.
- When feasible, smaller secondary turbidity curtains will be temporarily installed around specific project elements (e.g., drilled shaft bents) to further contain turbidity.
- Prior to drilled shaft installation, pile installation, and pile removal, an application of one to two feet of sand will be applied over the work area to minimize re-suspension of contaminated or potentially contaminated sediment.
- The project will result in a decrease in the amount of PGIS within the Action Area and all PGIS within the project area will undergo treatment, where none currently exists. The HI-RUN dilution modeling subroutine indicates that concentrations of dissolved copper and zinc would likely decrease, and would have a discountable possibility of exceeding biological thresholds for these contaminants at the point of interest or where stormwater generated from the site may enter Lake Union.
- The project will not include impact pile driving, blasting, or other construction activity that would cause levels in-water noise levels high enough to harm or kill fish.
- The project proponent will employ a Temporary Erosion and Sediment Control (TESC) plan during construction that will include BMPs such as silt fencing, straw bales, straw wattles, and check dams to minimize the potential for increased turbidity and sedimentation within Lake Union.

- The project proponent will adhere to a Spill Prevention Control and Countermeasure (SPCC) plan developed specifically for this project.

5.2 Critical Habitat

5.2.1 Puget Sound ESU Chinook Salmon Critical Habitat

Considering the information reference above, the project information provided in the construction plans, and based upon the minimization measures provided, a **may affect** determination for designated critical habitat for Puget Sound ESU Chinook salmon is warranted because:

- The Action Area, within Lake Union, contains designated critical habitat for Puget Sound ESU Chinook salmon.
- The project Action Area contains freshwater rearing and migration PCEs essential to the conservation of the species.
- The proposed action will include substantial in-water work, including installation of drilled shafts and piles and removal of both existing and temporarily installed piles. Resulting in a minor net reduction in critical habitat area (260 square feet)
- Some of the lakebed sediments within the project area (particularly the top ten feet of sediment) have been shown to be contaminated with a variety of hazardous materials, and other areas are likely contaminated. Construction activities will result in disturbances of these sediments, including potential sediment re-suspension.
- The project will result in an increase of over-water structure as compared to the existing structure.
- The project will result in changes in impervious surface area within the project boundaries.
- The project will require excavation within and adjacent to Lake Union.

A **not likely to adversely affect** determination for designated critical habitat for Puget Sound ESU Chinook salmon is warranted because:

- The proposed action will include the implementation of a TESC plan and erosion and sediment control BMPs to minimize the potential for increased turbidity and sedimentation of downstream areas.
- The project will meet all local, state, and federal water quality regulations.
- In order to minimize the exposure of juvenile Chinook salmon to turbidity and potential toxicants present in suspended sediment, the entire project area will be screened off by a floating sediment curtain prior to the juvenile outmigration period (April 15), to both: 1) contain sediment and turbidity within a confined area of Lake Union; and 2) preclude juvenile outmigrants from entering the project area during in-water work activities. The primary sediment curtain will remain in place for the duration of in-water work activities.

- When feasible, smaller secondary turbidity curtains will be temporarily installed around specific project elements (e.g., drilled shaft bents) to further contain turbidity.
- Prior to drilled shaft installation, pile installation, and pile removal, an application of one to two feet of sand will be applied over the work area to minimize re-suspension of contaminated or potentially contaminated sediment.
- The project will result in a decrease in the amount of PGIS within the Action Area and all PGIS within the project area will undergo treatment, where none currently exists. The HI-RUN dilution modeling subroutine indicates that concentrations of dissolved copper and zinc would likely decrease, and would have a discountable possibility of exceeding biological thresholds for these contaminants at the point of interest or where stormwater generated from the site may enter Lake Union.
- Habitat conditions under the bridge will generally improve post-project, also likely reducing potential predation of Chinook salmon. The number of in-water vertical structures will be reduced by 193, including 162 creosote treated piles. A substantial amount of in-water concrete rubble and garbage will also be removed.
- The project proponent will employ a Temporary Erosion and Sediment Control (TESC) plan during construction that will include BMPs such as silt fencing, straw bales, straw wattles, and check dams to minimize the potential for increased turbidity and sedimentation within Lake Union.
- The project proponent will adhere to a Spill Prevention Control and Countermeasure (SPCC) plan developed specifically for this project.

5.2.2 Coastal-Puget Sound DPS Bull Trout Critical Habitat

Considering the information reference above, the project information provided in the construction plans, and based upon the minimization measures provided, a **may affect** determination for designated critical habitat for Coastal-Puget Sound DPS bull trout is warranted because:

- The Action Area, within Lake Union, contains designated critical habitat for Coastal-Puget Sound DPS bull trout.
- The project Action Area contains freshwater rearing and migration PCEs essential to the conservation of the species.
- The proposed action will include substantial in-water work, including installation of drilled shafts and piles and removal of both existing and temporarily installed piles.
- Some of the lakebed sediments within the project area (particularly the top 10 feet of sediment) have been shown to be contaminated with a variety of hazardous materials, and other areas are likely contaminated. Construction activities will result in disturbances of these sediments, including potential sediment re-suspension.
- The project will result in an increase of over-water structure as compared to the existing structure.

- The project will result in changes in impervious surface area within the project boundaries.
- The project will require excavation within and adjacent to Lake Union.

A **not likely to adversely affect** determination for designated critical habitat for Coastal-Puget Sound DPS bull trout is warranted because:

- The proposed action will include the implementation of a TESC plan and erosion and sediment control BMPs to minimize the potential for increased turbidity and sedimentation of downstream areas.
- The project will meet all local, state, and federal water quality regulations.
- In order to minimize the exposure of adult and sub-adult bull trout to turbidity and potential toxicants present in suspended sediment, the entire project area will be screened off by a floating sediment curtain prior to the juvenile outmigration period (April 15), to both: 1) contain sediment and turbidity within a confined area of Lake Union; and 2) preclude bull trout from entering the project area during in-water work activities. The primary sediment curtain will remain in place for the duration of in-water work activities.
- When feasible, smaller secondary turbidity curtains will be temporarily installed around specific project elements (e.g., drilled shaft bents) to further contain turbidity.
- Prior to drilled shaft installation, pile installation, and pile removal, an application of one to two feet of sand will be applied over the work area to minimize re-suspension of contaminated or potentially contaminated sediment.
- The project will result in a decrease in the amount of PGIS within the Action Area and all PGIS within the project area will undergo treatment, where none currently exists. The HI-RUN dilution modeling subroutine indicates that concentrations of dissolved copper and zinc would likely decrease, and would have a discountable possibility of exceeding biological thresholds for these contaminants at the point of interest or where stormwater generated from the site may enter Lake Union.
- Habitat conditions under the bridge will generally improve post-project. The number of in-water vertical structures will be reduced by 193, including 162 creosote treated piles. A substantial amount of in-water concrete rubble and garbage will also be removed.
- The project proponent will employ a Temporary Erosion and Sediment Control (TESC) plan during construction that will include BMPs such as silt fencing, straw bales, straw wattles, and check dams to minimize the potential for increased turbidity and sedimentation within Lake Union.
- The project proponent will adhere to a Spill Prevention Control and Countermeasure (SPCC) plan developed specifically for this project.

6 MAGNUSON STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

Action Agency: Federal Highways Administration (FHWA)

Project Name: Fairview Avenue North Bridge Replacement

6.1 Essential Fish Habitat Background

The Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267), requires federal agencies to consult with NOAA Fisheries on activities that may adversely affect essential fish habitat (EFH).

The objective of this EFH assessment is to determine whether or not the proposed action(s) "may adversely affect" designated EFH for relevant commercially, federally-managed fisheries species within the proposed Action Area. It also describes conservation measures proposed to avoid, minimize, or otherwise offset potential adverse effects to designated EFH resulting from the proposed action.

The EFH designation for the Pacific salmon fishery includes all those streams, lakes, ponds, wetlands, and other water bodies, currently or historically accessible to salmon in Washington, Oregon, Idaho, and California, except above the impassable barriers identified by PFMC (1999). In estuarine and marine environments, proposed designated EFH extends from near-shore and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone offshore of Washington, Oregon, and California north of Point Conception (PFMC. 1999).

The Pacific salmon management unit includes Chinook, coho, and pink salmon. Two of the three species, Chinook and coho salmon, use the Lake Washington basin for spawning, rearing, and migration, although the Action Area includes only rearing and migration habitat. Pink salmon are not distributed within either the Action Area or the Lake Washington basin.

The objective of this EFH assessment is to determine whether or not the proposed action "may adversely affect" designated EFH for relevant commercially, federally-managed fisheries species within the proposed Action Area. It also describes conservation measures proposed to avoid, minimize, or otherwise offset potential adverse effects to designated EFH resulting from the proposed action.

6.2 Description of the Proposed Action

For the purpose of this assessment, the proposed action for the EFH assessment and BA incorporate the same project elements. The project proponent proposes replacing two existing bridges (East and West Bridge) on Fairview Avenue North, with a single new bridge spanning a portion of the southeast shoreline of Lake Union, in Seattle Washington.

A detailed description of the proposed action is included in Section 2.0 of the BA. Table 6-1 below indicates the federally managed Pacific salmon and life history forms that are potentially present within the project Action Area.

Table 6-1. Fish Species and Life-Stages with Essential Fish Habitat in the Action Area

Salmon Species	Eggs	Larvae	Young Juvenile	Juvenile	Adult	Spawning
Chinook salmon			X	X	X	
Coho salmon			X	X	X	
Pink salmon						

6.3 Potential Adverse Effects of Proposed Project

Potential impacts of the proposed action to ESA listed fish species and habitats are discussed in Section 4.0 and 5.0 of this BA and are expected to be similar for all federally managed Pacific salmon that occur within the Action Area.

6.3.1 Adverse Effects on Essential Fish Habitat for Salmonids

The proposed action will include in-water work within Lake Union, including drilled shaft installation, pile installation/removal, and changes in impervious surface areas that drain to Lake Union. Although Chinook and coho salmon may be present in the Action Area during construction, these fish will be excluded from the work area through deployment of a primary sediment curtain that will both preclude entry of migrating or foraging coho and Chinook into the in-water construction area. In addition, habitat conditions under the bridge will generally improve post-project, also likely reducing potential predation of steelhead. The number of in-water vertical structures will be reduced by 193, including 162 creosote treated piles. A substantial amount of in-water concrete rubble and garbage will also be removed, and the project will treat 100 percent of PGIS, where no such treatment currently exists. These project elements will minimize or eliminate the possibility of adverse effects on EFH resulting from these activities (see Section 1 for details).

6.3.2 Adverse Effects on Essential Fish Habitat for Ground Fishes

No areas of EFH for ground fish species occur within the Action Area.

6.3.3 Adverse Effects on Essential Fish Habitat for Coastal Pelagic Species

No areas of EFH for coastal pelagic species occur within the Action Area.

6.4 Essential Fish Habitat Conservation Measures

The following measures will be implemented to minimize the potential adverse effects on designated EFH described above:

- The project will meet all local, state, and federal water quality regulations.
- In order to minimize the exposure of juvenile salmonids to turbidity and potential toxicants present in suspended sediment, the entire project area will be screened off by a floating sediment curtain prior to the juvenile outmigration period (April 15), to both: 1) contain sediment and turbidity within a confined area of Lake Union; and 2) preclude juvenile outmigrants from entering the project area during in-water work activities. The primary sediment curtain will remain in place for the duration of in-water work activities.
- When feasible, smaller secondary turbidity curtains will be temporarily installed around specific project elements (e.g., drilled shaft bents) to further contain turbidity.
- Prior to drilled shaft installation, pile installation, and pile removal, an application of one to two feet of sand will be applied over the work area to minimize re-suspension of contaminated or potentially contaminated sediment.
- The project will result in a decrease in the amount of PGIS within the Action Area and all PGIS within the project area will undergo treatment, where none currently exists. The HI-RUN dilution modeling subroutine indicates that concentrations of dissolved copper and zinc would likely decrease, and would have a discountable possibility of exceeding biological thresholds for these contaminants at the point of interest or where stormwater generated from the site may enter Lake Union.
- The project proponent will employ a Temporary Erosion and Sediment Control (TESC) plan during construction that will include BMPs such as silt fencing, straw bales, straw wattles, and check dams to minimize the potential for increased turbidity and sedimentation within Lake Union
- The project proponent will adhere to a Spill Prevention Control and Countermeasure (SPCC) plan developed specifically for this project.
- All vegetated areas that undergo clearing will be re-vegetated following construction.

6.5 Conclusions

EFH for Pacific salmon is present in the project Action Area. The proposed action will require work within Lake Union, directly within EFH for federally managed Pacific salmon, including Chinook and coho salmon. The primary concern is with sediment, water quality, and the re-suspension of potential contaminants within the sediment, and the potential effects to EFH of these factors. Minimization measures, including isolation of the work area(s) through the use of containment curtains, the application of a layer of sand prior to sediment disturbance, and appropriate treatment and disposal of contaminated water, sediment, and other structures (e.g., creosote treated piles), will minimize or eliminate potential effects on Pacific salmon EFH in the project area. Stormwater discharge water quality, resulting from the proposed stormwater treatment facilities installed as part of the project is not expected to degrade baseline conditions. Long-term habitat conditions under the new bridge structure would likely be improved due to a reduction in vertical structures and removal of rubble and waste. All other potential effects of the action upon EFH, including very minor vegetation removal and soil disturbing activities, are expected to be short-term effects and will be further minimized by the conservation measures listed above. Therefore, the proposed action *will not adversely affect* EFH for Pacific salmon.

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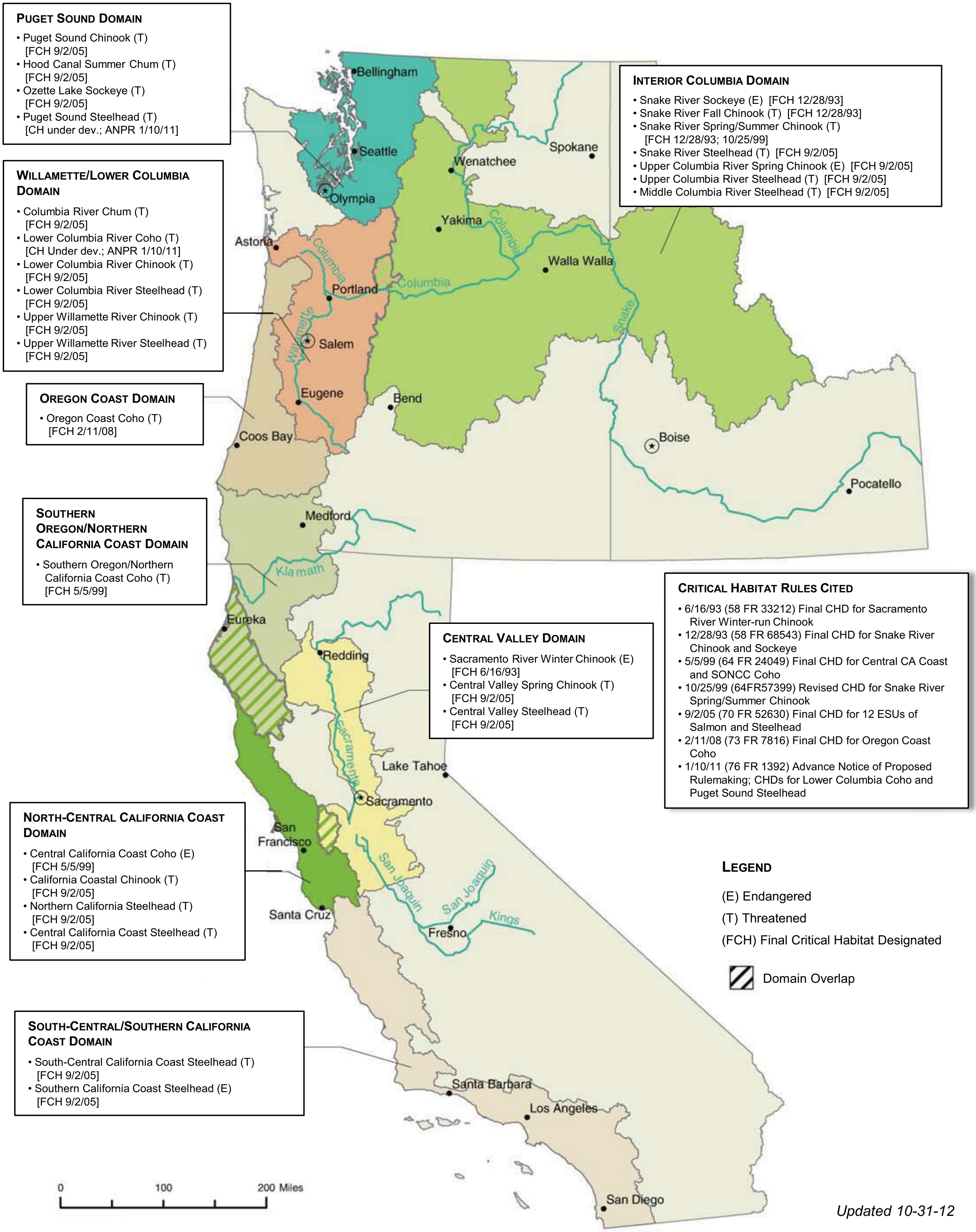
APPENDICES

APPENDIX A: NMFS AND USFWS SPECIES LISTS

Status of ESA Listings & Critical Habitat Designations for West Coast Salmon & Steelhead



Updated 10-31-12

LISTED AND PROPOSED ENDANGERED AND THREATENED SPECIES AND CRITICAL HABITAT; CANDIDATE SPECIES; AND SPECIES OF CONCERN IN KING COUNTY AS PREPARED BY THE U.S. FISH AND WILDLIFE SERVICE WASHINGTON FISH AND WILDLIFE OFFICE

(Revised September 3, 2013)

LISTED

Bull trout *(Salvelinus confluentus)*
Canada lynx *(Lynx canadensis)*
Gray wolf *(Canis lupus)*
Grizzly bear *(Ursus arctos = U. a. horribilis)*
Marbled murrelet *(Brachyramphus marmoratus)*
Northern spotted owl *(Strix occidentalis caurina)*

Major concerns that should be addressed in your Biological Assessment of project impacts to listed animal species include:

1. Level of use of the project area by listed species.

2. Effect of the project on listed species' primary food stocks, prey species, and foraging areas in all areas influenced by the project.

3. Impacts from project activities and implementation (e.g., increased noise levels, increased human activity and/or access, loss or degradation of habitat) that may result in disturbance to listed species and/or their avoidance of the project area.

Castilleja levisecta (golden paintbrush) [historic]

Major concerns that should be addressed in your Biological Assessment of project impacts to listed plant species include:

1. Distribution of taxon in project vicinity.

2. Disturbance (trampling, uprooting, collecting, etc.) of individual plants and loss of habitat.

1. Changes in hydrology where taxon is found.

DESIGNATED

Critical habitat for bull trout
Critical habitat for the marbled murrelet
Critical habitat for the northern spotted owl

PROPOSED

North American wolverine *(Gulo gulo luteus)* – contiguous U.S. DPS
Oregon spotted frog *(Rana pretiosa)* [historical]

CANDIDATE

Fisher *(Martes pennanti)* – West Coast DPS
Yellow-billed cuckoo *(Coccyzus americanus)*
Pinus albicaulis (whitebark pine)

SPECIES OF CONCERN

Bald eagle *(Haliaeetus leucocephalus)*
Beller's ground beetle *(Agonum belleri)*
Cascades frog *(Rana cascadae)*
Hatch's click beetle *(Eanus hatchi)*
Larch Mountain salamander *(Plethodon larselli)*
Long-eared myotis *(Myotis evotis)*
Long-legged myotis *(Myotis volans)*
Northern goshawk *(Accipiter gentilis)*
Northern sea otter *(Enhydra lutris kenyoni)*
Northwestern pond turtle *(Emys (= Clemmys) marmorata marmorata)*
Olive-sided flycatcher *(Contopus cooperi)*
Pacific lamprey *(Lampetra tridentata)*
Pacific Townsend's big-eared bat *(Corynorhinus townsendii townsendii)*
Peregrine falcon *(Falco peregrinus)*
River lamprey *(Lampetra ayresi)*
Tailed frog *(Ascaphus truei)*
Valley silverspot *(Speyeria zerene bremeri)*
Western toad *(Bufo boreas)*
Aster curtus (white-top aster)
Botrychium pedunculosum (stalked moonwort)
Cimicifuga elata (tall bugbane)

APPENDIX B: PROJECT PHOTOS

Photo 1. Aerial view of existing West and East Fairview Avenue North Bridges, looking south. Note bridge proximity to ZymoGenetics building and relic dock adjacent to bridge in Waterway 8.

Photo 2. View of existing bridge decks, looking northeast, from south end of existing bridge. Note bridge proximity to ZymoGenetics building on right side of photo.

Photo 3. View of existing bridge, looking southwest, fromnorth end of existing bridge. Note floating walkway along right side of bridge.

Photo 4. View under existing West Bridge, looking southerly. Note creosote treated piles and wooden bracing. Attachment system for floating walkway is shown on the right side of photo.

Photo 5. View under existing East Bridge, looking northerly. Note concrete piles and large amount of concrete rubble, wood waste, and garbage currently under bridge. This material would be removed as part of the project.

Photo 6. View looking northeast along at north shoreline, just west of floating walkay ramp. Note rip-rapped shoreline and non-native shrubs along shoreline (blackberry), typical of project area.

APPENDIX C: SPECIES LIFE HISTORY INFORMATION

Chinook Salmon Life History

NMFS completed an ESA status review of Chinook salmon populations from Washington, Oregon, Idaho, and California and defined 15 evolutionarily significant units (ESUs) within the region. Naturally spawned spring, summer/fall, and fall Chinook salmon runs from the Puget Sound ESU were considered likely to become endangered in the foreseeable future (Myers et al., 1998). NMFS issued a ruling in May 1999 listing the Puget Sound ESU as threatened (NMFS, 1999).

Chinook salmon in Hood Canal are included in the Puget Sound Chinook ESU, a population currently listed as threatened under the ESA in Washington State. The life history and habitat requirements of Puget Sound Chinook salmon are described by Myers et al. (1998) and are briefly summarized herein. Chinook salmon have a historic range from the Ventura River in California to Point Hope, Alaska in North America; and from Hokkaido, Japan to Anadyr River in Russia. Chinook require varied habitats during different phases of their life. Peak spawning occurs within the streams between mid-October and mid-November (Haring, 2000). Spawning habitat typically consists of lower mainstem areas with large quantities of gravel and greater flows (Haring, 2000). Upstream migration of adult fall Chinook salmon in south Puget Sound's lowland streams typically extends from mid-September to mid-November. After spending 3 to 4 months rearing in the lowland streams, fry enter the estuaries around May or early June, depending on the spring flows (Haring, 2000). Chinook generally migrate to salt water in the spring and summer. Most Chinook spend from two to four years feeding in the North Pacific before returning to spawn. Chinook salmon die after spawning.

The abundance of Chinook salmon in the Puget Sound ESU has declined substantially from historic levels, and there is concern over the effects of hatchery supplementation on genetic fitness of stocks, as well as severely degraded spawning and rearing habitats throughout the area (Myers et al., 1998). In addition, harvest exploitation rates in excess of 90 percent were estimated to occur on some Puget Sound Chinook salmon stocks. Subsequent to this status review, primary factors contributing to declines in Chinook salmon in the Puget Sound ESU were identified as habitat blockages, hatchery introgression, urbanization, logging, hydropower development, harvests, and flood control (NMFS, 1998).

Steelhead Life History

On May 7, 2007, NMFS announced the listing of the Puget Sound distinct population segment (DPS) of steelhead as a threatened species under the Endangered Species Act.

The DPS distribution extends from the United States/Canada border and includes all naturally spawned anadromous winter-run and summer-run populations in streams and river basins of the Strait of Juan de Fuca (east of and including the Elwha River), Puget Sound (north to include the Nooksack River), and Hood Canal. Possible factors influencing the depletion of Puget Sound steelhead populations include habitat destruction and fragmentation, inadequate regulatory mechanisms of hatchery practices and land use activities, and potential genetic introgression between hatchery - and natural-origin steelhead.

Steelhead exhibit one of the most complex suite of life history traits of any salmonid species. Steelhead may be anadromous or freshwater residents (which are usually referred to as rainbow or redband trout). Biologically, steelhead can be divided into two reproductive ecotypes: "stream maturing" and "ocean maturing." Stream maturing, or summer run steelhead enter fresh water in a sexually immature condition and require several months to mature and spawn. Ocean maturing, or winter run steelhead enter fresh water with well-developed gonads and spawn shortly after river entry. Steelhead adults typically spawn between December and June. Depending on water temperature, steelhead eggs may incubate in redds for 1.5 to 4 months before hatching. Puget Sound DPS steelhead typically smolt after 2 years, though they may spend 1 to 4 years in fresh water. They then reside in marine waters for typically 2 or 3 years prior to returning to their natal stream to spawn. Steelhead are iteroparous, but rarely spawn more than twice before dying; most that do so are females (64 CFR 222).

Bull Trout Life History

In 1998, USFWS completed a status review of bull trout, identifying five distinct population segments (DPSs) in the continental U.S. (USFWS, 1998a). The Coastal-Puget Sound bull trout DPS is composed of 34 subpopulations (USFWS, 1998b; USFWS, 1999). USFWS listed bull trout in the Coastal-Puget Sound DPS as threatened under the ESA on November 1, 1999 (USFWS, 1999).

Bull trout have a complex life history that includes a resident form and a migratory form. The individuals of the migratory form may be stream dwelling (fluvial), lake dwelling (adfluvial), or ocean/estuarine dwelling (anadromous) (USFWS, 1998). Resident bull trout spend their entire life cycle within their natal or nearby streams. Fluvial populations spawn in tributary streams where the young rear from two to three years before migrating to a river where they grow to maturity (Knowles and Gumtow, 1999). Adfluvial forms spawn and rear in headwater streams like fluvial fish, but migrate to lakes and reservoirs to mature (KCDNR, 2000). Anadromous bull trout spawn in tributary streams, with major growth and maturation occurring in the marine or estuarine environment (Sims, 2000). Individuals of each form may be represented in a single population; however, migratory populations may dominate where migration corridors and subadult rearing habitats are in good condition (USFWS, 1998).

Like many other salmonids, bull trout migrate to fresh water streams to spawn. Spawning begins in late August, peaking in September and October, and ending in November (WDFW, 2000). Bull trout spawn in streams with clean gravel substrates and cold water temperatures (less than 9ºC/48ºF) (USFWS, 1998). Redds are dug by females in water 8 to 24 inches deep, in substrate gravels 0.2 to 2 inches in diameter (Wydoski and Whitney, 1979). Fecundity for bull trout can reach up to 5,000 eggs. Emergence from the streambed typically occurs in late winter and early spring (KCDNR, 2000). Among migratory forms (fluvial, adfluvial, and anadromous), outmigration to larger rivers, lakes and the ocean most commonly occurs at age two, but has been observed for ages of one to three years (FERC, 1999).

Bull trout are opportunistic feeders, consuming fish in the water column and insects on the bottom (WDW, 1991). Low stream temperatures and clean substrates are key features of bull trout habitat. This species is most commonly associated with pristine or only slightly disturbed basins (USFWS, 1998).

The Coastal-Puget Sound DPS of bull trout is unique because it is thought to contain the only anadromous forms of bull trout within the continental U.S. (USFWS, 1998a). The status of the migratory (fluvial, adfluvial, and anadromous) forms is of greatest concern throughout most of their range. The majority of the remaining populations in some areas may be largely composed of resident bull trout (Leary et al., 1991; Williams and Mullan, 1992).

APPENDIX D: PROJECT AREA SEDIMENT DATA

Table 1
Parametrix, 1989 and HWA, 2013 Soil Analytical Results
(all results in milligrams per kilogram (mg/kg))

Sample ID	Parametrix, 1989				HWA, 2013			Soil Cleanup Levels		DMMP[3] Guidelines			
	SP-4-50	SP-5-50	SP-5-200	SP-6-50	BH-3 S-4 7.5'	BH-4 S-1 0.0'	BH-5 S-3 5-6'						
Sample Date	5/24/1989	5/24/1989	5/24/1989	5/24/1989	12/13/2011	12/20/2011	12/21/2011	MTCA A[1]	MTCA B[2]	Freshwater Standards			
Sample Depth (ft bgs)	0.8	0.5	0.9	0.5	7.5 to 8.5	0.0-1.0	5 to 6			SL1	SL2	BT	ML
Petroleum Hydrocarbons (by Method NWTPH)													
NWTPH-HCID Gasoline	NA	NA	NA	NA	<25	<58	>110	NE	NE	--	--	--	--
NWTPH-HCID Diesel	NA	NA	NA	NA	<62	>140	>260	NE	NE	--	--	--	--
NWTPH-HCID Lube Oil	NA	NA	NA	NA	<120	>290	>530	NE	NE	--	--	--	--
NWTPH-Gx Gasoline	NA	NA	NA	NA			**1100**	100/30[4]	NE[5]	--	--	--	--
NWTPH-Dx Diesel	NA	NA	NA	NA	<31	**2900**	**1100**	2000	NE[5]	--	--	--	--
NWTPH-Dx Lube Oil	NA	NA	NA	NA	<62	**5600**	**5200**	2000	NE[5]	--	--	--	--
Volatile Organic Compounds (VOCs by EPA Methods 5035A and 8260B)													
2-Butanone	<.076	NA	NA	NA	**0.006**	**0.15**	<0.42	NE	NE	--	--	--	--
Acetone	**0.044**	NA	NA	NA	**0.027**	**0.68**	<0.42	NE	72,000	--	--	--	--
Benzene	NA	NA	NA	NA	<0.0012	<0.0042	<0.84	0.03	18	--	--	--	--
Carbon disulfide	NA	NA	NA	NA	<0.0012	<0.0042	<0.084	NE	8,000	--	--	--	--
Ethylbenzene	NA	NA	NA	NA	<0.0012	<0.0042	<0.84	6	800	--	--	--	--
p-Isopropyltoluene	NA	NA	NA	NA	<0.0012	**0.0044**	<0.084	NE	NE	--	--	--	--
sec-Butylbenzene	NA	NA	NA	NA	<0.0012	**0.0045**	**0.36**	NE	NE	--	--	--	--
tert-Butylbenzene	NA	NA	NA	NA	<0.0012	<0.0042	<0.084	NE	NE	--	--	--	--
Toluene	<0.001	NA	NA	NA	<0.0059	<0.021	<0.42	7	6,400	--	--	--	--
Xylenes	**0.042**	NA	NA	NA	<0.0024	<0.0084	<0.17	9	160,000	--	--	--	--
Polycyclic Aromatic Hydrocarbons (PAHs by EPA Method 8270D/SIM)													
Naphthalene	<0.14	<0.06	<0.11	<0.038	**0.012**	**4.3**	**0.83**	5	1,600	0.5	1.3	--	2.4
1-Methylnaphthalene					<0.083	**0.38**	<0.088	NE	NA				
2-Methylnaphthalene	**4.3**	<0.06	<0.11	<0.038	**0.0086**	**1**	**0.23**	NE	NE	0.47	0.56	--	1.9
Total Naphthalenes[6]	**4.3**	<0.06	<0.11	<0.038	**0.02**	**5.68**	**1.06**	5	NE	--	--	--	--
Acenaphthene	**6.2**	**1**	<0.14	<0.038	**0.019**	**1.8**	**0.69**	NE	4,800	1.1	1.3	--	2
Acenaphthylene	<0.14	<0.06	<0.11	<0.038	<0.083	**0.36**	**0.093**	NE	NE	0.47	0.64	--	1.3
Anthracene	**0.6**	**0.11**	**0.19**	<0.038	<0.083	**1.1**	**0.36**	NE	24,000	1.2	1.2	--	13
Benzo[g,h,i]perylene	**1**	<0.06	**0.32M**	<0.038	<0.083	**0.31**	**0.65**	NE	NE	4	5.2	--	3.2
Fluoranthene	**4.8**	**0.51**	**1.2**	**0.11**	**0.022**	**3.6**	**2**	NE	3,200	11	15	4.6	30
Fluorene	**3**	**0.24**	**0.16**	<0.038	**0.018**	**1.6**	**0.58**	NE	3,200	1	3	--	3.6
Phenanthrene	**6.6**	**0.63**	**1**	**0.076**	**0.046**	**5**	**2**	NE	NA	6.1	7.6	--	21
Pyrene	**3.4**	**0.67**	**1.7**	**0.15**	**0.015**	**2.7**	**1.8**	NE	2,400	8.8	16	11.98	16

Sample ID	Parametrix, 1989				HWA, 2013			Soil Cleanup Levels		DMMP[3] Guidelines			
	SP-4-50	SP-5-50	SP-5-200	SP-6-50	BH-3 S-4 7.5'	BH-4 S-1 0.0'	BH-5 S-3 5-6'						
Sample Date	5/24/1989	5/24/1989	5/24/1989	5/24/1989	12/13/2011	12/20/2011	12/21/2011	MTCA A[1]	MTCA B[2]	Freshwater Standards			
Sample Depth (ft bgs)	0.8	0.5	0.9	0.5	7.5 to 8.5	0.0-1.0	5 to 6			SL1	SL2	BT	ML
Carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs by EPA Method 8270D/SIM)													
Benzo(j,k)fluoranthene	**2.7[7]**	**0.46[7]**	**0.92[7]**	**0.14[7]**	<0.083	**0.19**	**0.3**	NE	14	0.6	4	--	9.9
Benzo[a]anthracene	**1.7**	**0.2**	**0.41**	**0.43M**	<0.083	**0.78**	**1.1**	NE	1.4	4.3	5.8	--	5.1
Benzo[a]pyrene	**1.3**	**0.17**	**0.26**	**0.78M**	<0.083	**0.46**	**0.82**	NE	0.14	3.3	4.8	--	3.6
Benzo[b]fluoranthene	*[7]	*[7]	*[7]	*[7]	<0.083	**0.69**	**0.89**	NE	1.4	*	*	*	*
Chrysene	**2.2**	**0.37**	**0.71**	**0.086**	<0.083	**0.79**	**0.96**	NE	140	5.9	6.4	--	21
Dibenz[a,h]anthracene	**0.53**	<0.06	<0.11	<0.038	<0.083	**0.064**	**0.15**	NE	0.14	0.8	0.84	--	1.9
Indeno(1,2,3-c,d)pyrene	**0.92**	<0.06	<0.11	<0.038	<0.083	**0.3**	**0.5**	NE	1.4	4.1	5.3	--	4.4
cPAHs TEC[6]	**1.907**	**0.24**	**0.4**	**0.838**	<0.083	**0.67**	**1.12**	0.1	NE				
PCBs (by EPA Method 8082)													
Aroclor 1254	**0.56**	**0.1**	**0.76**	<0.05	<0.062	**0.31**	<0.066						
Aroclor 1260	**0.34**	<0.05	<0.2	<0.05	<0.062	<0.14	<0.066						
Total PCBs	**0.9**	**0.1**	**0.76**	<0.05	<0.062	**0.31**	<0.066	1	0.5	0.06	0.12	0.38	3.1
Metals (by EPA Methods 6010 and 7471A)													
Antimony	**6**	NA	NA	NA	NA	NA	NA		32	--	--	--	200
Arsenic	**29**	NA	NA	NA	<12	**28**	<13	20	24	20	51	507.1	700
Cadmium	**2**	NA	NA	NA	<0.62	**2.6**	**0.69**	2	NA	1.1	1.5	11.3	14
Chromium (total)	**78**	NA	NA	NA	**16**	**67**	**54**	2000/19[8]	240	95	100	260	--
Copper	**288**	**107**	**707**	**39**	NA	NA	NA		3200	80	830	1027	1300
Lead	**572**	**75**	**720**	**136**	<6.2	**540**	**190**	250	NE	340	430	975	1200
Mercury	**1.75**	**0.44**	**1**	**0.07**	<0.31	**1.9**	**0.7**	2	NE	0.28	0.75	1.5	2.3
Nickel	**117**	NA	NA	NA	NA	NA	NA	NE	NE	60	70	--	--
Silver	**4**	NA	NA	NA	NA	NA	NA	NE	400	2	2.5	6.1	8.4
Zinc	**481**	**157**	**298**	**79**	NA	NA	NA	NE	24000	130	400	2783	3800

Notes:

Bold - Analyte Detected

Bold/Yellow Highlighted – Analyte exceeds MTCA soil cleanup level

Bold/Blue Highlighted – Analyte exceeds DMMP screening level

Bold/Red Highlighted – Analyte exceeds both MTCA and DMMP levels

< - Analyte not detected at analytical method reporting limit

Blank – Not Analyzed

Listed cleanup levels may not apply at this site, and are provided as a screening level indication of the environmental quality of the site only.

M – Estimated concentration due to low sepectral match parameters

1 - Washington Model Toxics Control Act Method A (WAC 173-340 Table 740-1) soil cleanup levels for unrestricted land use

2 - MTCA Method B cleanup levels are from Ecology's CLARC (Cleanup Level & Risk Calculations) database

3- Dredged Material Management Program (DMMP) screening level (USACE, 2013)

SL1 –Screening Level 1 – suitable for open-water disposal

SL2 - Screening Level 2 - higher (less protective) sediment screening level value suitable for open-water disposal

BT – Bioaccumulation trigger - concentration requires further bioaccumulation testing to establish suitability for open-water disposal

ML – Maximum Level - unsuitable for open-water disposal

4 - The MTCA Method A soil cleanup level is 100 mg/kg for gasoline mixtures without benzene and if the total of ethylbenzene, toluene, plus xylenes is less than 1% of the gasoline mixture. The soil cleanup level for all other gasoline mixtures is 30 mg/kg"

5 - Sum of Naphthalene + 1-Methylnaphthalene + 2-Methylnaphthalene

6 - Toxic Equivalent Concentration of carcinogenic polynuclear aromatic hydrocarbons (cPAHs) per WAC 173-340-708(e)

7 – 1989 data reports total Benzo fluoranthenes

8 - The MTCA Method A soil cleanup level for trivalent chromium is 2,000 mg/kg. Geochemical conditions on site would not cause oxidation to hexavalent chromium having a cleanup level of 19 mg/kg

Table 2
Aspect, 2009 and HWA, 2013 Soil Analytical Results
(all results in milligrams per kilogram (mg/kg))

	Aspect, 2009		HWA, 2013		
Sample ID	**0810145-B1A**	**0810145-B2**	**BH-6 S-2 5.0'**	**MTCA Soil Cleanup Levels**	
Sample Date	**12/5/2008**	**12/4/2008**	**12/15/2011**		
Sample Depth (ft bgs)	**Composite**	**Composite**	**5 to 6**	**MTCA A[1]**	**MTCA B[2]**
Petroleum Hydrocarbons					
NWTPH-HCID Gasoline			>26	NA	NA
NWTPH-HCID Diesel			<2100	NA	NA
NWTPH-HCID Lube Oil			>130	NA	NA
NWTPH-Gx Gasoline			**540**	100/30[3]	NA
NWTPH-Dx Diesel	**18**	**150**	<410	2000	NA
NWTPH-Dx Lube Oil	**99**	**1300**	**1200**	2000	NA
Volatile Organic Compounds					
2-Butanone			**0.011**	NA	NA
Acetone			**0.061**	NA	72,000
Benzene			<0.0011	0.03	18
Carbon disulfide			**0.0048**	NA	8,000
Ethylbenzene			<0.0011	6	800
p-Isopropyltoluene			<0.0011	NA	NA
sec-Butylbenzene			**0.0042**	NA	NA
tert-Butylbenzene			**0.0044**	NA	NA
Toluene			<0.0057	7	6,400
Xylenes			<0.0023	9	160,000
Polynuclear Aromatic Hydrocarbons					
Naphthalene	<0.066	<0.066	**0.024**	5	1,600
1-Methylnaphthalene	<0.066	<0.066	<0.0085	NA	NA
2-Methylnaphthalene	<0.066	<0.066	<0.0085	NA	NA
Total Naphthalenes[4]	<0.066	<0.066	**0.02**	5	NA
Acenaphthene	<0.066	<0.066	**0.012**	NA	4,800
Acenaphthylene	<0.066	<0.066	**0.013**	NA	NA
Anthracene	<0.066	<0.066	**0.018**	NA	24,000
Benzo[g,h,i]perylene	<0.066	<0.066	**0.097**	NA	NA
Fluoranthene	<0.066	**0.078**	**0.092**	NA	3,200
Fluorene	<0.066	<0.066	**0.011**	NA	3,200
Phenanthrene	<0.066	<0.066	**0.035**	NA	NA
Pyrene	<0.066	**0.088**	**0.16**	NA	2,400

	Aspect, 2009		HWA, 2013		
Sample ID	0810145-B1A	0810145-B2	BH-6 S-2 5.0'	MTCA Soil Cleanup Levels	
Sample Date	12/5/2008	12/4/2008	12/15/2011		
Sample Depth (ft bgs)	Composite	Composite	5 to 6	MTCA A[1]	MTCA B[2]
Carcinogenic Polynuclear Aromatic Hydrocarbons					
Benzo(j,k)fluoranthene	<0.066	<0.066	**0.028**	NA	14
Benzo[a]anthracene	<0.066	<0.066	**0.083**	NA	1.4
Benzo[a]pyrene	<0.066	<0.066	**0.11**	NA	0.14
Benzo[b]fluoranthene	<0.066	<0.066	**0.11**	NA	1.4
Chrysene	<0.066	<0.066	**0.11**	NA	140
Dibenz[a,h]anthracene	<0.066	<0.066	**0.022**	NA	0.14
Indeno(1,2,3-c,d)pyrene	<0.066	<0.066	**0.072**	NA	1.4
cPAHs TEC[5]	<0.066	<0.066	**0.14**	0.1	NA
Polychlorinated Biphenyls					
Aroclor 1254	<0.033	<0.033	<0.064	1	0.5
Total Metals					
Barium	**80.5**	**53.9**			
Arsenic	<10	<10	<13	20	24
Cadmium	<0.5	<0.5	**1.1**	2	NA
Chromium (total)	**33**	**42**	**21**	2000/19[6]	240
Lead	**11**	**15**	**1200**	250	NA
Mercury	<0.1	<0.1	<0.32	2	NA

Notes:

Bold - Analyte Detected

Bold/Highlighted – Analyte exceeds MTCA cleanup level

< - Analyte not detected at analytical method reporting limit

Blank – Not Analyzed

Listed cleanup levels may not apply at this site, and are provided as a screening level indication of the environmental quality of the site only.

1 - Washington Model Toxics Control Act Method A (WAC 173-340 Table 740-1) soil cleanup levels for unrestricted land use

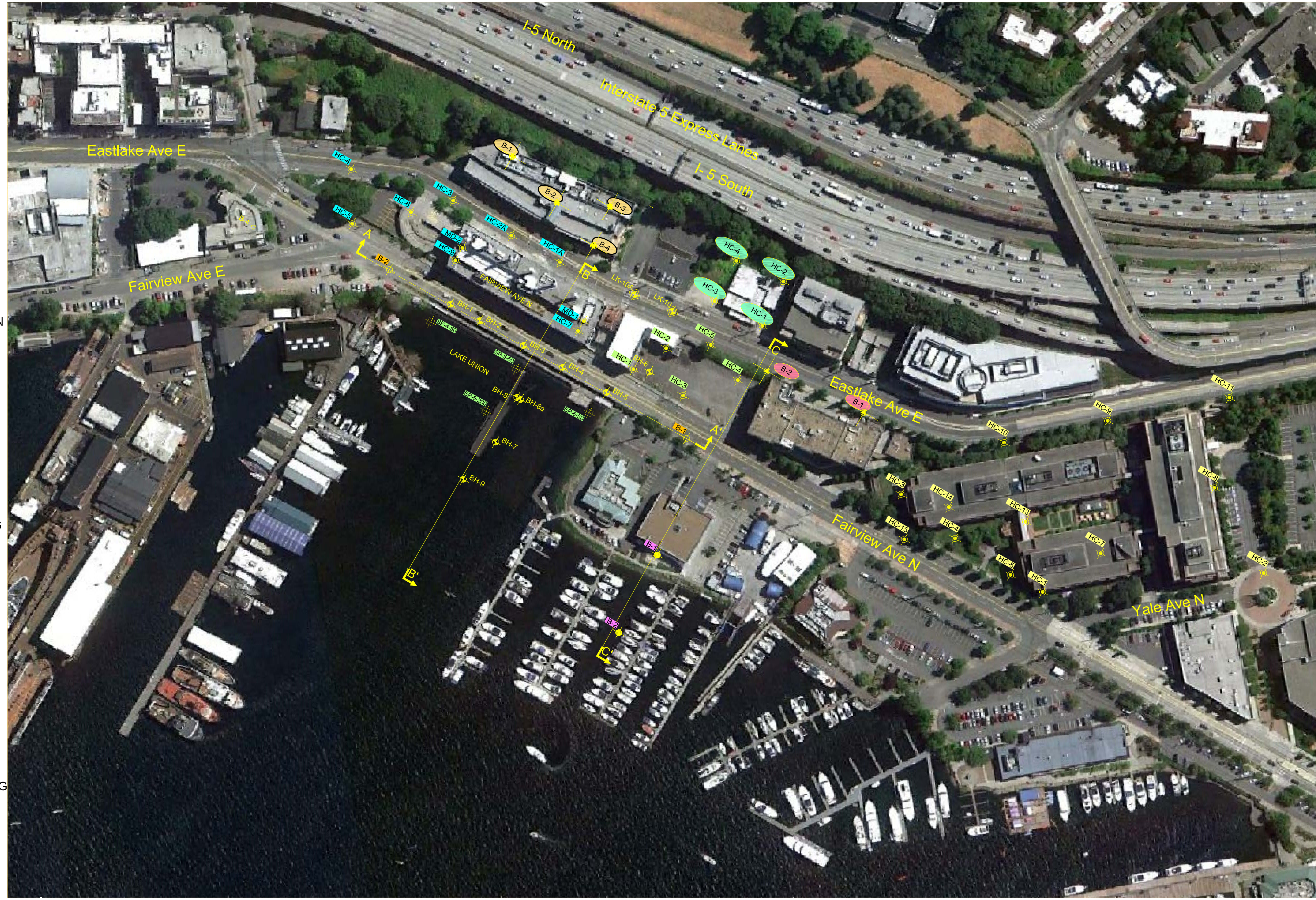
2 - MTCA Method B cleanup levels are from Ecology's CLARC (Cleanup Level & Risk Calculations) database

3 - The MTCA Method A soil cleanup level is 100 mg/kg for gasoline mixtures without benzene and if the total of ethylbenzene, toluene, plus xylenes is less than 1% of the gasoline mixture. The soil cleanup level for all other gasoline mixtures is 30 mg/kg"

4 - Sum of naphthalene + 1-Methylnaphthalene + 2-Methylnaphthalene

5 - Toxic Equivalent Concentration of carcinogenic polynuclear aromatic hydrocarbons (cPAHs) per WAC 173-340-708(e)

6 - The MTCA Method A soil cleanup level for trivalent chromium is 2,000 mg/kg. Geochemical conditions on site would not cause oxidation to hexavalent chromium having a cleanup level of 19 mg/kg



LEGEND

BH-9 — *HWA* (Lake Union, 2012) BORING DESIGNATION AND APPROXIMATE LOCATION

BH-5 — *HWA* (Fairview, 2011) BORING DESIGNATION AND APPROXIMATE LOCATION

B-2 — *Aspect* (Fairview, 2009) BORING DESIGNATION AND APPROXIMATE LOCATION

HC-5 — *Hart Crowser* (1165 Eastlake, 2007) BORING DESIGNATION AND APPROXIMATE LOCATION

HC-4 — *Hart Crowser* (ZynoGenetics, pilot building, 2002) BORING DESIGNATION AND APPROXIMATE LOCATION

B-4 — *Earth Consultants* (ZymoGenetics, 1996) BORING DESIGNATION AND APPROXIMATE LOCATION

B-2 — *AGRA* (Silver Cloud, 1995) BORING DESIGNATION AND APPROXIMATE LOCATION

LK-2 — *City of Seattle* (Lake Union CSO, 1994) BORING DESIGNATION AND APPROXIMATE LOCATION

HC-9 — *Hart Crowser* (Steam Plant, 1992) BORING DESIGNATION AND APPROXIMATE LOCATION

HC-15 — *Hart Crowser* (Fred Hutchinson, 1989) BORING DESIGNATION AND APPROXIMATE LOCATION

SP-6 — *Parametrix* (Seattle City Light, 1989) BORING DESIGNATION AND APPROXIMATE LOCATION

B-2 — *Shannon and Wilson* (Gunn-Wright, 1966) BORING DESIGNATION AND APPROXIMATE LOCATION

A A'

0 100' 200' 300' 600'

SCALE: 1"=200'

BASE MAP PROVIDED BY: PERTEET ENGINEERING

HWA GEOSCIENCES INC.

FAIRVIEW AVENUE BRIDGE REPLACEMENT
SEATTLE, WASHINGTON

SITE AND EXPLORATION PLAN

DRAWN BY EFK	FIGURE # 2
CHECK BY DC/DH	PROJECT #
DATE: 01.21.13	2011-118-21

S:\2011 PROJECTS\2011-118-21 FAIRVIEW AVENUE EAST BRIDGE\CAD 2011-118\HWA 2011-118 FAEB2.DWG <FIG 2 S&E Geotech Alt Report> Plotted: 12/27/2013 11:10 AM

APPENDIX E: PFC ASSESSMENT FOR AQUATIC HABITATS

The *Checklist for Documenting Environmental Baseline and Effects of Proposed Actions(s) on Relevant Indicators* (NMFS, 1996) was used to assess current baseline parameters, and guide the determination of effect for the proposed action on Chinook salmon, steelhead, and bull trout. While a number of the indicators are not applicable to the lentic environment in the Action Area, most of those that are applicable (Table E-1) are at risk or not properly functioning. However, in all cases the effects of the proposed project will maintain existing environmental baseline conditions.

TABLE E-1. CHECKLIST FOR DOCUMENTING ENVIRONMENTAL BASELINE AND EFFECTS OF PROPOSED ACTION(S) ON RELEVANT INDICATORS

	ENVIRONMENTAL BASELINE			EFFECTS OF THE ACTION(S)		
PATHWAYS **Indicators**	**Properly Functioning [1]**	**At Risk [1]**	**Not Properly Functioning [1]**	**Restore [2]**	**Maintain [3]**	**Degrade [4]**
WATER QUALITY						
Temperature		X			X	
Sediment			X		X	
Chemical Contamination/Nutrients			X		X	
HABITAT ACCESS						
Physical Barriers			X		X	
HABITAT ELEMENTS						
Substrate			X		X	
Refugia		X			X	
Floodplain Connectivity			X		X	
WATERSHED CONDITIONS						
Road Density/Location			X		X	
Disturbance History			X		X	
Riparian Reserves			X		X	

Watershed Name: Lake Washington Basin **Location: Section 19 Township 25N, Range 04E**

1 These three categories of function (*properly functioning*, at risk, and *not properly functioning*) are defined for each indicator in the "Matrix of Pathways and Indicators."

2 For the purposes of this checklist, *restore* means to change the function of an *at risk* indicator to *properly functioning* (it does not apply to "*properly functioning*" indicators).

3 For the purposes of this checklist, *maintain* means that the function of an indicator does not change (i.e., it applies to all indicators regardless of functional level).

4 For the purposes of this checklist, *degrade* means to change the function of an indicator for the worse (i.e., it applies to all indicators regardless of functional level). In some cases, a "not properly functioning" indicator may be further worsened, and this should be noted.

APPENDIX F: HI-RUN MODELING RESULTS

Highway Runoff Dilution and Loading model (HI-RUN) Version 2.0

End of Pipe Loading Subroutine Report

This model is for stormwater analysis associated with biological assessments, and is not a design tool.

Input Summary

Run Date/Time: 2/18/14 11:32
Outfall ID: Fairview Bridge 2-18-13
Rain Gauge: Puget West 36
Description: Fairview HI_RUN Results 2-18-2014

Discharge Areas

Subbasin 1 - Baseline Conditions - 0.75 acres
no treatment - 0% infiltration - 0.75 acres

Subbasin 1 - Proposed Conditions - 0.47 acres
basic treatment - 0% infiltration - 0.47 acres

Subbasin 2 - Baseline Conditions - 0.28 acres
no treatment - 0% infiltration - 0.28 acres

Subbasin 2 - Proposed Conditions - 0.75 acres
basic treatment - 0% infiltration - 0.75 acres

Subbasin 3 - Baseline Conditions - 0.38 acres
no treatment - 0% infiltration - 0.38 acres

Subbasin 3 - Proposed Conditions - 0.24 acres
basic treatment - 0% infiltration - 0.24 acres

Subbasin 4 - Baseline Conditions - 0.1 acres
no treatment - 0% infiltration - 0.1 acres

Load Analysis

	Dissolved Zinc Load (lb/yr)	
	Baseline	**Proposed**
Max	17.6	2.5
75th Percentile	0.517	0.24
Median	0.268	0.15
25th Percentile	0.139	0.094
Min	0.004	0.006
P (exceed)		**0.311**

Concentration Analysis

Subbasin 1	Dissolved Zinc Conc (mg/L)	
	Baseline	**Proposed**
Max	1.575	0.205
75th Percentile	0.051	0.024
Median	0.027	0.016
25th Percentile	0.014	0.01
Min	0	0.001
P (exceed)		0.316

Subbasin 2	Dissolved Zinc Conc (mg/L)	
	Baseline	**Proposed**
Max	1.293	0.381
75th Percentile	0.051	0.024
Median	0.027	0.016
25th Percentile	0.014	0.01
Min	0.001	0.001
P (exceed)		0.314

Subbasin 3	Dissolved Zinc Conc (mg/L)	
	Baseline	**Proposed**
Max	2.082	0.236
75th Percentile	0.052	0.024
Median	0.027	0.016
25th Percentile	0.014	0.01
Min	0	0.001
P (exceed)		0.313

Subbasin 4	Dissolved Zinc Conc (mg/L)	
	Baseline	**Proposed**
Max	1.918	0.281
75th Percentile	0.051	0.024
Median	0.027	0.016
25th Percentile	0.014	0.01
Min	0	0.001
P (exceed)		0.313

City of Seattle (SDOT)

Geology and Soil Technical Memorandum

Fairview Avenue North
Bridge Replacement Project

April 2014

HWA GeoSciences Inc.

HWA GeoSciences Inc.
21312 30th Drive SE, Suite 110
Bothell, Washington 98021

LIST OF EXHIBITS

LIST OF FIGURES

EXECUTIVE ESUMMARY

The purpose of the Geology and Soil Technical Memorandum is to present an assessment of the geologic conditions present along the project alignment of the Fairview Avenue North Bridge Replacement Project and to provide a description of the anticipated construction and operational impacts of the project on the geology and soil environment. This report describes the geologic conditions present along the project alignment and summarizes the results of HWA's subsurface explorations and geotechnical analyses as they pertain to the alternatives evaluation for the Fairview Avenue North Bridge Replacement Project. This technical memorandum has been prepared to provide additional technical information and analysis in support of the review of the project by SDOT pursuant to the State Environmental Policy Act (SEPA).

The project will be constructed in a highly variable geologic environment. Potential project impacts to the geology and soil environment during construction will include excavations, placement of fill at the abutments, installation of bridge foundations and an increased erosion potential. Each of these impacts will be mitigated through the implementation of best management practices (BMPs). These issues are routinely encountered and addressed by SDOT on other projects through the implementation of proper BMPs.

The project alignment is located in an area that is susceptible to geologic hazards. The geologic hazard with the greatest potential to impact the project is seismically induced liquefaction and liquefaction-induced flow sliding. Shallow fill soils encountered near the surface are susceptible to liquefaction and liquefaction-induced flow sliding under the design earthquake. Liquefaction occurs during ground shaking and results in a reduction of the shear strength of a soil, like quick sand. Liquefaction can result in ground movement (lateral spreading) towards Lake Union. The potential adverse impact of liquefaction and liquefaction-induced flow sliding will be mitigated through proper structural design of the bridge foundations and abutments as outlined in the WSDOT *Geotechnical Design Manual* and the WSDOT *Bridge Design Manual.*

The project will not generate any adverse operational impacts to the geology and soil environment.

1. INTRODUCTION

This project is part of the City of Seattle's transportation Bridging the Gap (BTG) program. One of the nine-year goals of the BTG program, and the primary purpose of the Bridge Replacement and Rehabilitation Program (BRRP), is to evaluate and identify the most cost effective approach to improve and maintain the City's most vulnerable bridge structures by either rehabilitating or replacing the bridge.

1.1. Project Setting and Background

The Fairview Bridge Replacement Project is located on the east side of Lake Union in Seattle, King County, Washington (Figure 1). The Fairview Avenue North Bridge consists of two bridges built in parallel, spanning a narrow embayment of Lake Union at the southeastern end of Waterway 8.

The West Bridge, built in 1948, carries one lane of southbound traffic and a bike lane (Figure 2). It has a concrete deck and is supported on creosote treated timber piles, many of which are deteriorated and in poor condition, or previously repaired. The West Bridge has a sufficiency rating of 23.98.

The East Bridge, built in 1963, has a pre-stressed concrete girder superstructure supported on pre-stressed concrete piles and carries two lanes of northbound traffic and one raised 8-foot-wide sidewalk for pedestrians. The East Bridge has a sufficiency rating of 40.98.

Historical research indicates the project corridor (Fairview Avenue and bridge) was originally constructed in the early 20th Century during a period of filling and development along the Lake Union shoreline. The project corridor was replaced and improved in the 1940's and 1960's. Development in the surrounding area has been of an urban and commercial nature since the late 19th Century and early 20th Century.

Locally, the project area consists of a re-graded and flattened lakefront area. To the east, the ground surface slopes up to I-5 and the Capitol Hill district. The topography of the site is flat at both ends of the bridge due to previous grading and filling of the area. The bridge straddles the east edge of Waterway 8 with water depths up to 26 feet near the center of the bridge and becoming shallower to the east. The mudline along the north end of the bridge inclines steeply to the north while the southern end has a more gentle increase in elevation to the south. The ordinary high water mark (OHWM) of the lake extends under the ZymoGenetics building, which is built on piles in this area.

1.2. Project Description

The project will include bridge and roadway reconstruction, relocation of underground and underwater utilities, and the installation of stormwater treatment and conveyance, where none currently exists. The proposed new roadway will not add capacity and will include three travel lanes, a cycle track, a sidewalk and a mixed use trail/walkway. The project will temporarily relocate and slightly modify an existing floating walkway, presently connected to the existing West Bridge. The relocated floating walkway will be anchored to an estimated 16 steel pipe piles, up to 16-inches in diameter, which will be vibrated into place.

The proposed project will completely remove and replace the existing East and West Bridge structures with a new structure. Bridge removal includes removal of numerous creosote-treated wood piles supporting the existing West Bridge and cleanup of existing concrete rubble and waste under both existing bridges. Four new bridge spans will be supported on bents of 4-foot diameter, reinforced concrete bridge columns, constructed on 8-foot diameter shafts that will be installed to an approximate depth of 140 feet. Drilled shaft construction will also require construction of two temporary trestles, constructed on temporary drilled shafts. The project also includes reconstruction of the roadway approaches on the north and south sides of the bridge.

2. METHODOLOGY

Geologic and soils conditions along the project alignment were identified through a combination of project specific subsurface explorations and a review of available geotechnical data. Geologic and soils conditions were reviewed because the project would require the movement and alteration of soil materials. Understanding the local geologic and soils conditions in the project area is necessary to understand and limit potential environmental impacts associated with these project requirements.

The project specific subsurface information was obtained from six (6) borings along the bridge alignment and four (4) borings perpendicular to the alignment (HWA, 2013a), as shown on Figure 2. These borings were advanced to evaluate subsurface geologic conditions. HWA also conducted appropriate laboratory tests on selected soil samples to determine relevant engineering properties of the subsurface soils.

A review of the City of Seattle archives resulted in the acquisition of several geotechnical reports associated with past and proposed property development in the vicinity of the Fairview Avenue Bridge. The location and designation of field explorations associated with adjacent property development is presented in Figure 2.

Additional geologic and soil information for the project alignment was obtained from the King County Critical Areas Ordinance, Seattle Department of Planning and Development (DPD) Maps (DPD GIS), Washington Department of Natural Resources (WDNR), King County Soil Survey (National Resource Conservation Service: NRCS, 1973), and United States Geological Survey (USGS).

Where potential adverse impacts to these resources were found, recommended BMPs were developed for each impact identified. The recommended BMPs were selected based on adherence to the WSDOT *Geotechnical Design Manual* and the WSDOT B*ridge Design Manual.*

3. AFFECTED ENVIRONMENT

3.1. Topography

The project site is situated along the southeast shoreline of Lake Union. The existing bridge decks are approximately 30 feet above Mean Sea Level. It is located between the 1200 and 1400 blocks of Fairview Avenue East, as shown on Figures 1 and 2. Locally, the project area consists of a re-graded and flattened lake front area. To the east, the ground surface slopes up to I-5 and the Capitol Hill district. The topography of the site is flat at both ends of the bridge due to previous grading and filling of the area. The bridge straddles a shallow inlet with water depths up to 36 feet near the center of the bridge and becoming shallower to the east. The mudline along the north end of the bridge inclines steeply to the north while the southern end has a more gentle increase in elevation to the south.

3.2. Regional Geology

During the Vashon stade, from approximately 20,000 to 13,000 years ago, the Puget lobe of the Cordilleran continental ice sheet advanced south from western British Columbia, filling the Puget Sound lowland with an approximate 3,000-foot thickness (maximum) of ice at the latitude of Sammamish. During advance of the ice, the sedimentary environment of lakes distant from the ice front transitioned from non-glacial to glacial. As the ice approached, glacial flour (silt and clay) was deposited in areas of slack water. Next, advance outwash consisting mostly of clean sand with pebbles was deposited in broad fans by meltwater emanating from the glacier. As the advancing glacier overrode the advance outwash, a layer of lodgment till was deposited at the base of the ice. The till consists of an unsorted, non-stratified mixture of silt, sand, gravel, clay, and boulders. Due to the weight of the ice, the lodgment till, advance outwash, glaciolacustrine, and older non-glacial terrestrial deposits have been over-consolidated to a very dense or hard condition. Post-glacial geomorphic processes have included mass-wasting of steep slopes, alluvial reworking of sediments, and formation of wetlands in poorly drained areas.

3.3. Local Geology

General geologic information for the project area is published in the *Geologic Map of Seattle – A Progress Report* (Troost et al., 2005). This map indicates that the near surface deposits at the project location consist of Vashon Recessional Lacustrine deposits that have been modified by human activity. Also mapped in the area are recent lake deposits to the north and southwest, Pre-Fraser glacial deposits, Olympia Beds (interglacial) deposits, Vashon Outwash deposits, Vashon Lawton Clay deposits to the southeast, and Vashon till deposits to the north and south. Upslope and southeast of the project site the area is mapped as landslide deposits. A geologic map of the project area, including geologic unit descriptions, is shown on Figure 3, Geologic Map.

Based on our subsurface exploration program, the project site is underlain by a series of fill soils that are subsequently underlain by lake deposits, alluvium, coarse-grained landslide deposits, disturbed finer-grained deposits, a shear zone, recessional lacustrine deposits, glacially consolidated coarse grained deposits, and glaciolacustrine deposits at depth (HWA, 2013a). Descriptions of the geologic units encountered during exploration within the project area are presented in Exhibit 1. Our interpretation of geologic conditions along the length of the west bridge alignment is shown in Figure 4, Geologic Profile A-A'. Geologic profiles B-B' and C-C', extending perpendicular to the bridge alignment, are shown in Figure 5 and Figure 6, respectively. The following units were observed in our exploratory borings and are shown in the above referenced geologic profiles:

Exhibit 1. Near Surface Geology in the Study Area

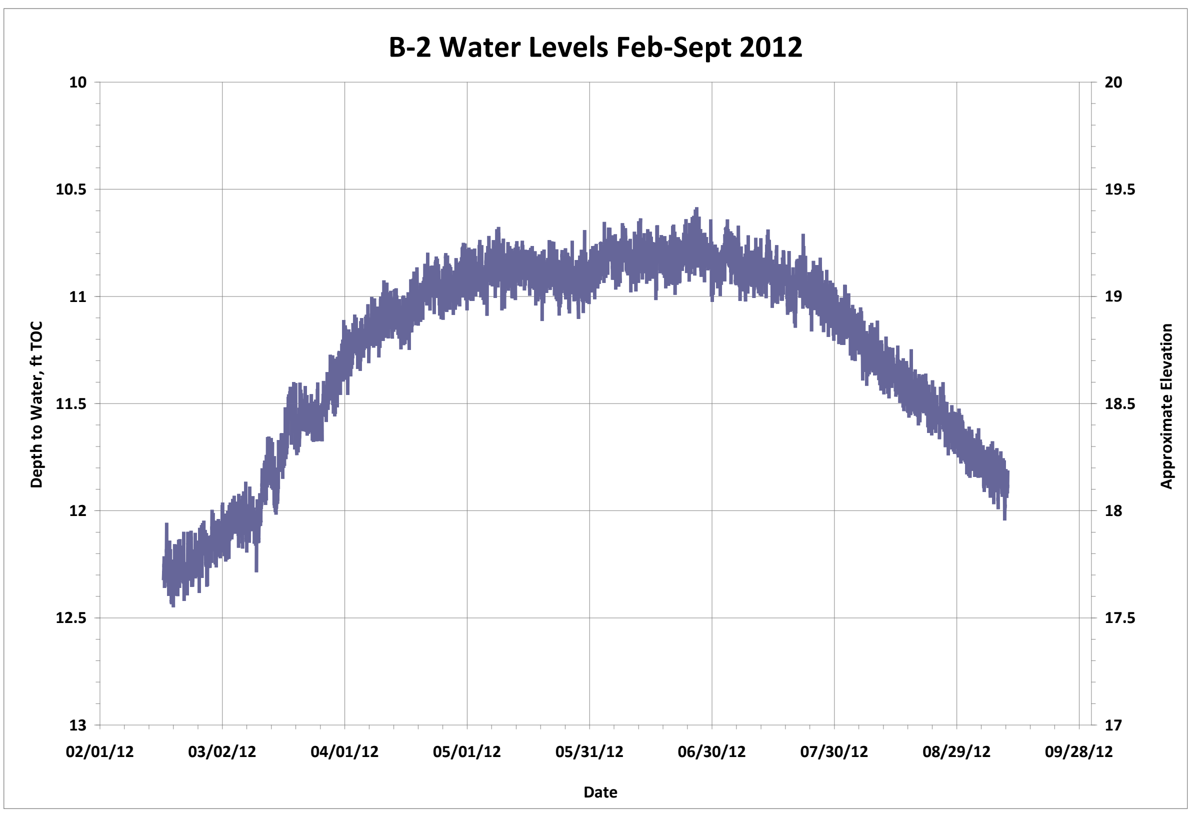
Geologic Unit	Description
Historic Fill	There were three different fills encountered in the project area. Fill soils are associated with lakefront development: • Historic fill - loose, silty sand to slightly silty sand with gravel and wood debris. • Gunn-Wright fill - soft silts and clays with scattered gravel and sand. • Counterbalance fill - soft to medium stiff clay with sand and gravel.
Lake Deposits	This deposit consisted of soft to medium stiff silt and clay interbedded with very loose to medium dense silty sands to slightly silty sands. Wood debris, thin organic layers, and organic rich silt, sand, and clay were observed within this deposit.
Alluvium	This deposit consisted of loose to medium dense sandy soils with lenses of fine detrital organics and scattered wood debris The Alluvium was likely deposited by a local stream or streams from the hillside to the east, depositing sediment as a delta into the lake.
Coarse-Grained Landslide Deposits	This deposit is comprised of several soil types but generally consists of a downward-fining sequence containing thicker deposits of sand in the north than in the south. It generally consists of loose to dense, slightly silty, poorly to well graded sands, with fine to medium gravels and occasional layers of silt and clay. This unit appears to consist of glacially-derived soils, in particular recessional outwash soils that were subsequently disturbed by a landslide.
Disturbed Fine-Grained Deposits	This deposit consists of very soft, lean to fat clays with layers of silt and fine sand. These fine-grained layers appear to have undergone deformation. Samples showed signs of deformation and off-set bedding above and below a shear zone.
Recessional Lacustrine Deposits	The four lake borings encountered distinct glacial lake deposits that were less consolidated than the Fine-Grained Glacial Deposits described below. This unit consists of very stiff to hard silt with gravel dropstones, and lenses of dense sand with variable silt content.
Coarse-Grained Glacial Deposits	This deposit generally consists of very dense sand with variable amounts of silt and gravel. Consistently high density and the absence of any soft clay/silt layers differentiate these deposits from the coarse-grained landslide deposits.
Fine-Grained Glacial Deposits	This deposit generally consists of very stiff to hard, dark gray, fat and lean clay that is predominately massive with scattered zones exhibiting faint laminations. Fine gravels and thin fine sand layers were also observed within the clay.

3.4. Surface Water and Groundwater

Ground water was not observed during our explorations due to the water level in the lake and the drilling methods used. No laterally continuous impermeable layers were observed during drilling, which suggests that the ground water level on either side of the bridge is the same as Lake Union. A water level transducer was installed in a monitoring well (B-2 installed by Aspect Engineering for another local project), located at the north end of the bridge, to monitor groundwater fluctuations over a 7 month period. Groundwater elevation data collected from this transducer is presented in Exhibit 2. Groundwater elevation data collected from the transducer at this location indicates that the ground water level appears to fluctuate between elevation 17.5 and 19.5 feet throughout the year. This fluctuation is due to controlled changes in the surface elevation of Lake Union by the Ballard Locks. During construction of the bridge replacement, the contractor should anticipate a 2 foot fluctuation range in lake and ground water levels throughout the year. No artesian ground water conditions were encountered in our borings at the time of the explorations.

Exhibit 2.

Groundwater Level Data from Boring B-2



3.5. Geologic Hazards

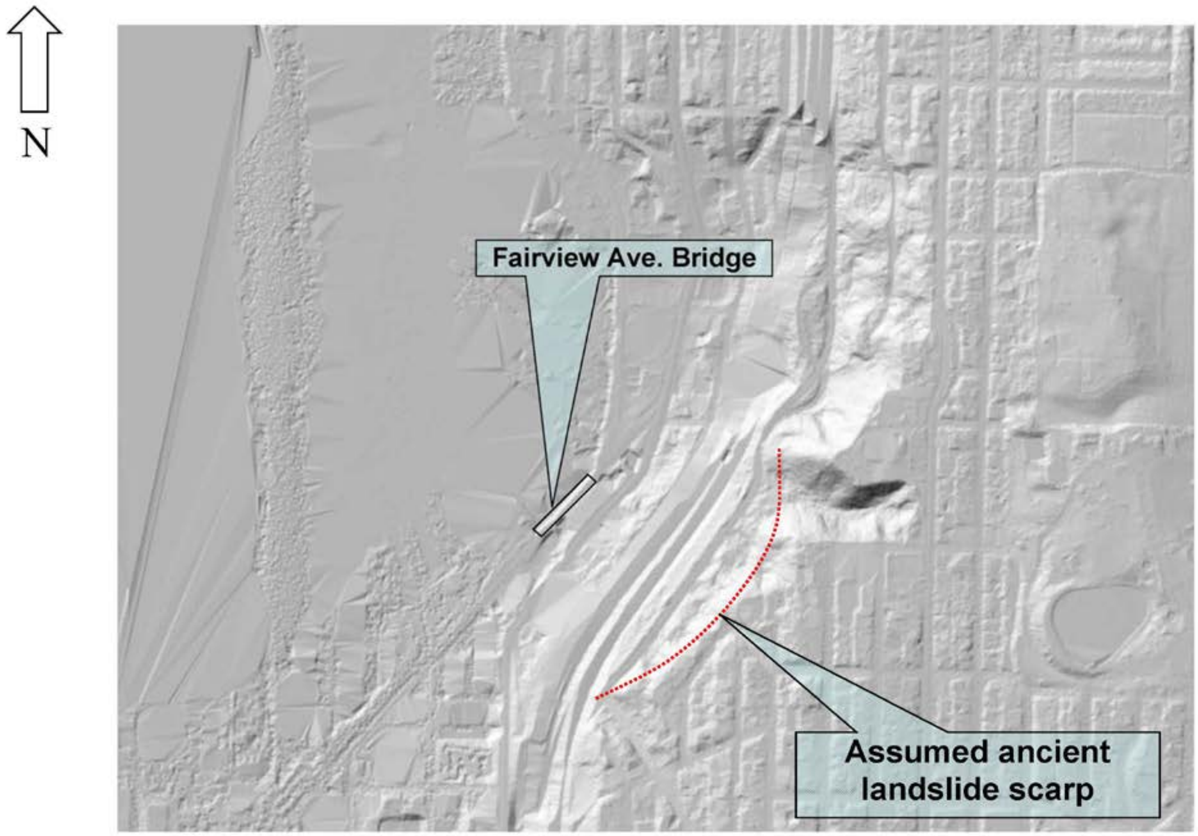
The City of Seattle's Environmentally Critical Areas Ordinance (SMC 25.09) is intended to fulfill Washington State's Growth Management Act (Chapter 36.70A RCW) requiring identification of critical areas within Municipal jurisdictions and to formulate development regulations for their protection. Among the critical areas designated by the Washington State Growth Management Act are geologically hazardous areas, classified as such because of their potential susceptibility to earthquakes, sliding, erosion, or other geologic events. These areas may not be suitable for development consistent with public health and safety concerns without conducting specific studies during the design and permitting process.

3.5.1 Landslides

HWA determined that the Fairview Avenue Bridge spans over a portion of a previously unidentified ancient landslide area. Based on our explorations and a review of explorations by others, the landslide area appears to extend from project Station 12+25 in the north to some southern terminus located an unknown distance north of the Fred Hutchison Cancer Care facility. In the east-west direction the slide area extends beneath the ZymoGenetics building to approximately 330 feet west of the existing bridge structure. We are postulating that the ancient landslide most likely occurred as a result of the loss of lateral confining pressures associated with the northward retreat of the Puget Lobe of the Cordilleran Ice Sheet during the Fraser Glaciation. At this time, the Lake Union Basin would have been considerably deeper and would not have been filled with buttressing lake sediments as the basin is today.

A LIDAR map of the project area, presented in Exhibit 3, suggests the presence of a large landslide scarp, located upslope from the project site. We postulate that the slide mass identified under the bridge alignment is related to the subject scarp. Based on the topographic evidence of the scarp feature and a lack of damage to existing structures down-slope, such a landslide would have occurred sometime post-glacial but likely pre-development of the area. The presence of a thick lake deposit, containing an undisturbed volcanic ash layer, over a deltaic alluvial deposit is an indication that the landsliding occurred during the early Holocene period or before. A weak zone (shear zone) of fine-grained soil was identified near the base of the slide mass, on which the ancient slide mass propagated downslope. The soft consistency of the soils along the shear zone (similar to toothpaste) is indicative of soils that have undergone large strains. As the shear zone is a result of past sliding, it is believed to be continuous along the base of the slide and possess residual shear strength properties. This hypothesis is further supported by the presence of disturbed fine-grained soils above and below the shear zone.

Exhibit 3.
Lidar Map



3.5.2 Seismicity

The project site is located in a moderately active seismic zone. Earthquakes have been historically recorded in the area for about the past 160 years. Western Washington is located in a moderately active seismic zone due to its location at the edge of an active plate margin where subduction is occurring. Currently, the North American plate is overriding the oceanic, or Juan de Fuca plate at a rate of about 1.5 inches per year. The converging plates produce typical subduction zone features. These features include a small trench off the west coast of Washington State where the Juan de Fuca plate begins its descent below the North American plate and an active volcanic arc in the overriding plate, where partial melting of the subducting Juan de Fuca plate generates the geologically young and active volcanoes of the Cascade mountain range.

The area between the trench in the Pacific to the west, and the Cascade volcanoes in the east, is called the Cascadia Subduction Zone. Researchers identify three earthquake source regions in this tectonic setting:

1) The first source region delineated is in the subducting Juan de Fuca plate. This source is relatively deep, about 45 to 60 km. The 1949 Olympia earthquake, the 1965 Sea-Tac

earthquake, and the 2001 Nisqually earthquake are recent events associated with the subducting Juan de Fuca plate.

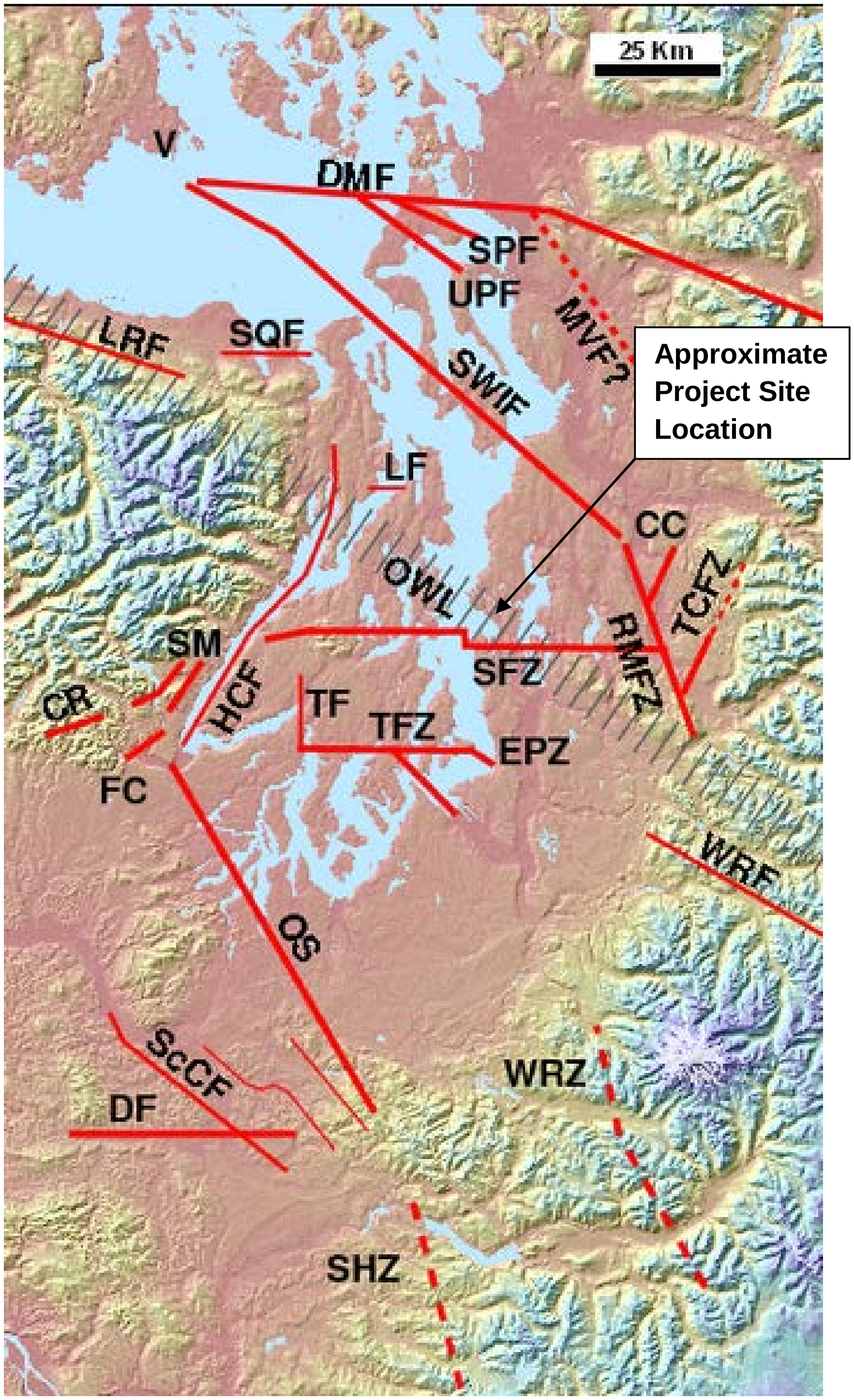
2) The second source zone is in the overriding North American plate. This source zone produces shallow crustal earthquakes with focal depths less than 30 km. The United States Geological Survey recently identified several major crustal faults in the region, including the Seattle Fault Zone located approximately 3 miles south of the proposed project area and the Southern Whidbey Island Fault zone approximately 23 miles to the north. Recent field evidence suggests that these zones have been active during Holocene time. No potentially active faults are mapped in the immediate vicinity of the project area (Gower and Crosson, 1985, Johnson et al, 1994, and Blakeley et al, 2002).
3) A third source region is located at the interface between the converging plates, e.g. the Cascadia Subduction Zone fault. The latest to occur was in 1700 (Atwater et al, 2005), and recurrence interval is estimated to be from approximately 300 to 800 years (Goldfinger, et al, 2012).

Geophysical investigations suggest that earthquakes may also occur from a network of faults beneath the Puget Sound Basin.

3.5.3 Faulting

The nearest potentially active fault is the Seattle Fault Zone (SFZ) which lies approximately 3 miles south of the project site. The principal Puget Sound Faults are presented in Exhibit 4. Recent field evidence suggests that the south Whidbey Island Fault Zone has been active during Holocene (recent) time; this fault is approximately 23 miles north of the project site. Rupture of the ground surface and vertical offset within the subject site is not anticipated.

Exhibit 4.
Fault Location Map



NORTH

Map Symbol Legend	Fault Name
SWIF	South Whidbey Island Fault
SFZ	Seattle Fault Zone
OWL	Olympic-Wallowa Lineament

3.5.4 Liquefaction and Lateral Spreading

When shaken by an earthquake, loose, saturated sandy soils lose strength and temporarily behave as if they were liquid when the water pressure in the pore spaces nears the level sufficient to separate the soil grains from each other. This phenomenon is known as liquefaction. The seismically induced loss of strength can result in failure of the ground surface, which is typically expressed as lateral spreads, surface cracks, and settlement. Bridges, buildings and other structures founded on, or in, potentially liquefiable soils may settle, tilt, move laterally, or collapse. The degree of liquefaction depends on the consistency and density of the soils, grain size distribution of the soil, and the magnitude of the seismic event.

Our analyses indicate that the historic fill and the coarse-grained portions of the alluvium and lake deposits composed of loose saturated sands along the entire bridge alignment from north to south will likely liquefy during the 1,033-year design earthquake. The depth to which liquefaction is anticipated to occur varies along the alignment of the bridge in the north-south direction from 20 to 40 feet, as shown in Figure 7. In addition to varying in the north-south direction, liquefaction is also anticipated to vary across the bridge in the east-west direction as shown in Figure 8. Our studies have also indicated that the deeper landslide deposits and glacially overridden soils have a low susceptibility for liquefaction.

When soils liquefy they tend to flow downslope under the forces of gravity and in this case toward Lake Union. Depending upon location, large lateral forces are expected to act on the bridge structure as a result of liquefaction-induced flow sliding.

3.5.5 Seiches

A seiche is a standing wave in an enclosed or partially enclosed body of water, and can be induced by seismic ground motion. Seiche phenomena have been observed in lakes and reservoirs. The extent and severity of these waves depends on location, fault offset and ground motions. In 1964 and 2002, seiche phenomena developed within Lake Union due to large magnitude earthquakes in Alaska. Damage was limited to houseboats, buckled moorings, broken sewer and water lines. The threat to the bridge would more likely be damage from battering by floating debris.

3.5.6 Erosion Hazards

The project location is classified as urban development and thus is not an erosion hazard area. However during construction, the removal of existing pavement and sidewalk will expose fill soils that may have a potential for erosion if not protected from excessive disturbance, surface water and precipitation.

3.6. Hazardous Materials

As part of our environmental review, HWA reviewed the following reports:

- Parametrix, Inc., 1989, Lake Union Sediment Quality, prepared for Seattle City Light, dated November.
- Aspect Consulting, LLC, 2009, Fairview Avenue Bridge Rehabilitation, Preliminary Geotechnical Report, Seattle, Washington, Aspect Project Number 080145-002, March 24, 2009.

- Moshenberg, K, 2004, A Sediment Triad Analysis of Lakes Sammamish, Washington, and Union, King County Department of Natural Resources.

Sediment and soil sample analytical results are compared to open water sediment disposal criteria under the Puget Sound Dredged Material Management Program (USACE, 2013), as well as soil cleanup levels under the Washington Department of Ecology Model Toxics Control Act (MTCA, WAC 173-340). The MTCA criteria generally apply to upland soils, not to lake sediments, and are provided as a screening level indication of the environmental quality of the soils only, and for handling and disposal purposes.

The Parametrix study (1989) was performed as part of a Seattle City Light power line project. This work included sediment sampling at several locations throughout the waterway west of the bridge. Parametrix conducted sampling of shallow sediments at eight locations in the vicinity of the Lake Union Steam Plant, four of which are near the planned bridge work area. Polychlorinated biphenyls (PCBs), polynuclear aromatic hydrocarbons (PAHs), and the metals arsenic, cadmium, copper, mercury, nickel, silver, and zinc were detected in sediment exceeding current criteria for offshore open water sediment disposal under the Puget Sound Dredged Material Management Program (USACE, 2013) at three of the locations west of the bridge (SP-4-50, SP-5-50, and SP-5-200). One sample located approximately 200 feet west of the bridge exceeded Dangerous Waste criteria for PAHs.

Other prior studies of lake sediments also identified elevated metals, PAHs and PCBs in the vicinity of the Steam Plant (Parametrix, 1989; Moshenberg, 2004), with generally similar results to the Parametrix study.

Aspect Consulting (2009) conducted a geotechnical investigation as part of a bridge rehabilitation study. Aspect completed two borings, one each at the north and south approach to the bridge deck, and within the planned bridge work area. The borings encountered approximately 18 to 25 feet of fill soils over lacustrine and glacial recessional deposits. Field screening identified potential contamination impacts in Boring B1, completed at the south approach. Aspect collected composite soil samples from soil cuttings at each boring and analyzed them for petroleum hydrocarbons, PAHs, PCBs, and metals. Results were below criteria for offshore open water sediment disposal, although not all analytes required for offshore disposal were tested.

However, because these samples were collected as composite samples of soils throughout the borings, there is the potential for discrete soils within the soil column to contain higher concentrations of individual contaminants.

HWA collected environmental soil samples from the upper 0 to 7.5 feet of boreholes BH-3, BH-4, BH-5, and BH-6 for chemical laboratory analyses (HWA, 2013a). Borings BH-3 through BH-5 were drilled below the bridge deck into lake sediments and underlying soils. Boring BH-6 was an upland boring east of the south approach. Samples were collected from fill soils overlying native lake deposits and alluvial soils with the exception of BH-3, where the sample was collected from shallow alluvial deposits.

Gasoline, diesel and/or oil-range petroleum hydrocarbons, as well as carcinogenic PAHs were detected in three of the four soil samples (BH-4, BH-5 and BH-6) at concentrations above MTCA Method A and Method B soil cleanup levels. Volatile organic compounds (VOCs) were detected in all soil samples, but at concentrations below the soil cleanup levels. None of the VOCs detected were halogenated solvents. The metals arsenic, cadmium, and/or lead were detected above soil cleanup levels in two samples (BH-4 and BH-6). Lead exceeded the total metals screening level for Dangerous Waste characterization of 100 mg/kg in three samples (BH-4 S-1, BH-5 S-3 and BH-6 S-2). Further testing by the Toxicity Characteristic Leaching Procedure (TCLP) method during design or construction would be required to establish Dangerous Waste characterization status.

The HWA testing results generally fell within ranges for open water disposal criteria that would require additional (e.g., bioassay) testing (USACE, 2103).

Impacted soils were primarily in the fill layer. Undisturbed native alluvial soils below the fill sampled at BH-3 contained only trace concentrations of VOCs, PAHs, and chromium. Based on this, contamination does not appear to persist into the underlying native soils, and deeper native soils are not likely to be impacted. The fill layer ranges in thickness up to about 40 feet.

For more information regarding hazardous material refer to the Environmental Discipline Report (HWA, 2014).

4. IMPACTS

Construction impacts are primarily related to earthworks and occur during construction or within a short time after. The potential geology and soils related impacts to the proposed project would generally be related to impacts associated with earthworks on existing features, such as structures and utilities. The following sections present discussions of different types of construction impacts and related mitigation measures for the proposed project during construction.

4.1. Erosion and Sediment Transport

The study area is classified primarily as urban development and is, therefore, not an erosion hazard area. However, areas disturbed by construction are likely to be subject to increased erosion potential prior to implementation of permanent erosion control measures. Surface areas within the vicinity of the bridge approaches and foundation areas would be stripped of all existing pavement, structures, vegetation, organic soils and debris. The debris generated from stripping would be removed from the site area. The resulting bare soil surfaces would have a high potential for erosion if exposed during the rainy season or in the presence of surface water. In addition, construction traffic moving over disturbed ground could sink, dislodge, and carry surface soils onto adjacent roadways or haul routes unless BMPs are implemented.

4.2. Fill Embankments

About 1 to 2 feet of new fill may be placed and compacted within the bridge approach areas. Use of unsuitable soils (those containing debris or organics), fill placement during wet weather, or improper fill placement and compaction methods could result in excessive settlement of the fill over time, regardless of subsurface conditions.

4.3. Consolidation Settlement

The south abutment is underlain by varying amounts of soft compressible soils. Placement of 1 to 2 feet of fill to facilitate increases in grade will result in modest consolidation settlements of the underlying soils. Consolidation settlements will vary depending on the location and are expected to be less than 3 inches if standard embankment fill is utilized. Consolidation settlements are expected to occur primarily under the proposed roadway. However, some settlement is expected to migrate outside the prism of the proposed roadway. If the adjacent Gunn Building development is completed prior to the construction of the bridge, the subject settlement could cause unwanted down drag loads on the proposed building foundations.

4.4. Soil Stockpiles

During construction, soil material may be temporarily stored on site in stockpiles. Without proper management, stockpiles may be placed over existing structures that could be damaged by loading or induced settlement. Site soils contained in stockpiles have a high potential for erosion during periods of wet weather if not protected.

4.5. Pavements

Construction activities and traffic could result in unintended damage to existing roadway pavements within SDOT right-of-way adjacent to the project site.

4.6. Bridge Demolition and Pile Foundation Removal

The existing bridge structures and supporting foundations will be removed to make way for the new bridge structure. This work will involve demolition of the existing concrete bridge deck and removal of the supporting bridge foundations. Work will begin at the north or south shoreline and will move in a north or south direction, until the work trestle is completed across the lake. Demolition of the bridge deck and superstructure could result in debris falling into the lake. This debris could suspend lake sediment and increase turbidity within the lake.

Upon demolition of the bridge deck and superstructure, all of the existing piles supporting the existing Bridges will require removal. An estimated 60 to 250, 16- to 20-inch diameter creosote-treated wooden piles will be removed for construction of the west bridge. A total of 58, 18-inch diameter concrete piles will be removed for construction of the east bridge. There are an unknown number of relic wooden piles from previous bridges that may require removal. The existing piles are creosote-treated and many are severely degraded and structurally compromised. Removal of existing bridge foundations could result in suspension of contaminated lake sediments. Parametrix (1989) evaluated potential effects of sediment disturbance, within the subject waterway, due to pile removal by breaking or cutting. Worst-case conditions were estimated based on highest detected contaminant concentrations within a radius of 15 meters of a pile. Based calculations by Parametrix, suspended sediments would likely exceed water quality criteria outside the selected dilution zone (15 meters) for metals, but not for organics (PAHs, etc.).

4.7. Bridge Foundation Installation

The proposed bridge structure will be supported on drilled shaft foundations at 3 interior piers and 2 abutments. The drilled shaft foundations will be installed from the temporary work trestle utilizing the oscillating casing method of shaft installation. This method utilizes a full depth temporary casing that is advanced through a slow oscillating motion which minimizes vibration to surrounding structures. As the casing is advanced, the soils inside the casing are excavated with a clam shell and placed in lined dump trucks for transfer to the on-site decanting facility (in the case of wet soil) or to an off-site disposal site (for dry soil). Excavated materials that are potentially contaminated will be kept separate, tested for contaminants, and decanted or disposed of at a licensed facility.

Each section of casing will be rotated or oscillated into the ground. Additional sections will be bolted onto the top of the installed section until the desired depth is achieved. Once the termination depth of the shaft is achieved (elevation -120 to -130 feet NAVD-88) and the base of the shaft is cleaned out, a full-length rebar cage will be lowered into the excavated shaft. Concrete will then be pumped to the base of the excavation with a concrete pump truck and tremie, through which concrete is placed below water level. All fresh and curing concrete will be fully contained within the shaft during construction. As the concrete is placed, the temporary casing is slowly removed to the specified elevation of the permanent casing. This general sequence will continue until all piers are completed. The tops of the drilled shafts are estimated to be constructed at an elevation of +10 feet NAVD-88.

Excavation of soils for drilled shaft installation overwater could result in spillage of spoils into Lake Union, resulting in increased turbidity.

Positioning of the drilled shaft casing for overwater piers could result in the suspension of lake sediments in the immediate vicinity of the shaft locations.

A total of approximately 5,500 cubic yards of soil excavation will be required for construction of the permanent drilled shaft foundations. The majority of these spoils will be excavated from below the groundwater level and will be saturated upon removal. Transportation of these wet spoils could result in the unwanted spread of sediment along local streets.

It is expected that approximately the upper 10 feet of sediments within Lake Union are likely to be contaminated. Based on this assumption, it is anticipated that approximately 400 cubic yards of contaminated soil will be removed from the drilled shaft casings during the bridge foundation installations.

5. MITIGATION

5.1. Erosion and Sediment Transport

Erosion control measures include vegetative and structural controls. Structural controls would primarily be used because the site is highly developed and/or adjacent to highly urbanized area and waterfront. Structural controls consist of means other than vegetation to prevent sediment from leaving the construction area, such as silt fences, ditches, berms, check dams, tire wash facilities, etc. Proposed mitigation measures would comply with storm water design and treatment procedures in the current version of the City of Seattle's Storm Water Management Code and those of WSDOT, where applicable. The erosion and sediment control measures should be in place before any clearing, grading or construction.

5.2. Fill Embankments

Suitable fill materials would be used to construct the fills. For structural fill, the material should consist of sand and gravel meeting the requirement for aggregate. Structural fill would be densely compacted to the criteria required by the City of Seattle and WSDOT, as appropriate.

5.3. Consolidation Settlement

If the anticipated consolidation settlement is determined to be too large or is determined to induce down drag loads on adjacent structures, settlement mitigation measures such as lightweight fill will be utilized. Lightweight fill would be constructed to offset the proposed increases in load associated with proposed grade increases. Lightweight fill could consist of the placement of geofoam blocks or the use of lighter weight conventional aggregates such as open graded gravels.

5.4. Soil Stockpiles

On site stockpiles would be covered to prevent erosion and sediment transport. Stockpiles would not be located over utilities or pavements that could be damaged from loads or settlement caused by the stockpiles. Stockpile areas will be delineated with construction fencing and BMPs implemented to contain all materials and runoff from entering project waters.

5.5. Pavements

Construction traffic would be routed to City-approved haul routes, which include roadways capable of handling heavy loading. In areas where construction traffic cannot be re-routed onto suitable roadways, existing roadways would either have to be improved prior to construction or repaired following construction. To reduce dust during hauling, the loads would be covered during transport.

5.6. Bridge Demolition and Pile Foundation Removal

To mitigate the geology and soil impacts associated with bridge demolition and pile foundation removal, several BMPs are proposed. These include the implementation of containment BMPs, placement of a sand layer around piles to be removed and specific procedures for implementation of the bridge demolition. Additional details are provided below.

The project will implement containment BMPs consisting of a series of floating containment curtains in order to contain suspended, and potentially contaminated, sediments to the immediate work area. The floating curtains will consist of a primary outer containment system and series of secondary containment systems placed around specific work areas.

The primary, outer portion of this containment system will be present during the entirety of all in-water work activities. The primary containment system will consist of a permeable barrier capable of trapping suspended solids. The containment curtain will be supported on floats or booms. Although the exact material, specifications, and location of the primary containment system will be determined by the contractor, the contractor will be required to ensure that the curtain: 1) encompasses the entire in-water work area; 2) extends horizontally the full extent of the water column, from the water surface to the lakebed (the bottom of the curtain may have attached weights ["lead-line"] to ensure it is fully deployed to the depth of the lakebed); and 3) extends vertically to connect to the locations where the OHWM crosses the west edge of the project on the north and south banks of Waterway 8. The primary outer curtain will be placed to extend offshore to an extent that the curtain will surround all wetted areas of Lake Union where in-water and overwater work activities associated with bridge demolition and construction will occur. It is anticipated the curtain will extend from the shoreline and extend from the water surface to the mudline.

A secondary containment curtain or curtains will be placed prior to bridge demolition to further minimize the spread of re-suspended materials in Lake Union. This secondary curtain will be of similar construction to the primary curtain, although it will be sized much smaller to encapsulate the specific work area(s). The secondary curtains will remain in place until completion of the specific sediment-disturbing activity, and then removed.

To limit the potential for disturbance of contaminated lake sediments during bridge demolition, due to falling debris, the contract documents will specify that the contractor shall utilize specific methods of demolition. The contractor will be required to saw cut the bridge deck and superstructure into sections that can be easily lifted by a crane or large excavator and placed onto a truck for disposal at an appropriate facility. Saw cutting should reduce or eliminate demolition debris from entering the water. In addition, the project will apply containment BMPs to ensure that no materials from demolition will fall into the water. The specific BMPs to be utilized will be determined by the contractor, but may include containment tarps below the bridge or small floating Styrofoam barges placed beneath the construction area.

To limit the suspension of contaminated lake sediments during pile removal a one to two-foot thick layer of sand will be placed immediately around each individual pile slated for removal. This clean fill will be placed to contain and minimize disruption of existing contaminated sediment. The precise particle size and composition of the fill material will be determined based on slope conditions. The mixture will be fine-grained enough to effectively cover and contain lakebed sediments, while containing enough larger-grained materials (e.g., larger grained sand or pea gravel) to ensure the treatment remains on the bottom and does not immediately shift downslope. The sand layer will either be applied using uniform broadcast methods over the entire project area or the application will be targeted around each individual pile to be removed, with application subsequent to deck removal along each bridge span. The second scenario is more likely, due to access limitations associated with the large number of existing piles present under the existing bridge. The sand material may be placed with a track hoe or a crane with a skip box.

5.7. Bridge Foundation Installation

To mitigate the geology and soil impacts associated with bridge foundation construction, several BMPs are proposed. These include the implementation of containment BMPs, placement of a sand layer around the proposed foundations and construction of decant facilities. Additional details are provided below.

Secondary containment curtains will be placed around the proposed drilled shaft foundation locations prior to commencing construction of the shafts to further minimize the spread of re-suspended materials in Lake Union. This secondary curtain will be of similar construction to the primary curtain, although it will be sized much smaller to encapsulate the specific work area(s). The secondary curtains will remain in place until completion of the drilled shaft installation, and then removed.

To limit the potential for suspension of contaminated lake sediment, a one to two-foot thick layer of sand will be placed immediately around each drilled shaft location prior to positioning the osculating casing. This clean fill will be placed to contain and minimize disruption of existing contaminated soils during the placement and advancement of the drilled shafts. The precise particle size and composition of the fill material will be determined based on slope conditions. The mixture will be fine-grained enough to effectively cover and contain lakebed sediments, while containing enough larger-grained materials (e.g., larger grained sand or pea gravel) to ensure the treatment remains on the bottom and does not immediately shift downslope. The sand layer will either be applied using uniform broadcast methods over the entire project area or the application will be targeted around each individual drilled shaft to be installed, with application subsequent to deck removal along each bridge span. The second scenario is more likely, due to access limitations associated with the large number of existing piles present under the existing bridge. The sand material may be placed with a track hoe or a crane with a skip box.

To isolate the contaminated soils excavated from the drilled shafts, the bid contract will specify that the contractor separate the near surface contaminated soils from the deeper clean soils during excavation. Testing will also likely be required to determine the extent of contamination. The existing analytical data may be sufficient to establish a disposal profile, although deeper native soils will likely need additional characterization for purposes of segregation and documentation for 'clean' soil receiving facilities.

To limit the potential for the spread of sediment along local streets, saturated soils excavated from the drilled shafts will be decanted in approved on-site decant facilities prior to removal from the project site. Due to the near surface soils being contaminated and the soils at depth being clean, multiple decanting facilities in a staging area adjacent to the project site will be required. One facility would be required for decanting of contaminated soils and the other facility would be required for decanting clean soils excavated from the shafts. Decanted water will be stored in tankage, tested for compliance with applicable discharge criteria, and either: 1) discharged under permit into the sanitary sewer system, 2) treated, tested again, and then discharged to storm drain system, or 3) discharged to storm drain system, if compliant with discharge criteria. Wastewater will be treated on-site to the greatest extent practicable.

Treatment of the clean soil decant water will likely be only for suspended solids and turbidity, and include primary settling in a weir tank, bag filtration, sand or Chitosan filtration. Treatment of the contaminated soil decant water will likely be for turbidity as well as for dissolved contaminants, and might include activated carbon filtration or electrocoagulation. In either case, no contaminated water or water with turbidity or pH outside of state water quality standards will be allowed to re-enter Lake Union.

6. POTENTIAL OPERATIONAL IMPACTS

Operational impacts are those that will occur over the long term operation of the proposed new transportation features. No operational impacts to the geology and soil are expected as a result of this project.

7. CONCLUSION

Construction or operational impacts of the proposed project would not significantly affect soil conditions outside of the study area. The proposed bridge project would be constructed to address geotechnical and seismic constraints according to requirements of AASHTO, WSDOT, SDOT and the City of Seattle. As currently proposed this project will in fact enhance local soil stability and replace a structure with severe load limitations and limited useful life.

8. REFERENCES

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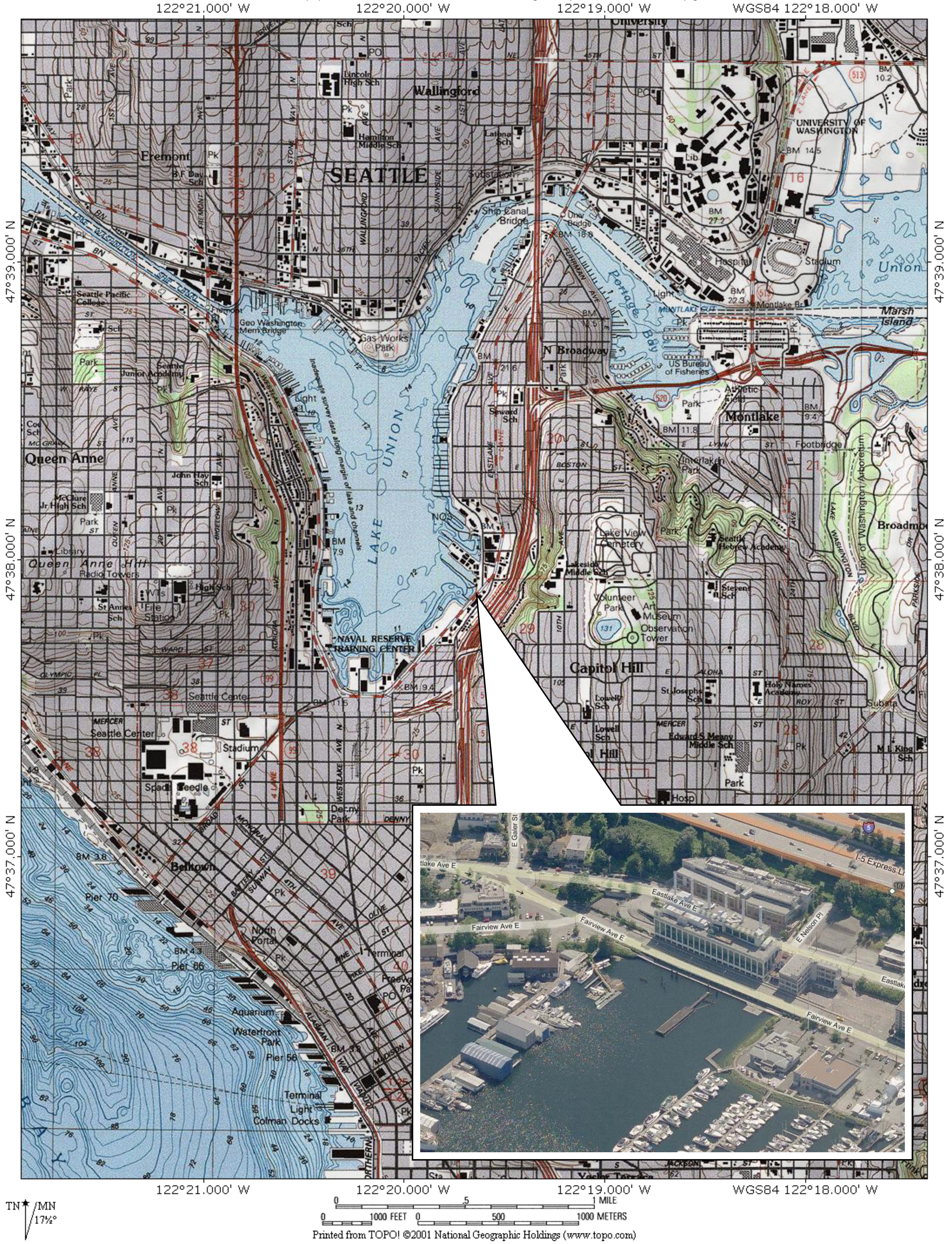
TOPO! map printed on 01/30/12 from "Washington.tpo" and "Untitled.tpg"



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HWA GEOSCIENCES INC.

SITE VICINITY MAP

GEOLOGY & SOILS TECHNICAL MEMORANDUM
FAIRVIEW AVENUE NORTH BRIDGE REPLACEMENT
SEATTLE, WASHINGTON

FIGURE NO. 1

PROJECT NO. 2011-118

LEGEND

BH-9 *HWA* (Lake Union, 2012) BORING DESIGNATION AND APPROXIMATE LOCATION

BH-5 *HWA* (Fairview, 2011) BORING DESIGNATION AND APPROXIMATE LOCATION

B-2 *Aspect* (Fairview, 2009) BORING DESIGNATION AND APPROXIMATE LOCATION

HC-5 *Hart Crowser* (1165 Eastlake, 2007) BORING DESIGNATION AND APPROXIMATE LOCATION

HC-4 *Hart Crowser* (ZynoGenetics, pilot building, 2002) BORING DESIGNATION AND APPROXIMATE LOCATION

B-4 *Earth Consultants* (ZymoGenetics, 1996) BORING DESIGNATION AND APPROXIMATE LOCATION

B-2 *AGRA* (Silver Cloud, 1995) BORING DESIGNATION AND APPROXIMATE LOCATION

LK-2 *City of Seattle* (Lake Union CSO, 1994) BORING DESIGNATION AND APPROXIMATE LOCATION

HC-9 *Hart Crowser* (Steam Plant, 1992) BORING DESIGNATION AND APPROXIMATE LOCATION

HC-15 *Hart Crowser* (Fred Hutchinson, 1989) BORING DESIGNATION AND APPROXIMATE LOCATION

SP-6 *Parametrix* (Seattle City Light, 1989) BORING DESIGNATION AND APPROXIMATE LOCATION

B-2 *Shannon and Wilson* (Gunn-Wright, 1966) BORING DESIGNATION AND APPROXIMATE LOCATION

A A'

0 100' 200' 300' 600'

SCALE: 1"=200'

BASE MAP PROVIDED BY: PERTEET ENGINEERING

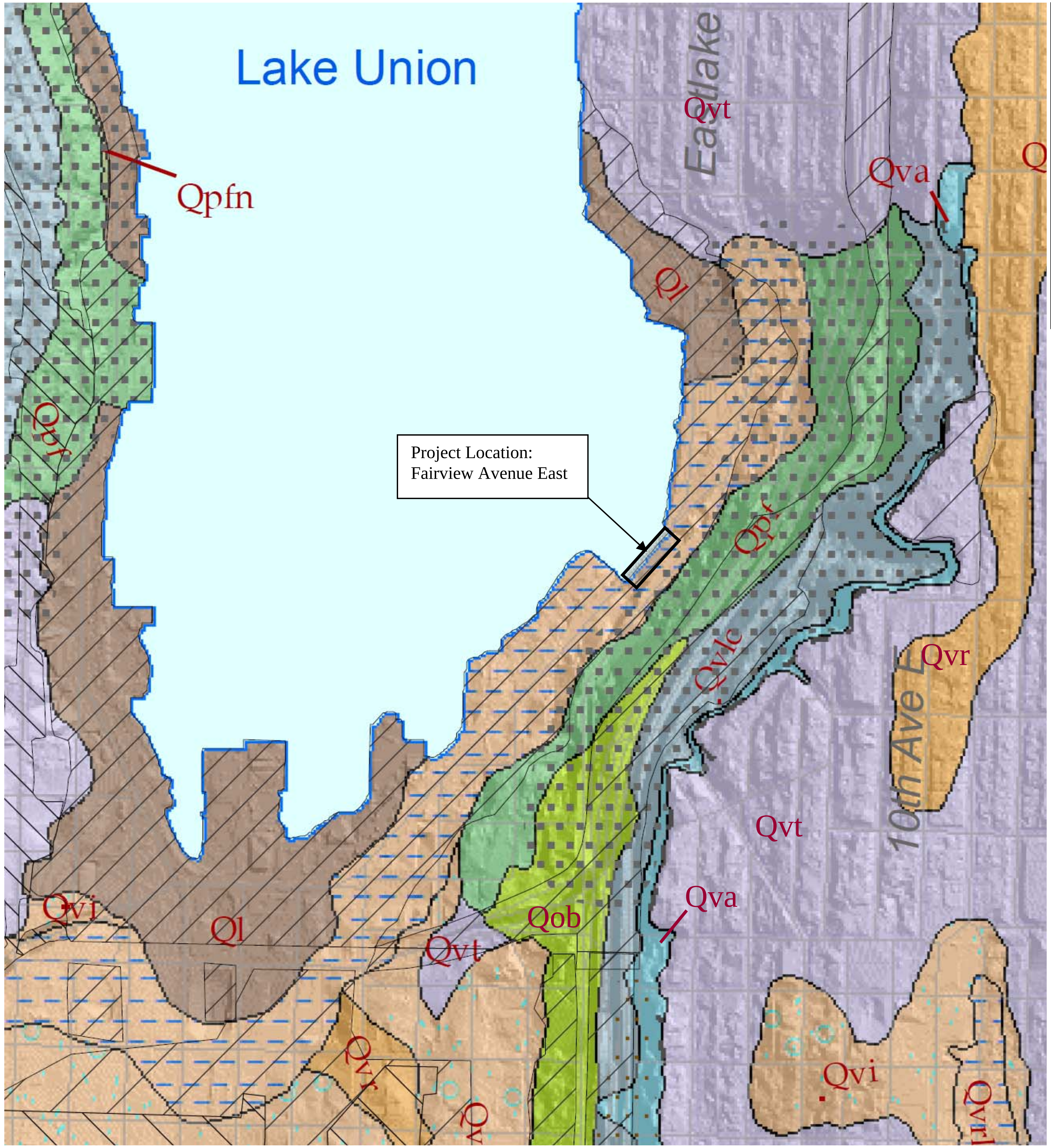
HWA GEOSCIENCES INC.

GEOLOGY & SOILS TECHNICAL MEMORANDUM
FAIRVIEW AVENUE
NORTH BRIDGE REPLACEMENT
SEATTLE, WASHINGTON

SITE AND EXPLORATION PLAN

DRAWN BY	FIGURE #
EFK	2
CHECK BY DC/DH	PROJECT #
DATE: 01.21.13	2011-118-21

S:\2011 PROJECTS\2011-118-21 FAIRVIEW AVENUE EAST BRIDGE\CAD 2011-118\HWA 2011-118 FAEB2.DWG <FIG 2 S&ETechnical Memo T1502.2> Plotted: 2/13/2014 9:25 AM



Geologic Units:

- water
- Ql - Lake deposits
- Qvr - Vashon recessional outwash deposits
- Qvrl - Vashon recessional lacustrine deposits
- Qvi - Vashon ice-contact deposits
- Qvt - Vashon subglacial till
- Qva - Vashon advance outwash deposits
- Qvlc - Lawton Clay member of the Vashon Drift
- Qpf - Pre-Fraser glaciation age deposits
- Qpfn - Pre-Fraser nonglacial deposits
- Qob - Olympia beds
- Landslide deposits
- Modified land
- regraded land
- Contact

Geologic Unit Descriptions

Age & Geologic Unit	Name	Summary Description	Thickness	Density/ Hardness	Permeability Factors
Ql	Lake deposits	Silt and clay with local sand layers, peat, and other organic sediments, deposited in slow-flowing water. Most mapped areas are lake-bottom sediments exposed by the lowering of Lake Washington in 1916. Locally gradational with units Qvrl, Qal, and Qp	Typically 3 to 5 m on upland in recessional channels; 1 to 3 m adjacent to Lake WA	Very soft to medium stiff or very loose to medium dense	Predominantly fine grained and horizontally bedded
Pleistocene	YOUNGER GLACIAL DEPOSITS				
Qv	Deposits of Vashon stade of Fraser glaciation of Armstrong and others (1965) , not used as a map unit				
Qvr	Recessional outwash deposits	Stratified sand and gravel, moderately sorted to well sorted, and less common silty sand and silt. Deposited in outwash channels that carried south-draining glacial meltwater during ice retreat away from the ice margin. Also includes deposits that accumulated in or adjacent to recessional lakes. Discontinuous. May include thin lag on glacial till uplands although deposits less than about 1 m (3 ft) thick not shown on map. Locally divided into:	~1 to 6 m; typically in channels	Loose to dense	Horizontally bedded to cross bedded, uniformly to well graded, channelized, coarse lag deposits common
Qvrl	Recessional lacustrine deposits	Laminated silt and clay, low to high plasticity, with local sand layers, peat, and other organic sediments, deposited in slow-flowing water and ephemeral lakes. Locally includes high-plasticity clay with swell potential. Lenses and layers of ash and diatomite may be present. Gradational with units Qvr, Qp, and Ql	5 m typically on uplands; up to 16 m at the heads of recessional channels, locally 18 m in Rainier valley	Very soft to stiff	Horizontally bedded; sandy channels may breach the lacustrine deposits
Qvi	Ice-contact deposits	Intercalated till and outwash, irregularly shaped bodies of till and outwash. Outwash consists of sand and gravel, clean to silty, horizontally bedded to steeply dipping. The till consists of matrix supported gravelly sandy silt that may or may not have been glacially overridden. Deposits intermittently flank the west margin of the Duwamish River valley south to the edge of quadrangle and are common on the upland southwest of the Duwamish River. Gradational with units Qvr and Qvt	3 to 15 m; in patches on the upland	Loose to very dense	Intermixed irregularly-shaped bodies of till and coarse-grained deposits
Qvt	Vashon till	Compact diamict of silt, sand and subrounded to well-rounded gravel, glacially transported and deposited under ice. Commonly fractured and has intercalated sand lenses. Generally forms undulating, elongated surfaces. Upper 1 meter of unit generally weathered and only medium dense to dense. Locally divided into:	Typically 1 to 10 m	Very dense	Vertical fractures, sand lenses, and crude sub-horizontal bedding common
Qva	Advance Outwash Deposits	Well-sorted sand and gravel deposited by streams issuing from advancing ice sheet. May grade upward into till. Silt lenses locally present in upper part and are common in lower part. Generally unoxidized to only slightly oxidized. May be overlain by Vashon till in areas too small to show at map scale. Includes Esperance Sand Member of the Vashon Drift of Mullineaux and others (1965). Grades downward into unit Qvlc with increasing silt content	Locally over 60 m thick; wide-spread	Dense to very dense	Predominantly medium grained sand, horizontally to cross bedded, hard silt beds common throughout
Qvlc	Lawton Clay of Mullineaux and others (1965)	Laminated to massive silt, clayey silt, and silty clay with scattered dropstones deposited in lowland proglacial lakes. Marks transition from nonglacial to earliest glacial time, although unequivocal evidence for glacial or nonglacial origin may be absent. Deposits of correlative age and texture may be included in older fine-grained units where evidence of age and/or depositional environment is absent. Locally may include fine-grained sediment of unit Qob or distal deposits from the Cascade Mountains where indistinguishable from Qvlc	> 30 m; generally present in pre-Vashon valleys below 240 ft in elevation	Very stiff to hard	Vertical fractures, fine sand partings common near top and bottom of unit
Pleistocene	OLDER GLACIAL AND NONGLACIAL DEPOSITS				
Qpf	Deposits of pre-Fraser glaciation age	Interbedded sand, gravel, silt, and diamicts of indeterminate age and origin. Locally divided into:		Very dense and hard	Localized iron-oxide cemented layers, interbedded and intermixed fine- and coarse-grained layers
Qpfn	Nonglacial deposits	Sand, gravel, silt, clay, and organic deposits of inferred nonglacial origin, based on the presence of peat, paleosols, and tephra layers; or a southern Cascade Range provenance for sedimentary clasts	3 to 7 m	Very dense and hard	Localized iron-oxide cemented layers, interbedded and intermixed fine- and coarse-grained layers
Qob MIS 3 18-70 ka	Olympia beds of Minard and Booth (1988)	Sand, silt (locally organic-rich), gravel, and peat, discontinuously and thinly interbedded; may contain tephra and/or diatomaceous layers. Sand and gravel clast lithology varies depending on source area, from volcanic to reworked northern lithologies. Assigned to the Olympia interglaciation of Mullineaux and others (1965) on the basis of stratigraphic position, correlation, and radiocarbon dates. Distinguished from Qvlc on the basis of coarser grain size and presence of organics. Locally identified previously as the 'sandy phase of the Lawton'	Absent to 25 m	Very dense and hard	Localized iron-oxide cemented layers, interbedded and intermixed fine- and coarse-grained layers

Map not to scale.

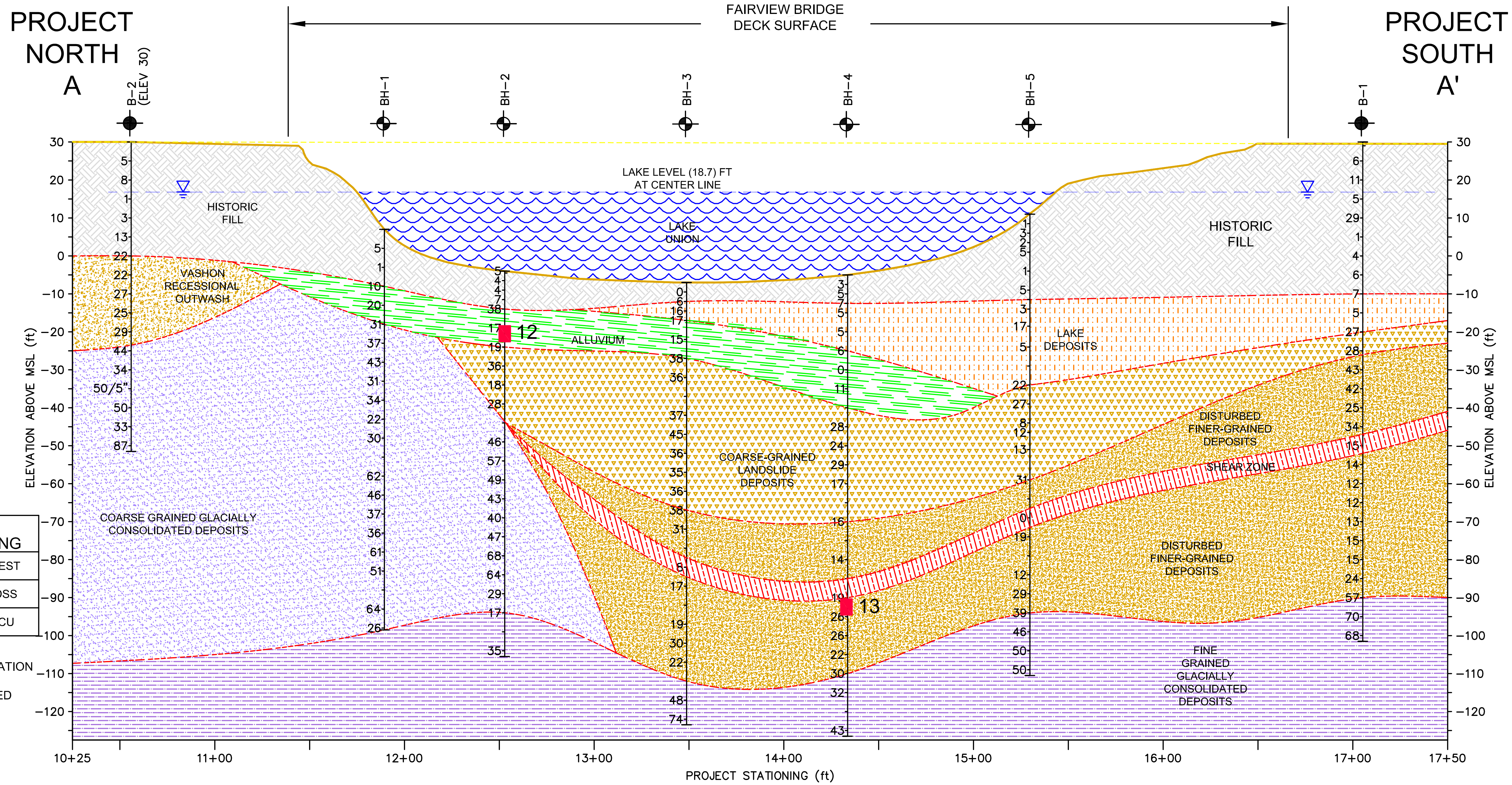
HWA GEOSCIENCES INC.

GEOLOGIC MAP

GEOLOGY & SOILS TECHNICAL MEMORANDUM
FAIRVIEW AVENUE NORTH BRIDGE REPLACEMENT
SEATTLE, WASHINGTON

FIGURE NO. 3

PROJECT NO. 2011-118



LOCATION OF ADVANCED TESTING

No.	SAMPLE ID	TEST
12	S-6b	DSS
13	S-21	CU

13 ■ APPROXIMATE LOCATION OF ADVANCED LAB TESTING COMPLETED

LEGEND

BH-1 BOREHOLE DESIGNATION

SP USCS SOIL CLASSIFICATION

29 STANDARD PENETRATION BLOW COUNT (N-VALUES)

INFERRED GEOLOGIC CONTACT

35 BOTTOM OF BORING

BH-5 HWA BORINGS

B-2 ASPECT (2009) BORINGS

HISTORIC FILL - Loose, silty sand to slightly silty sand with gravel and wood debris.

VASHON RECESSIONAL OUTWASH - Loose to medium dense, slightly silty fine sand with gravel, scattered wood debris and thin organic layers.

COARSE GRAINED GLACIALLY CONSOLIDATED DEPOSIT - Very dense sand with variable amounts of silt and gravel.

LAKE DEPOSITS - Very soft to medium stiff organic rich, silt and clay interbedded with very loose to medium dense silty sands to slightly silty sands with wood debris.

ALLUVIUM - Loose, silty sand to slightly silty sand with gravel and wood debris.

COARSE-GRAINED LANDSLIDE DEPOSITS - Medium dense to very dense sand with disturbed bedding. Variable gravel and silt content.

DISTURBED FINER-GRAINED DEPOSITS - Silt and sand deposits with disturbed bedding; scattered gravel.

SHEAR ZONE - Soft, clayey silt to silty clay, possessing a highly disturbed appearance and the consistency of toothpaste.

FINE GRAINED GLACIALLY CONSOLIDATED DEPOSITS - Hard clay with scattered slickensides and massive bedding.

SCALE: 1H:2V

HORIZONTAL SCALE: 1"=60'

0' 30' 60' 120'

0' 15' 30' 60'

VERTICAL SCALE: 1"=30'

SCALES ARE SET FOR 11X17 SHEETS. IF OTHER SIZE SHEET ARE USE SCALE TO FIT

HWA GEOSCIENCES INC.

GEOLOGY & SOILS TECHNICAL MEMORANDUM
FAIRVIEW AVENUE
NORTH BRIDGE REPLACEMENT
SEATTLE, WASHINGTON

GEOLOGIC PROFILE A-A'

DRAWN BY: EFK	FIGURE #: 4
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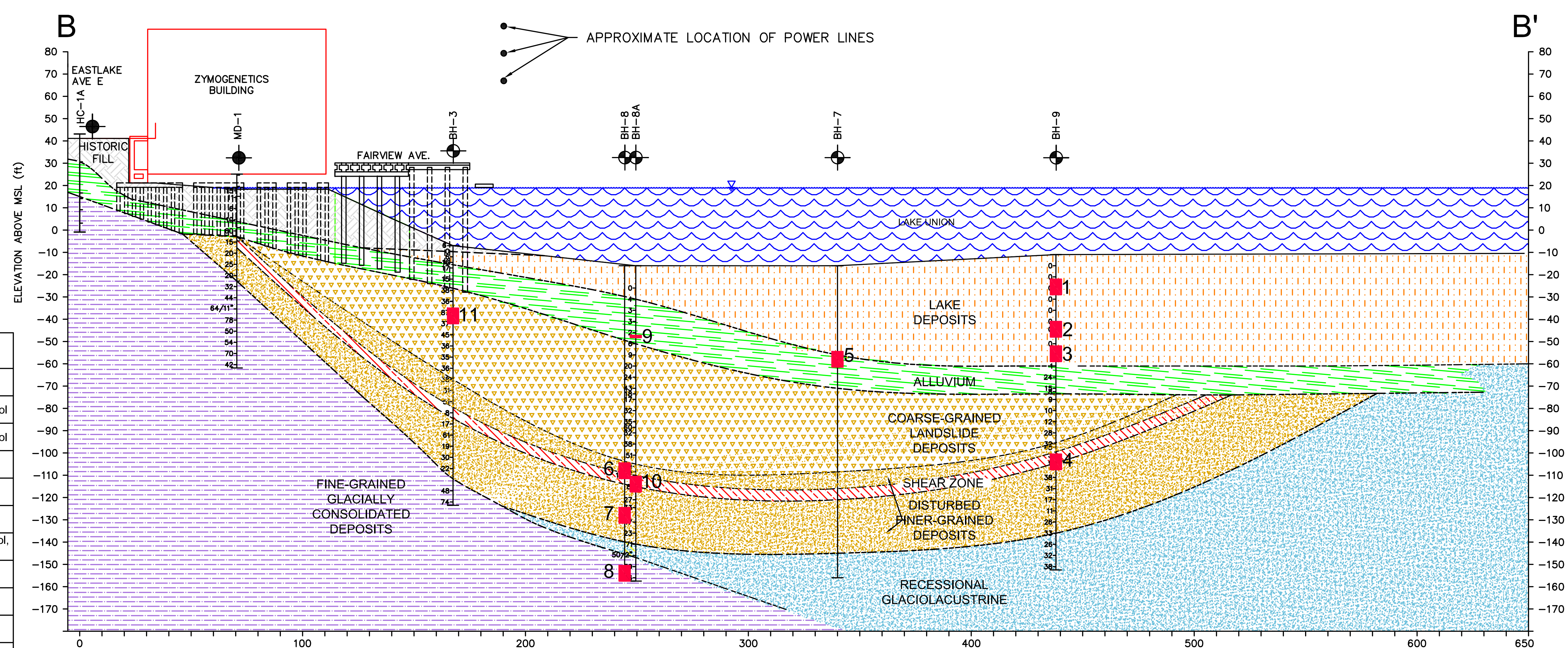
DATE: 1-21-13	



LOCATION OF ADVANCED TESTING		
No.	SAMPLE ID	TEST
1	S-3	I-D Consol
2	S-8	I-D Consol
3	S-11	CU
4	S-24	UU
5	SS-1	UU
6	SS-1	I-D Consol, CU
7	SS-2	CU
8	SS-3	CU
9	S-7a	DSS
10	S-23	UU
11	S-9	DSS

11 APPROXIMATE LOCATION OF ADVANCED LAB TESTING COMPLETED

HISTORIC FILL - Loose, silty sand to slightly silty sand with gravel and wood debris.

FINE GRAINED GLACIALLY CONSOLIDATED DEPOSITS - Hard clay with scattered slickensides and massive bedding.

LAKE DEPOSITS - Very soft to medium stiff organic rich, silt and clay interbedded with very loose to medium dense silty sands to slightly silty sands with wood debris.

ALLUVIUM - Loose, silty sand to slightly silty sand with gravel and wood debris.

COARSE-GRAINED LANDSLIDE DEPOSITS - Medium dense to very dense sand with disturbed bedding. Variable gravel and silt content.

DISTURBED FINER-GRAINED DEPOSITS - Silt and sand deposits with disturbed bedding; scattered gravel.

SHEAR ZONE - Soft, clayey silt to silty clay, possessing a highly disturbed appearance and the consistency of toothpaste.

RECESSIONAL GLACIOLACUSTRINE - Very stiff silt and clay and dense to very dense silty sand with scattered gravel.

LEGEND

BH-1 — BOREHOLE DESIGNATION

SP — USCS SOIL CLASSIFICATION

29 — STANDARD PENETRATION BLOW COUNT (N-VALUES)

35 — INFERRED GEOLOGIC CONTACT

BOTTOM OF BORING

BH-5 HWA BORINGS

B-2 HART CROWSER BORINGS

VERTICAL SCALE: 1"=50'

HORIZONTAL SCALE: 1"=50'

BASE MAP PROVIDED BY: PERTEET ENGINEERING

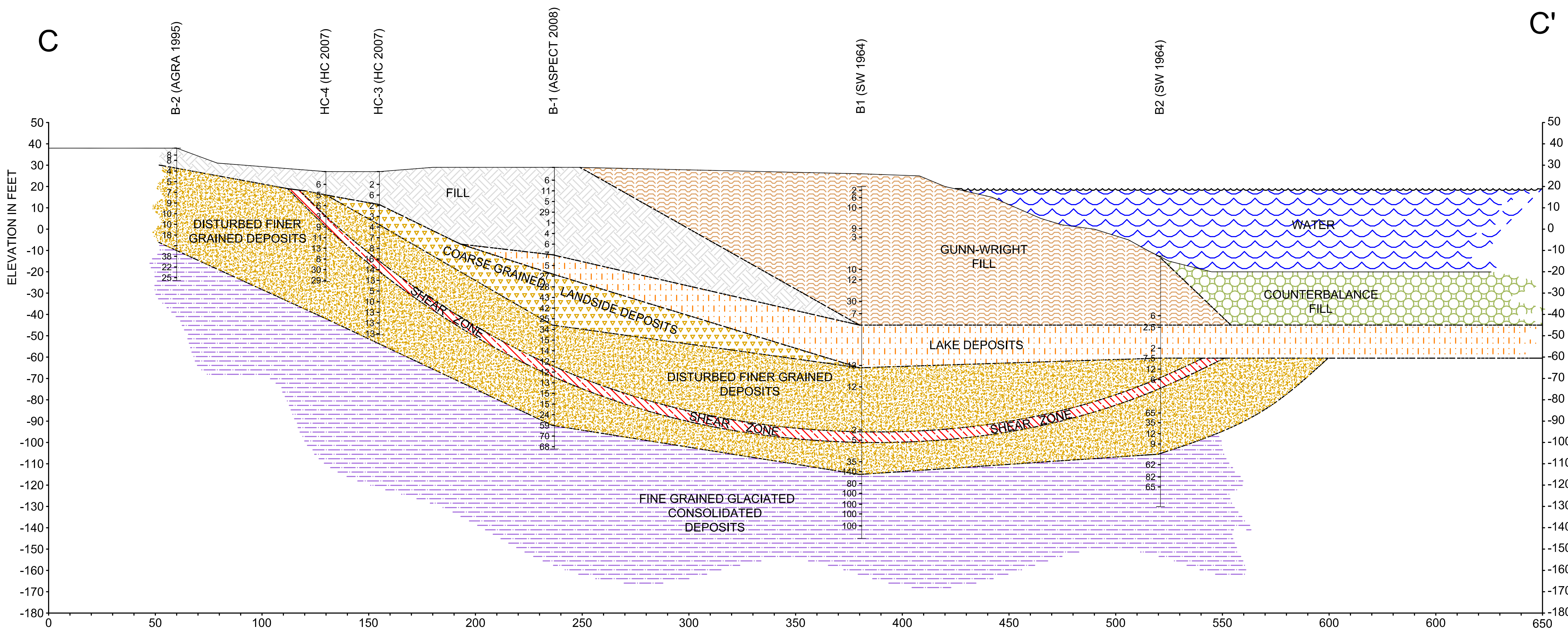
HWA GEOSCIENCES INC.

GEOLOGY & SOILS TECHNICAL MEMORANDUM
FAIRVIEW AVENUE
NORTH BRIDGE REPLACEMENT
SEATTLE, WASHINGTON

GEOLOGIC PROFILE B-B'

DRAWN BY	FIGURE #
EFK	5
CHECK BY	PROJECT #
DH/BT	2011-118-21
DATE: 1-21-13	

S:\2011 PROJECTS\2011-118-21 FAIRVIEW AVENUE EAST BRIDGE\CAD 2011-118\HWA 2011-118 FAEB3.DWG <Fig 5 Geology & soils Tech Memo T1502.2> Plotted: 2/13/2014 9:45 AM



GUNN-WRIGHT FILL - Soft to medium stiff silt and clay placed in the 1960's.

COUNTERBALANCE FILL - Soft to medium stiff clay with sand and gravel placed in 1965.

FILL - Loose, silty sand to slightly silty sand with gravel and wood debris.

ALLUVIUM - Loose, silty sand to slightly silty sand with gravel and wood debris.

SHEAR ZONE - Soft, clayey silt to silty clay, possessing a highly disturbed appearance and the consistency of toothpaste.

FINE GRAINED GLACIALLY CONSOLIDATED DEPOSITS - Hard clay with scattered slickensides and massive bedding.

COARSE-GRAINED LANDSLIDE DEPOSITS - Medium dense to very dense sand with disturbed bedding. Variable gravel and silt content.

RECESSIONAL GLACIOLACUSTRINE - Very stiff silt and clay and dense to bery dense silty sand with scattered gravel.

LAKE DEPOSITS - Very soft to medium stiff organic rich, silt and clay interbedded with very loose to medium dense silty sands to slightly silty sands with wood debris.

DISTURBED FINER-GRAINED DEPOSITS - Silt and sand deposits with disturbed bedding; scattered gravel.

LEGEND

BH-1	BOREHOLE DESIGNATION
SP	USCS SOIL CLASSIFICATION
29	STANDARD PENETRATION BLOW COUNT (N-VALUES)
	INFERRED GEOLOGIC CONTACT
35	BOTTOM OF BORING

VERTICAL SCALE: 1"=50'

0 25' 50' 75' 100'

HORIZONTAL SCALE: 1"=50'

BASE MAP PROVIDED BY: PERTEET ENGINEERING

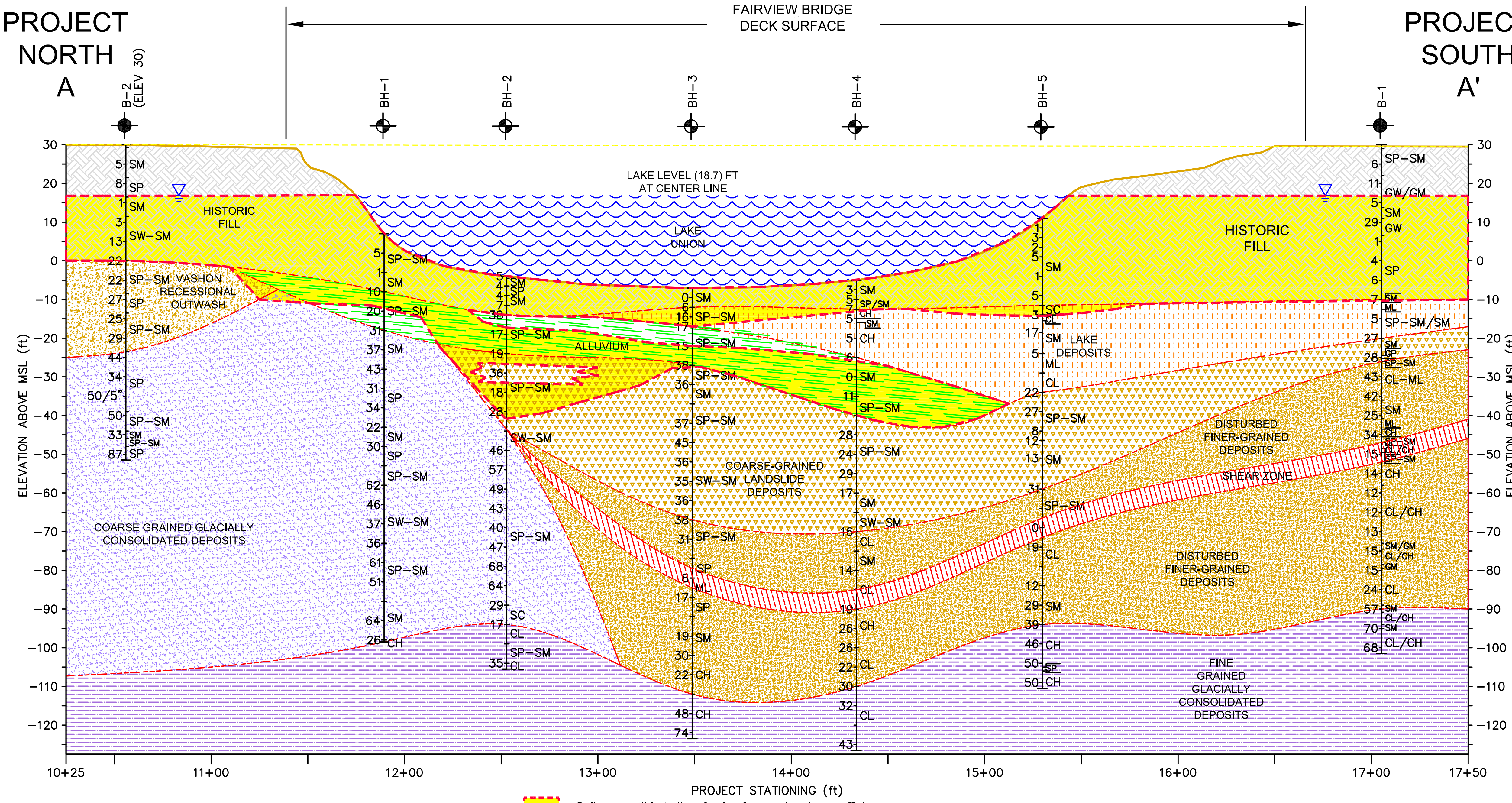
HWA GEOSCIENCES INC.

GEOLOGY & SOILS TECHNICAL MEMORANDUM
FAIRVIEW AVENUE
NORTH BRIDGE REPLACEMENT
SEATTLE, WASHINGTON

GEOLOGIC PROFILE C-C'

DRAWN BY: EFK	FIGURE #: 6
CHECK BY: DH	PROJECT #: 2011-118-21
DATE: 1.21.13	

S:\2011 PROJECTS\2011-118-21 FAIRVIEW AVENUE EAST BRIDGE\CAD 2011-118\HWA 2011-118 FAEB3.DWG <Fig 6 Geology & Soils Tech Memo T1502.2> Plotted: 2/13/2014 9:47 AM



Soil susceptible to liquefaction for acceleration coefficient = 0.37g obtained from site response analyses

FILL - Loose, silty sand to slightly silty sand with gravel and wood debris.

VASHON RECESSIONAL OUTWASH - Loose to medium dense, slightly silty fine sand with gravel, scattered wood debris and thin organic layers.

COARSE GRAINED GLACIAL DEPOSIT - Very dense sand with variable amounts of silt and gravel.

LAKE DEPOSITS - Very soft to medium stiff organic rich, silt and clay interbedded with very loose to medium dense silty sands to slightly silty sands with wood debris.

ALLUVIUM - Loose, silty sand to slightly silty sand with gravel and wood debris.

COARSE-GRAINED LANDSLIDE DEPOSITS - Medium dense to very dense sand with disturbed bedding. Variable gravel and silt content.

DISTURBED FINER-GRAINED DEPOSITS - Silt and sand deposits with disturbed bedding; scattered gravel.

SHEAR ZONE - Soft, clayey silt to silty clay, possessing a highly disturbed appearance and the consistency of toothpaste.

FINE GRAINED GLACIALLY CONSOLIDATED DEPOSITS - Hard clay with scattered slickensides and massive bedding.

BH-5 HWA BORINGS

B-2 ASPECT (2009) BORINGS

LEGEND

BH-1 BOREHOLE DESIGNATION

SP USCS SOIL CLASSIFICATION

29 STANDARD PENETRATION BLOW COUNT (N-VALUES)

INFERRED GEOLOGIC CONTACT

35 BOTTOM OF BORING

SCALE: 1H:2V

HORIZONTAL SCALE: 1"=60'

0' 30' 60' 120'

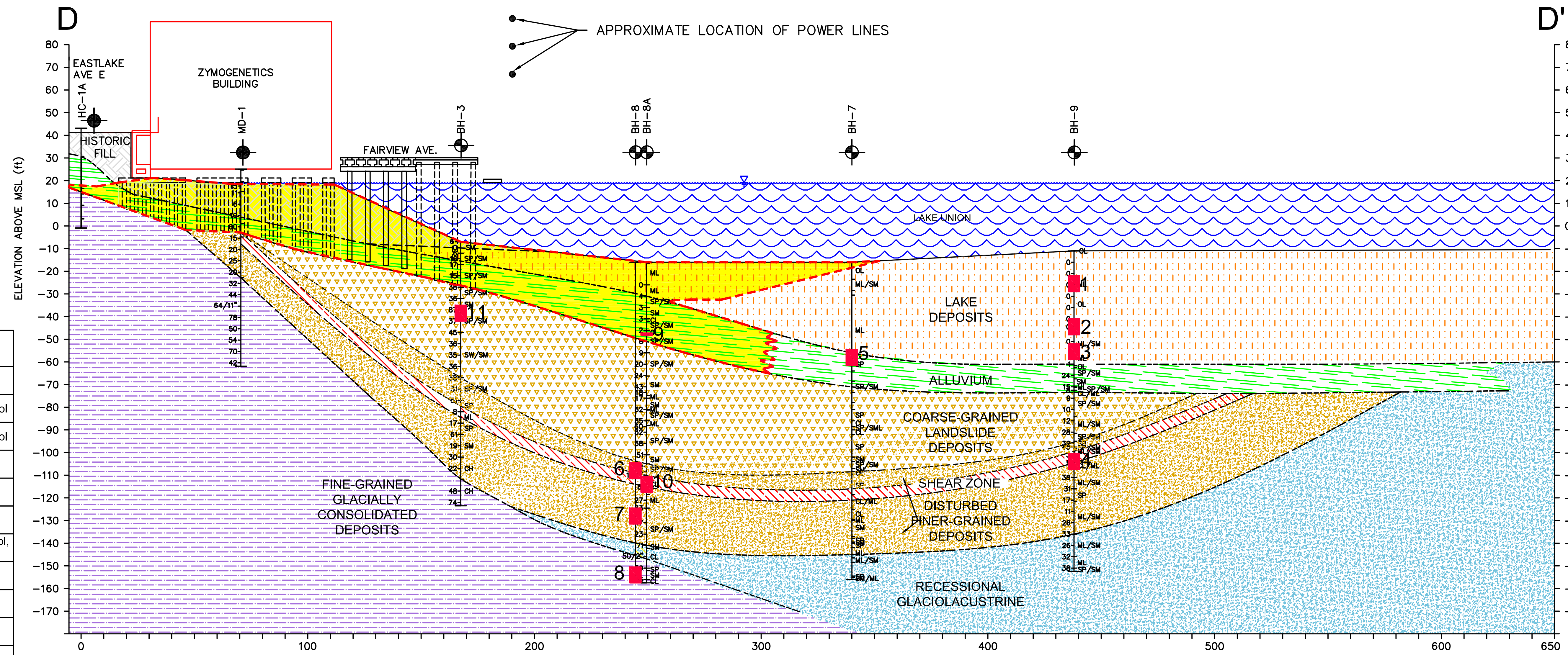
0' 15' 30' 60'

VERTICAL SCALE: 1"=30'

SCALES ARE SET FOR 11X17 SHEETS. IF OTHER SIZE SHEET ARE USE SCALE TO FIT

HWA GEOSCIENCES INC.	GEOLOGY & SOILS TECHNICAL MEMORANDUM FAIRVIEW AVENUE NORTH BRIDGE REPLACEMENT SEATTLE, WASHINGTON	LIQUEFIABLE SOILS ALONG GEOLOGIC PROFILE A-A'	DRAWN BY EFK CHECK BY DC/DH DATE: 1-21-13	FIGURE # 7 PROJECT # 2011-118-21

S:\2011 PROJECTS\2011-118-21 FAIRVIEW AVENUE EAST BRIDGE\CAD 2011-118\HWA 2011-118 FINAL DWG 2.DWG <Fig 7 Geology & Soils Tech Memo T1502.2> Plotted: 3/19/2014 2:34 PM



LOCATION OF ADVANCED TESTING		
No.	SAMPLE ID	TEST
1	S-3	I-D Consol
2	S-8	I-D Consol
3	S-11	CU
4	S-24	UU
5	SS-1	UU
6	SS-1	I-D Consol, CU
7	SS-2	CU
8	SS-3	CU
9	S-7a	DSS
10	S-23	UU
11	S-9	DSS

11 APPROXIMATE LOCATION OF ADVANCED LAB TESTING COMPLETED

Soil susceptible to liquefaction

FILL - Loose, silty sand to slightly silty sand with gravel and wood debris.

ALLUVIUM - Loose, silty sand to slightly silty sand with gravel and wood debris.

SHEAR ZONE - Soft, clayey silt to silty clay, possessing a highly disturbed appearance and the consistency of toothpaste.

FINE GRAINED GLACIALLY CONSOLIDATED DEPOSITS - Hard clay with scattered slickensides and massive bedding.

COARSE-GRAINED LANDSLIDE DEPOSITS - Medium dense to very dense sand with disturbed bedding. Variable gravel and silt content.

RECESSIONAL GLACIOLACUSTRINE - Very stiff silt and clay and dense to very dense silty sand with scattered gravel.

LAKE DEPOSITS - Very soft to medium stiff organic rich, silt and clay interbedded with very loose to medium dense silty sands to slightly silty sands with wood debris.

DISTURBED FINER-GRAINED DEPOSITS - Silt and sand deposits with disturbed bedding; scattered gravel.

LEGEND

BH-1 — BOREHOLE DESIGNATION

SP — USCS SOIL CLASSIFICATION

29 — STANDARD PENETRATION BLOW COUNT (N-VALUES)

INFERRED GEOLOGIC CONTACT

35 — BOTTOM OF BORING

BH-5 HWA BORINGS

B-2 HART CROWSER BORINGS

VERTICAL SCALE: 1"=50'

HORIZONTAL SCALE: 1"=50'

BASE MAP PROVIDED BY: PERTEET ENGINEERING

HWA GEOSCIENCES INC.

GEOLOGY & SOILS TECHNICAL MEMORANDUM
FAIRVIEW AVENUE
NORTH BRIDGE REPLACEMENT
SEATTLE, WASHINGTON

LIQUEFIABLE SOILS ALONG GEOLOGIC PROFILE B-B'

DRAWN BY: EFK
CHECK BY: DH/BT
DATE: 1-21-13
FIGURE #: 8
PROJECT #: 2011-118-21

S:\2011 PROJECTS\2011-118-21 FAIRVIEW AVENUE EAST BRIDGE\CAD 2011-118\HWA 2011-118 FINAL DWG 2.DWG <Fig 8 Geology & soils Tech Memo T1502.2> Plotted: 3/19/2014 2:32 PM