3. ACTION AREA

The *action area* for ESA analysis is defined as “all areas to be affected directly or indirectly by the proposed action and not merely the immediate area directly adjacent to the action” (50 CFR 402.02). The action area includes the project area and all surrounding areas where project activities could potentially affect the environment. The extent of the action area encompasses direct and indirect effects, as well as any effects of interrelated or interdependent actions.

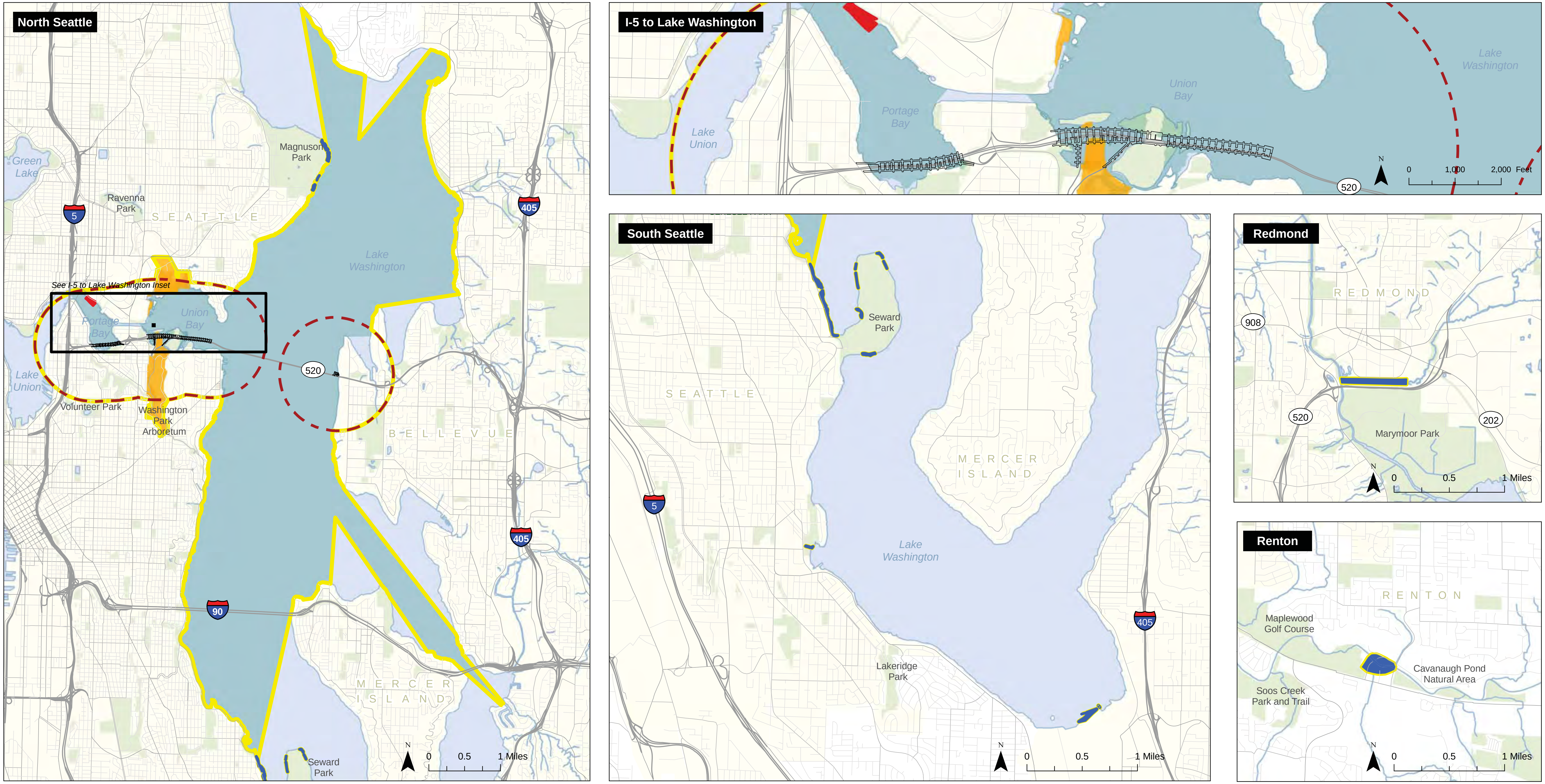
This BA addresses the construction and delivery of pontoons as well as bridge replacement activities in and around Lake Washington (Exhibit 3-1). The action area consists of the locations of several distinct project components and the maximum extent of potential effects associated with each component. These components include the following:

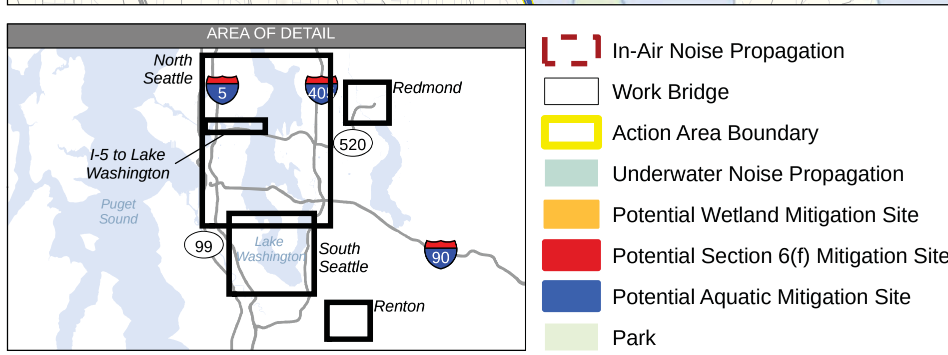
- Pontoon delivery components
  - Port of Olympia (pontoon construction)
  - Port of Tacoma (pontoon construction)
  - Port of Grays Harbor (pontoon retrieval)
  - Pontoon transport from Port facilities
- SR 520, I-5 to Medina components
  - Limits of construction
  - Extent of underwater noise
  - Extent of airborne noise
- Mitigation sites for effects on natural resource and Section 6(f) resources

Summaries of the action area boundary based on each project component are provided in the following subsections.

3.1 Pontoon Delivery Components

This section addresses the pontoon fabrication sites, retrieval of pontoons moored in Grays Harbor, and the routes of pontoon transport to Lake Washington. This BA does not address the construction or moorage of the 33 pontoons in Grays Harbor. These activities are addressed in the ESA Section 7 consultation for the Pontoon Construction Project.





Source: King County (2008) GIS Data (Streams, Streets, Water Bodies), CH2M HILL (2008) GIS Data (Park). Horizontal datum for all layers is NAD83(91), vertical datum for layers is NAVD88.

Exhibit 3-1. **Freshwater Action Areas**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

3.1.1 Port of Olympia

Pontoons will be fabricated at the Port of Olympia Marine Terminal, in Olympia, Washington, located in Sections 11 and 14, Township 18 North, Range 2 West. The facility is located along the West Bay of Budd Inlet. The extent of project-related effects is defined as the aquatic habitat of Budd Inlet, within a 0.5-mile radius of the terminal area (Exhibit 3-2) to capture activities associated with placing pontoons ready for transport on barges. Pontoon fabrication activities on the terminal site will be within the baseline conditions for the port.

3.1.2 Port of Tacoma

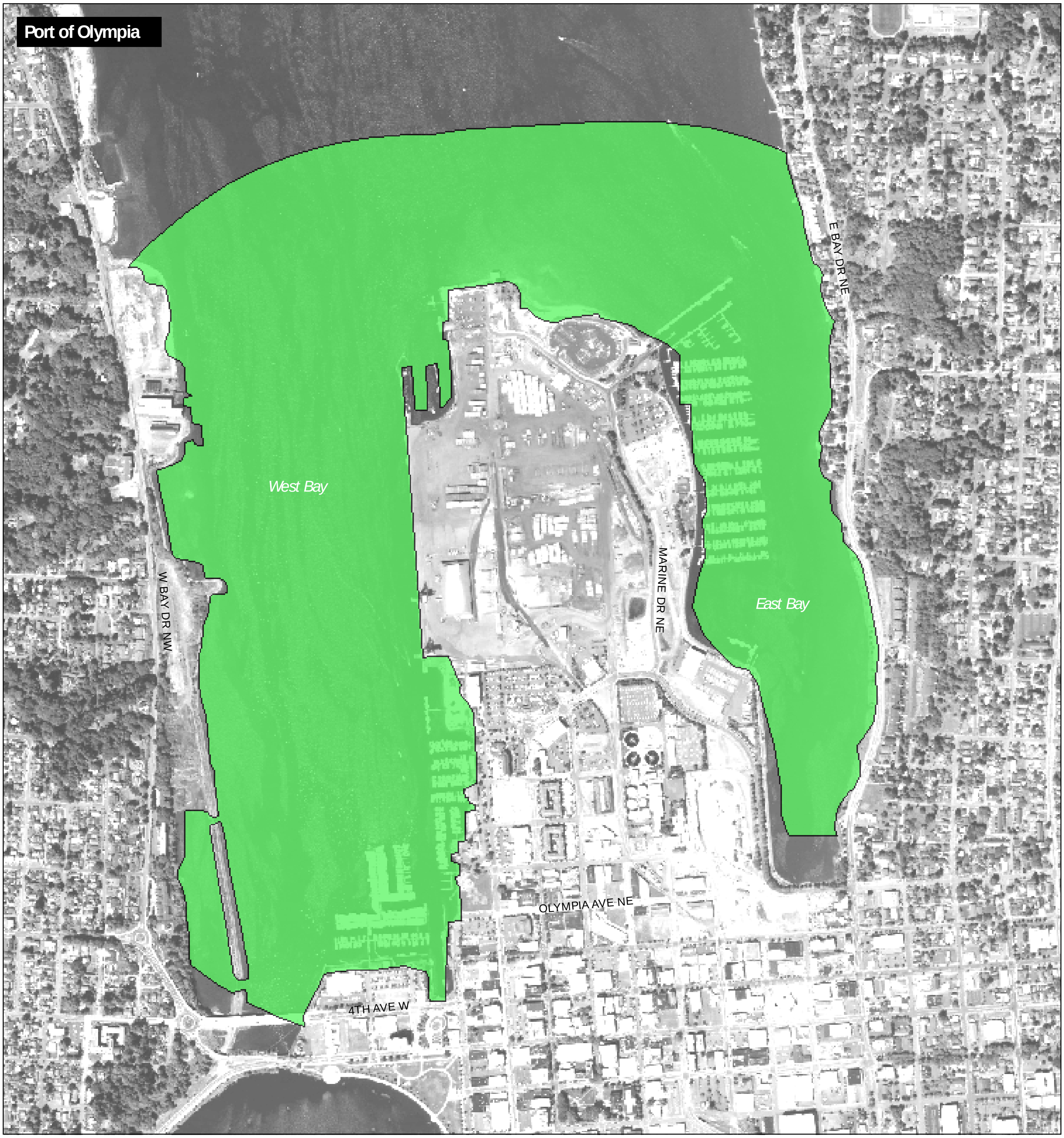
Pontoons will be fabricated at the Port of Tacoma facility located at 1202 Port of Tacoma Road, Tacoma, Washington, in Section 34, Township 21 North, Range 3 East. The facility is located along the Blair Waterway. The extent of project-related effects is defined as the Blair Waterway, extending 0.5 mile northwest and southeast (i.e., up current and down current) of the project area (Exhibit 3-3).

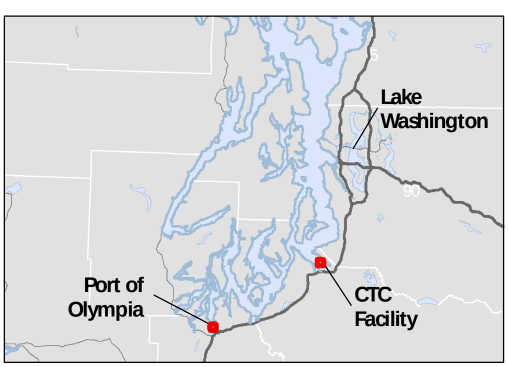
3.1.3 Port of Grays Harbor

Pontoons constructed at the Gray Harbor facility as part of the Pontoon Construction Project will be moored at a designated moorage location in the south-central portion of Grays Harbor. Those pontoons will be towed from their moorage location for incorporation into the new floating bridge (Exhibit 3-4).

3.1.4 Pontoon Transport

The action area includes the travel routes over which the pontoons will be towed to Lake Washington from Grays Harbor and Puget Sound (Exhibit 1-3). These routes will follow existing shipping channels along the Washington coast, within Puget Sound and through the Lake Washington Ship Canal to Lake Washington and the Evergreen Point Bridge.





Action Area

Source: USDA-FSA (2006) Aerial Photo, NAIP (2009) Aerial Photo. Horizontal datum for all layers is NAD83(91) ; vertical datum for layers is NAVD88.

0 250 500 1,000 Feet

Exhibit 3-2. **Action Area – Port of Olympia**

SR520, I-5 to Medina: Replacement and HOV Project

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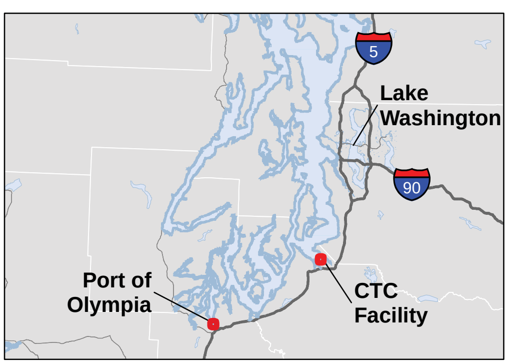

Action Area

N
0 250 500 1,000 Feet

Source: USDA-FSA (2006) Aerial Photo, NAIP (2009) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 3-3. **Action Area – Port of Tacoma**

SR 520, I-5 to Medina: Replacement and HOV Project

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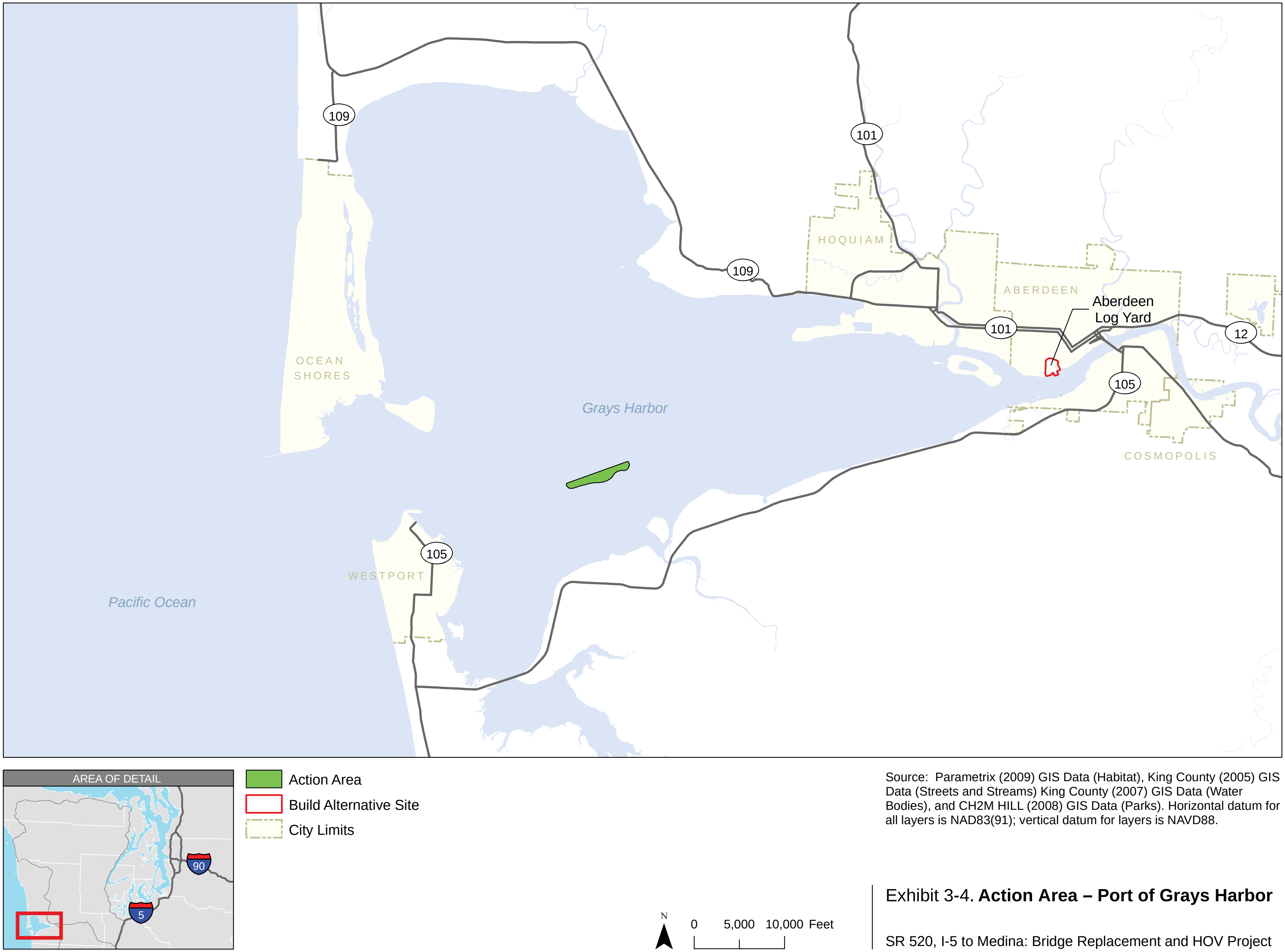

Action Area

Build Alternative Site

City Limits

N

0 5,000 10,000 Feet

Source: Parametrix (2009) GIS Data (Habitat), King County (2005) GIS Data (Streets and Streams) King County (2007) GIS Data (Water Bodies), and CH2M HILL (2008) GIS Data (Parks). Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 3-4. **Action Area – Port of Grays Harbor**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

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3.2 SR 520, I-5 to Medina Project Components

The SR 520, I-5 to Medina components of the action area are defined by the greater of the extents of either the limits of construction or the loudest piece of proposed construction equipment that will be used for project construction. The project may result in indirect effects that could extend beyond these limits, such as lake-scale water quality improvements due to stormwater management (Section 6.3.4) or minor shifts in traffic or land use (Section 6.5). However the spatial extents of these possible effects are not readily quantifiable.

Pile driving will create the greatest amount of noise during project construction. The pile-driving components of the action area are divided into two zones associated with each pile-driving location: an above-water (or airborne) noise zone and an aquatic (underwater) noise zone. Each of the components is discussed below and followed by a definition of the action area based on these findings (see Exhibit 3-1).

3.2.1 Limits of Construction

The limits of construction are the boundaries within which the construction activities will occur. The limits of construction encompass any physical disturbance of the ground or Lake Washington. This area captures any proximal effects of construction-related ground or aquatic habitat disturbance.

3.2.2 Extent of Airborne Noise

A general equation shows noise propagation loss as 6 A-weighted decibels (dBA) for each doubling of distance in areas of hard surfaces, such as concrete or water (WSDOT 2010b). In areas with landscape features and vegetation that intercept sound waves, also referred to as soft sites, noise attenuates at 7.5 dBA per doubling of distance from the source (WSDOT 2010b). The project area is considered to exhibit hard site conditions.

Pile driving will be required for constructing temporary work bridges, constructing new bridge structures, and shoring up hillsides before installing retaining walls. Pile driving can produce maximum short-term noise levels of 99 to 105 dBA at 50 feet (WSDOT 20010b. For the purposes of this BA, pile driving is assumed to generate noise levels of 105 dBA at 50 feet.

Baseline daytime environmental noise levels in the project area were measured as a part of the SR 520 Test Pile Program (Illingworth and Rodkin 2010). Based on a review of these data, ambient noise in Portage Bay, Union Bay, and the west approach area was conservatively estimated at 73 dBA (at 50 feet from the source). Traffic noise levels were established with the use of a table in the WSDOT *Advanced Training Manual: Biological Assessment Preparation for Transportation Projects* (WSDOT 2010b) to predict line-source traffic noise levels. The table uses both the average hourly traffic volume at the site and the posted speed limit of the roadway. Within the action area, SR 520 conveys more than 6,000 vehicles per hour and has a posted speed limit of 55mph, indicating that traffic noise is approximately 77dBA.

The pile driving is considered a point source, whereas the traffic is considered a line source, and noise from the two sources attenuates at different rates (6 and 3 dBA per doubling of distance, respectively). Therefore, the range in which the attenuation lines cross (become indistinguishable) is well beyond the range in which sound levels from pile driving attenuate to less than the estimated urban background noise levels (about 73 dBA) (WSDOT 2010b). Based on the noise analysis, the point where airborne construction noise attenuates to background (ambient) levels is about 4,000 feet, or about 0.75 miles, from the location of impact pile-driving activities.

3.2.3 Extent of Underwater Noise

The lowest recorded background noise level in Lake Washington taken during monitoring for the SR 520 Test Pile Program was 120 decibels root mean square (dB_{RMS}) (Illingworth and Rodkin 2010). Using this noise level in the practical spreading loss model (WSDOT 2010b), the distance required for noise transmission from impact pile driving to attenuate to background levels was determined using site-specific measurements on incident-mitigated pile-driving noise (Illingworth and Rodkin 2010). Three separate zones of underwater noise transmission were calculated for Portage Bay and Union Bay, the west approach area, and the east approach area. Noise transmission from pile driving in Portage Bay and Union Bay will extend approximately 2,154 meters (7,065 feet) from the pile-driving locations. Noise transmission from pile driving in the west approach area will extend approximately 13,594 meters (44,588 feet) from the pile-driving locations. Noise transmission from pile driving in east approach area will extend approximately 215,443 meters (706,653 feet) from the pile-driving locations. In all cases, these noise transmission distances are assumed to be interrupted at intersections with land masses.

3.3 Mitigation Sites for Effects on Natural Resources and Section 6(f) Resources

The action area includes sites proposed for mitigating the effects on natural resources and Section 6(f) resources. Mitigation activities are proposed to occur within the project area and at the following sites:

- Washington Department of Natural Resources parcel in Renton (northeast quarter, Section 7, Township 23 North, Range 4 East)
- Cedar River (northwest quarter, Section 23, Township 23 North, Range 5 East)
- Seward Park (west half, Sections 14, 23, and 24, Township 24 North, Range 4 East)
- Magnuson Park (southeast quarter, Section 2 and Southwest quarter, Section 1, Township 24 North, Range 4 East)
- Beer Sheeva Park (southwest quarter, Section 35, Township 24 North, Range 4 East)
- Bear Creek (Sections 11 and 12, Township 25 North, Range 5 East)

- Union Bay Natural Area (Sections 15 and 16, Township 25 North, Range 4 East)
- WSDOT-owned peninsula (northeast quarter, Section 21, Township 25 North, Range 4 East)
- Washington Park Arboretum (east half, Sections 21 and 28, Township 25 North, Range 4 East)
- Arboretum West Site (north side of Portage Bay, off NE Boat Street)

WSDOT is currently developing restoration plans for these sites, and the specific activities that would occur at each site have not been determined. The action area is therefore defined to include these mitigation sites, as well as any adjacent water bodies within 300 feet of the mitigation site boundary. It should be noted that beneficial effects from the proposed mitigation are anticipated on a watershed scale for multiple species. However, no estimate has been made to quantify the spatial extent of these effects. The mitigation site components of the action area are shown in Exhibit 3-5.

3.4 Definition of the Action Area

In summary, the overall action area is defined as the combined area of all of the described components. It includes the greater of the limits of construction, the extent of airborne noise within a 4,000-foot radius of the work bridges, or the extent of underwater noise transmission within a 2,154- to 215,443-meter (7,065- to 706,653-foot) radius of the work bridges, as well as the mitigation sites and the pontoon construction, outfitting, delivery and transport locations. The overall action area is shown in Exhibit 3-5. This is a conservative estimate of the extent to which both in-water and in-air disturbance from construction activities has the potential to affect listed species.

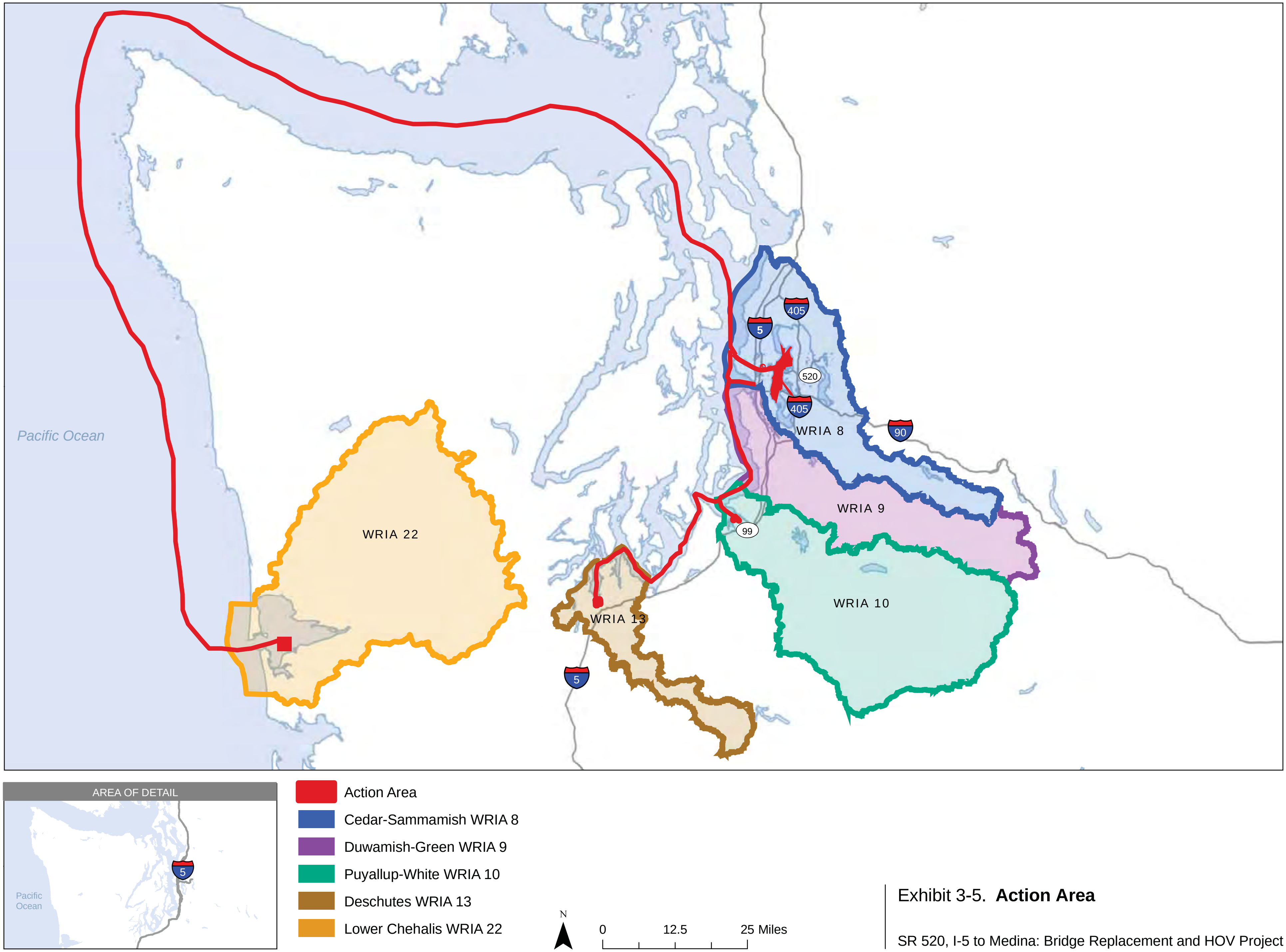

Exhibit 3-5. **Action Area**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

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4. ENVIRONMENTAL SETTING

This section summarizes the current status of the species, their habitat (including designated critical habitat), and the ecosystem in the action area resulting from the past and present effects of all federal, state, or private actions and other human activities , the anticipated effects of all proposed federal projects in the action area that have already undergone ESA consultation, and the effects of state or private actions that are concurrent with the consultation in process (50 CFR 402.02).

4.1 Grays Harbor

4.1.1 Existing Features of Grays Harbor

Grays Harbor is a large estuary, approximately 15 miles long and 13 miles wide, characterized by expansive intertidal mud and sand flats and intervening channels created by discharge from the Chehalis, Hoquiam, Humptulips, Wishkah, Johns, and Elk Rivers. The main tributary to Grays Harbor is the Chehalis River. The Chehalis River basin drains approximately 2,170 square miles and includes portions of Lewis and Thurston Counties, limited areas of Pacific, Cowlitz, Mason, Wahkiakum, and Jefferson Counties, and most of Grays Harbor County.

Grays Harbor is a deepwater port, more than 36 feet deep at MLLW, that contains a sea cargo operation and an activated Foreign Trade Zone (Grays Harbor Economic Development Council 2009). The harbor is divided into two channels (north and south) by shallow flats in the center of the harbor and by Rennie Island at the east end of the harbor.

4.1.2 Past and Present Land Uses of Grays Harbor

Grays Harbor has a long maritime history because of its location as the only deepwater port on the Pacific Coast north of San Francisco and its proximity to timber resources (City of Hoquiam 2008, pg. 105). The harbor is also home to Washington’s largest charter fishing fleet (Grays Harbor Economic Development Council 2009).

Native American tribes within the area, including the Quinault, Chehalis, Queets, Humptulips, Satsop, Wynoochee, and Copalis, were the first to embrace commerce by means of fishing, hunting, and gathering, using the harbor for its supply of salmon, sturgeon, clams, oysters, crabs, mussels, and barnacles. The Quinault retain fishing treaty rights within Grays Harbor.

The harbor was also used by white settlers for its abundance of salmon, oysters, razor clams, and crabs, which led to harvesting, processing, and canning industries. Currently, much of the shoreline of Grays Harbor consists of industrial and commercial development, including active and inactive log yards, lumber and wood processing plants, and ship building businesses (Grays Harbor Economic Development Council 2009).

To enhance the harbor as a shipping port, two jetties (North Jetty and South Jetty) were constructed at the mouth of Grays Harbor in the early 1900s and raised in the 1930s and 1940s. Navigation channels were also dredged within the harbor, which caused adjacent areas of the harbor to erode shortly after the navigation channels were deepened in the early 1990s. Dredging of the navigation channels has changed circulation and physical processes within the harbor (USACE 2006, pg. 15). Currently, there are two deepwater access routes in the estuary: the north and south channels. These channels are periodically dredged to maintain deepwater access for shipping.

Past and present land uses that affect habitat within Grays Harbor include recreational boating; commercial fisheries (i.e., Dungeness crab and salmon); commercial navigation; recreational crabbing, clamming, and fishing; port operations and shipping; anchoring and mooring of recreational vessels; log storage; aquaculture; and pollution from adjacent upland areas (DNR 2008, pg. 27).

4.2 Port of Olympia

There is no riparian vegetation at the Port of Olympia facility. The facility is adjacent to the federal navigation channel in West Bay. West Bay is open to Budd Inlet, a small embayment without an entrance sill, which is subject to the rise and fall of tidal waters. Fresh water enters West Bay through the Deschutes River. According to Ecology (2009), water bodies in the action area are on the 303(d) list for dissolved oxygen.

Aquatic habitat associated with the action area consists of industrial areas that are consistent with the area’s history as a maritime industrial and shipping center. The shoreline consists of completely modified areas, and much of the adjacent shorelines are armored with riprap or concrete. Some pile-supported over-water pier structures are also present in the vicinity. Macroalgae coverage is sparse, and there are no eelgrass beds in Budd Inlet (DNR 2001).

There are no fish barriers between Budd Inlet and the West Bay; therefore, any fish using the bay, including forage fish and salmonids, could migrate into the bay, action area, and facility vicinity. Puget Sound Chinook salmon and steelhead trout currently use Budd Inlet for foraging and migration into the Deschutes River (StreamNet 2010a). Juveniles use the estuary during their transition to the marine environment and for foraging. The closest Puget Sound tributary with migratory bull trout is the Puyallup River, located more than 30 miles via water to the northeast (StreamNet 2010a); therefore, bull trout use of Budd Inlet and the West Bay is likely limited to foraging.

4.3 Port of Tacoma

There is no riparian vegetation at the CTC facility, but there is a thin strip of riparian vegetation just east of the facility. Generally, riparian vegetation in the Blair Waterway is limited to sparse weedy vegetation along the top of the shoreline bank, including Himalayan blackberry

(*Rubus discolor*), Scot's broom *Cytisus scoparius*), Japanese knotweed (*Polygonum cuspidatum*), and butterfly bush (*Buddleja davidii*) (Port of Tacoma 2008).

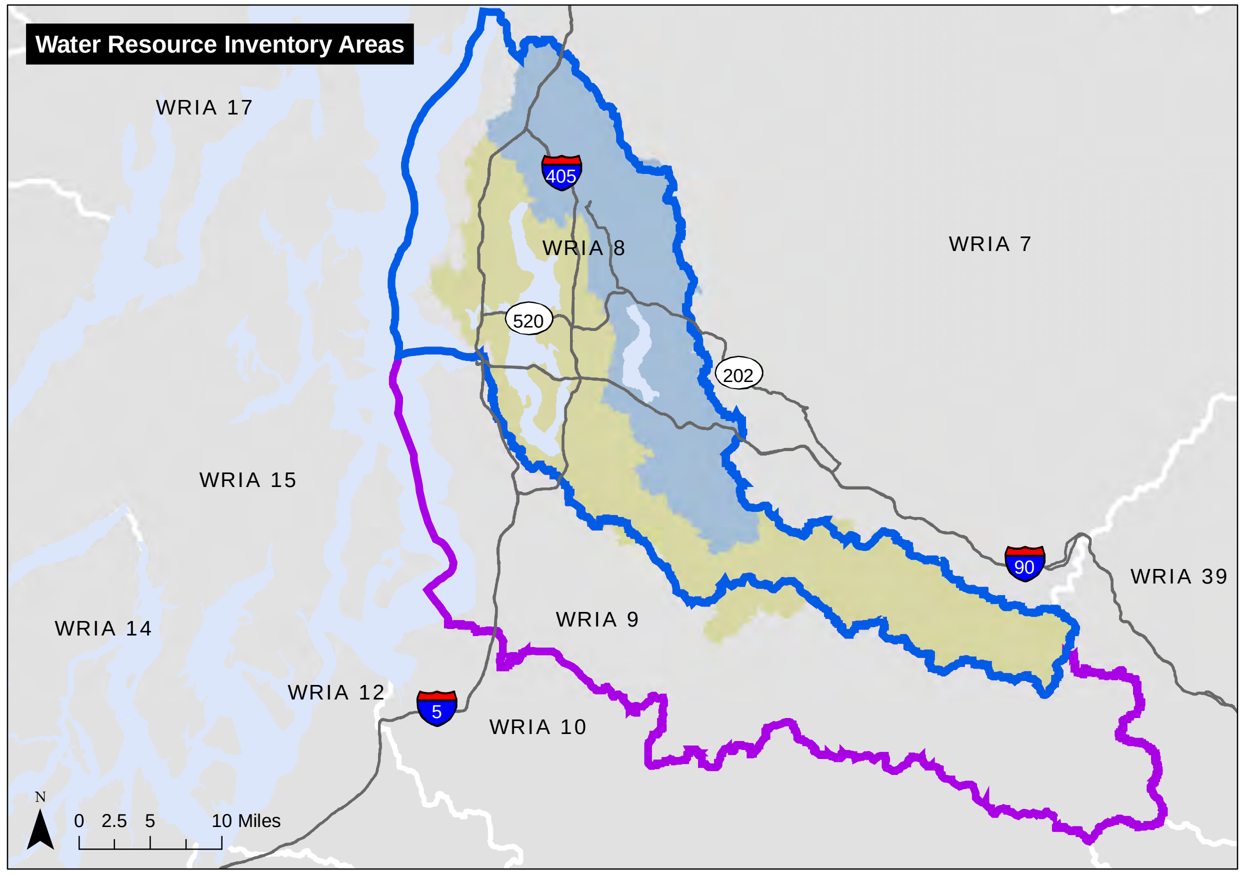
Aquatic conditions associated with the action area are consistent with historical maritime industrial and shipping activities. The shoreline consists of completely modified areas, and much of the adjacent shorelines are armored with riprap or concrete. Some pile-supported over-water pier structures are also present in the vicinity. Macroalgae coverage is sparse, consisting primarily of sea lettuce (*Ulva fenestrata*). At approximately +1 foot MLLW, sea lettuce, sugar kelp (*Saccharina latissima*), *Gracilaria* spp., and *Ceramium* spp. have been observed in the waterway (Port of Tacoma 2008).

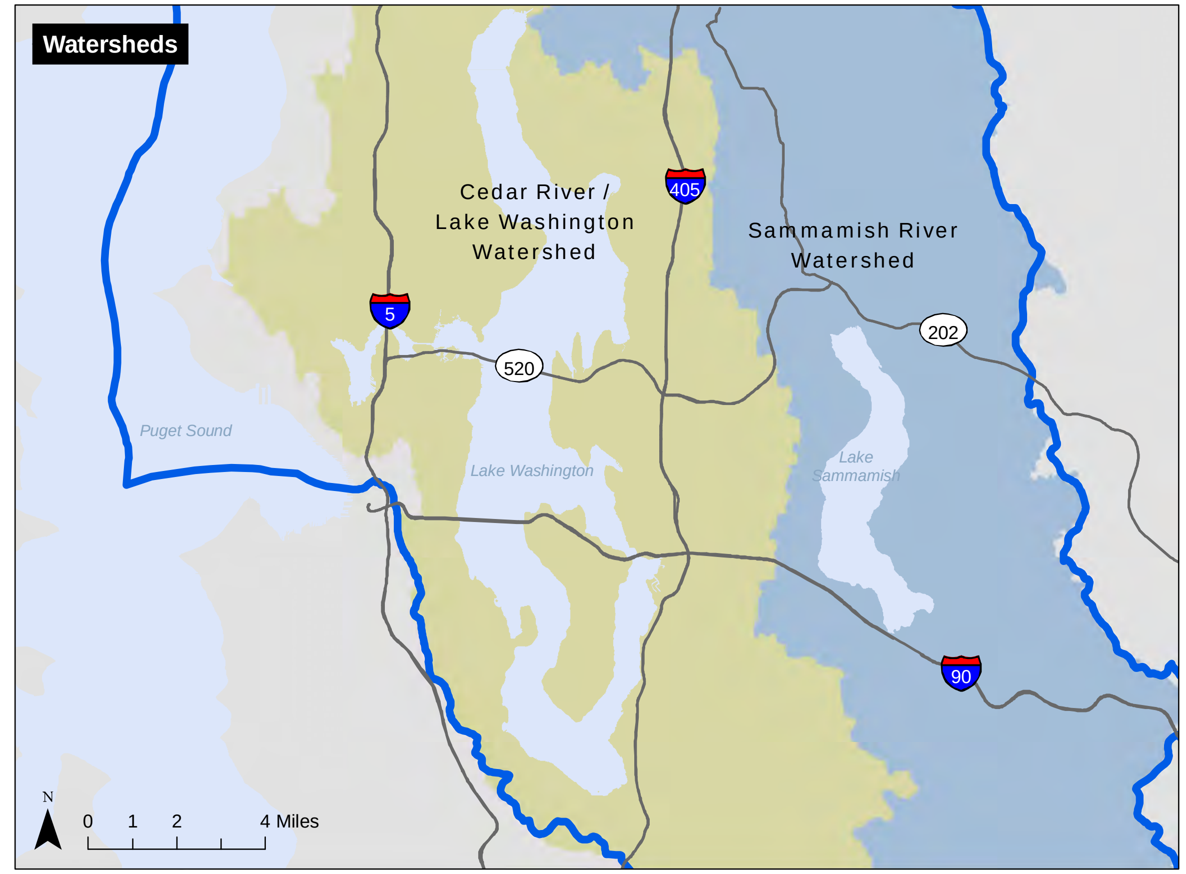
The Blair Waterway is open to Commencement Bay and is tidally influenced. Fresh water enters the Blair Waterway through Wapato Creek, located at the head of the waterway, and numerous stormwater outfalls. According to Ecology (2009), water quality in the area is listed as impaired in terms of benzene concentrations, and the sediment concentrations of hexachlorobenzene exceed state sediment management standards.

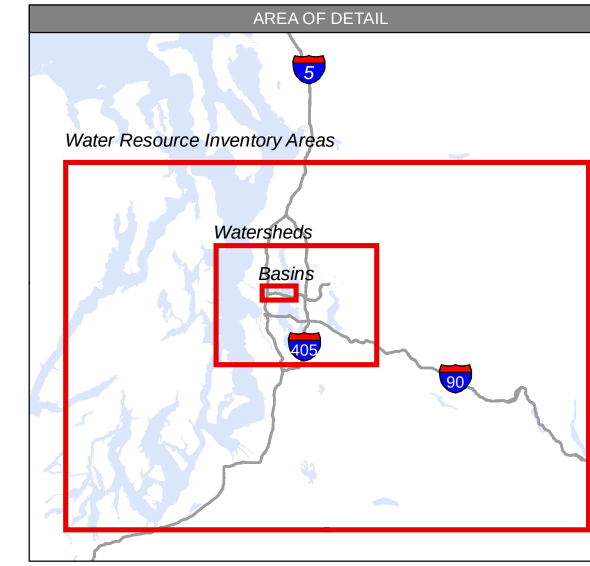
There are no fish barriers between Commencement Bay and the Blair Waterway; therefore, any fish using the bay, including forage fish and salmonids, could migrate into the waterway. Juvenile Chinook salmon have been documented as using the shorelines of the Blair Waterway early in the spring, and are present nearshore and offshore throughout the waterway and adjacent areas after mid-May. Chinook use of the waterway is up to three times greater near the mouth of the waterway than near the head (Duker et al. 1989). While Chinook salmon and bull trout have not been documented in Wapato Creek, winter steelhead have been documented in the creek (StreamNet 2010a). Therefore, Chinook salmon or bull trout use of Blair Waterway is likely limited to foraging, while steelhead trout use likely includes adult and juvenile migration, as well as foraging.

4.4 Lake Washington Watershed

The Lake Washington watershed comprises 13 major drainage basins and numerous smaller drainages, totaling about 656 miles of streams, two major lakes, and numerous smaller lakes (Exhibit 4-1). The watershed, which is also referred to as (WRIA 8, has been dramatically altered from its pre-settlement conditions due to removal of the surrounding forest and extensive urban development. However, the most dramatic alterations occurred in 1903, when the Cedar River was rerouted to flow into Lake Washington rather than into the Black River, the Lake Washington outlet was rerouted from the Black River to the Lake Washington Ship Canal, and the lake elevation was lowered correspondingly by about 9 feet. The majority of the Lake Washington watershed is highly developed, with 63 percent of the watershed fully developed. Lake Washington is the most populated watershed in Washington state (King County 2003).







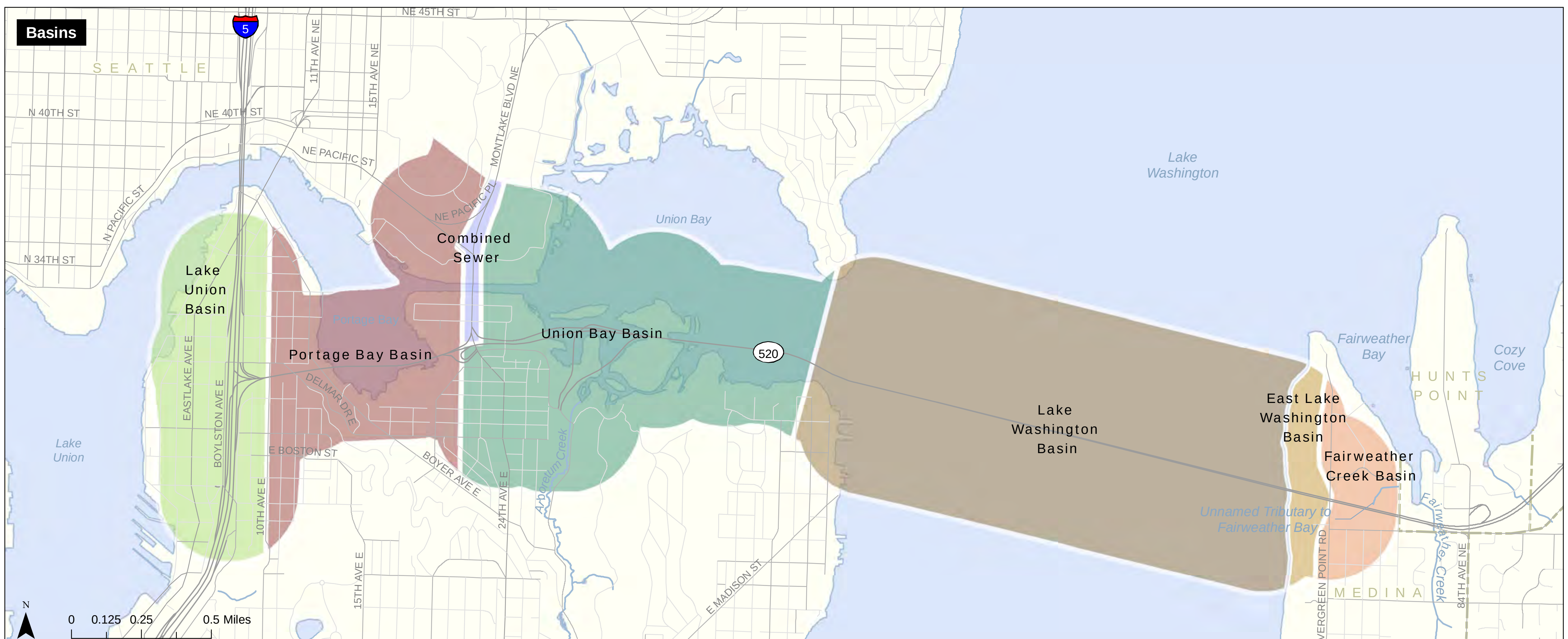
- Water Resource Inventory Area 8 Boundary
- Water Resource Inventory Area 9 Boundary
- Water Resource Inventory Area

Watershed

- Cedar River / Lake Washington Watershed
- Sammamish River Watershed

Basin

- Combined Sewer
- East Lake Washington
- Fairweather Creek
- Lake Union
- Lake Washington
- Portage Bay
- Union Bay



Source: King County (2007) GIS Data Water Bodies), King County (2005) GIS Data (Streets and Streams), King County (2006) GIS Data (Watershed), Ecology (2000) GIS Data (WRIA), Ecology (2001) GIS Data (Shoreline), WSDOT (2004) GIS Data (State Routes). Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 4-1. **Lake Washington Watershed**

I-5 to Medina: Bridge Replacement and HOV Project

In addition to the changes associated with construction of the Ship Canal, the limiting factors report for WRIA 8 (Kerwin 2001) identified five limiting habitat factors and effects on Lake Washington:

- Current and future land use practices and extensive shoreline modifications all but eliminate the possibility of a naturally functioning shoreline to benefit salmonids.
- Introduced plant and animal species have altered trophic interactions between native animal species.
- Historical practices and discharges have contaminated lake sediments.
- The presence of extensive numbers of docks, piers, and bulkheads has greatly altered the shoreline habitat.
- Riparian habitats are generally nonfunctional.

4.5 Lake Washington

Lake Washington is the second largest natural lake in Washington, with 80 miles (128 kilometers) of shoreline. The lake is approximately 20 miles long, with a mean width of approximately 1.5 miles and a circumference of 50 miles. The lake covers 22,138 surface acres and has a mean depth of approximately 100 feet and a maximum depth of approximately 200 feet (Jones and Stokes 2005). Exhibit 4-1 shows the Lake Washington watershed and project subbasins.

4.5.1 Hydrology

The Cedar River is the major source of fresh water to Lake Washington, providing about 50 percent (663 cubic feet per second [cfs]) of the mean annual flow into the lake (NMFS 2008a). The Sammamish River and its tributaries, including the surface waters of Lake Sammamish, are also a substantial source of fresh water to Lake Washington, providing about 25 percent (307 cfs) of the mean annual flow into the lake. The remainder of freshwater input into Lake Washington comes from numerous small creeks located primarily along the northern and eastern shores of the lake.

The natural hydrologic cycle of Lake Washington has been altered from pre-settlement conditions. Historically, the lake’s surface elevation was nearly 9 feet higher than it is today, and seasonal fluctuations further increased that elevation by an additional 7 feet each year (Williams 2000). In 1903, the average lake elevation was recorded at approximately 32 feet (NMFS 2008a).

Historically, elevations of Lake Washington peaked in winter and declined in summer. Current operation of the Ballard Locks, managed by the USACE, produces peak elevations throughout most of the summer. USACE maintains the level of the lake between 20 and 22 feet (City of Seattle and USACE 2008), as measured at the Ballard Locks. 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 (City of Seattle and USACE 2008):

- **Spring refill.** Lake level increases between February 15 and May 1 to 22 feet.
- **Summer conservation.** Lake level is 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 decreases to about 20 feet from the onset of the fall rains until December 1.
- **Winter holding.** Lake level is maintained at 20 feet between December 1 and February 15.

4.5.2 Shoreline Habitat

After construction of the Lake Washington Ship Canal and the subsequent lowering of Lake Washington, about 1,334 acres of shallow-water habitat were transformed into upland areas, reducing the lake surface area by 7 percent and decreasing the shoreline length by about 13 percent (10.5 miles) (Chrzastowski 1981). The most extensive changes occurred in the sloughs, tributary delta areas, and shallow portions of the lake. The area of freshwater marshes decreased about 93 percent, from about 1,136 acres to about 74 acres (Chrzastowski 1981). Essentially, all of the existing wetland and riparian habitat in the lake developed after the lake elevation was lowered. Currently, these habitats primarily occur in Union Bay, Portage Bay, Juanita Bay, and Mercer Slough (Dillon et al. 2000).

The regulation of Lake Washington's surface elevation by USACE has altered the historical shape and structure of the lake shoreline. Historically, vegetation communities predominantly consisting of hardstem bulrush (*Scirpus acutus*) and willows (*Salix* spp.) dominated the shoreline; however, these communities have been replaced with developed shorelines (e.g., armored banks, piers, and floats) and landscaped yards. A survey of 1991 aerial photographs estimated that 4 percent of the shallow-water habitat within 100 feet of the shore was covered by residential piers (excluding coverage by commercial structures and vessels) (Watershed Company 2006). Later studies reported that about 2,700 docks are present in Lake Washington and approximately 71 to 81 percent of the shoreline is armored (Warner and Fresh 1999; City of Seattle 2000; Toft 2001). The density of docks and shoreline modifications throughout the Ship Canal, Portage Bay, and Lake Union is even greater (City of Seattle 1999; Weitkamp and Ruggerone 2000).

Portage Bay is lined by University of Washington facilities, commercial facilities, and houseboats. The southeastern portion of Portage Bay has an area of freshwater marsh habitat and naturally sloped shoreline, while the remainder of the shoreline is developed, with little natural riparian vegetation. The Montlake Cut is a concrete-banked canal that connects Portage Bay to Union Bay, which extends eastward to Webster Point and the main body of Lake Washington.

Before construction of the Ship Canal, Union Bay consisted of open water and natural shorelines extending north to NE 45th Street. The lowered lake levels resulting from the Ship Canal construction produced extensive marsh areas around Union Bay, with substantial portions of this marsh habitat subsequently filled, leaving only the fringe marsh on the south end (Jones and Jones 1975). The south side of the bay is bordered by the Washington Park Arboretum, with a network of smaller embayments and canals and extensive marsh habitats. The north side of Union Bay contains a marshy area previously filled with landfill material that is owned by the University of Washington. Numerous private residences with landscaped waterfronts and dock facilities dominate the remainder of the shoreline.

Some portions of the Lake Washington shoreline are undeveloped, including areas south of SR 520 in Portage Bay and Union Bay. While vegetation is generally limited in the overall action area, the areas south of SR 520 have the highest abundance of natural riparian vegetation, consisting primarily of cattails (*Typha* spp.) and small trees (Weitkamp and Ruggerone 2000).

The loss of natural shoreline has reduced the presence of complex shoreline features such as overhanging and emergent vegetation, woody debris (especially fallen trees with branches and/or rootwads intact), and gravel/cobble beaches. The loss of natural shoreline vegetation and wetlands has reduced the input of terrestrial detritus and insects to support the aquatic food web. The loss of complex shoreline features and shallow-water habitat has reduced the availability of prey refuge habitat and forage for juvenile salmonids.

4.5.3 Water and Sediment Quality

The water quality of Lake Washington has been degraded from historical conditions by both point and nonpoint pollution sources. Nonpoint sources include stormwater and subsurface runoff containing pollutants from roadway runoff, failing septic systems, underground petroleum storage tanks, gravel pits/quarries, landfills and solid waste management facilities, sites with improper hazardous waste storage, and commercial and residential sites treated with fertilizers and pesticides.

Historically, Lake Washington, Lake Union, and the Lake Washington Ship Canal were the direct receiving waters for untreated or partially treated municipal sewage. Most untreated effluent discharges into Lake Washington were eliminated by cleanup efforts in the 1960s and 1970s. Although raw sewage can no longer be discharged directly to the lake, untreated discharges occasionally enter Lake Washington during periods of high precipitation.

Phosphorus concentrations in the lake increased and led to extensive eutrophication (a process of excessive plant growth that occurs when water bodies receive excess nutrients). In the past, blue-green algae dominated the phytoplankton community and suppressed the production of zooplankton. In the mid-1960s, when sewage discharges were diverted from Lake Washington to Puget Sound; the dominance by blue-green algae in the lake subsided, and the zooplankton populations rebounded.

Despite the reversal of the eutrophication trend in the lake, the introduction of Eurasian watermilfoil (*Myriophyllum spicatum*) to Lake Washington in the 1970s has caused additional water quality problems. Watermilfoil and other aquatic vegetation now dominate much of the shallow shoreline habitat of Lake Washington, Lake Union, Portage Bay, and the Ship Canal. Dense communities of aquatic vegetation or floating mats of detached plants can adversely affect localized water quality conditions. Dense communities can reduce the concentration of dissolved oxygen to less than 5 parts per million; moreover, the decomposition of dead plant material increases the biological oxygen demand, further reducing dissolved oxygen concentrations and pH (DNR 1999). Under extreme conditions, these situations can become anoxic, i.e., the oxygen supply is depleted.

In addition, excessive accumulation and decomposition of organic material has transformed areas of natural sand or gravel substrate to fine silt and mud. Substantial shoreline areas of Lake Washington, including the action area, have soft substrate, with substantial accumulations of organic material due to the decomposition of watermilfoil and other aquatic vegetation. The dense vegetation reduces the currents and wave energy in these areas, encouraging the accumulation of fine sediment material. As microorganisms in the sediment break down the organic material, they consume much of the oxygen in the lower part of the lake. By the end of summer, concentrations of dissolved oxygen in the hypolimnion can approach zero. (The hypolimnion is the lowest layer of water in a lake; it is cold and stationary and contains less oxygen than the upper layers.) Despite these effects in some shallow nearshore habitats, mean concentrations of hypolimnetic dissolved oxygen recorded at long-term monitoring sites in the lake between 1993 and 2001 ranged from 7.7 to 8.9 milligrams per liter (mg/L) (King County 2003).

In addition to biological changes in the lake, historical industrial uses in the Lake Washington basin have led to increased concentrations of persistent toxins, such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and heavy metals in lake sediments (King County 1995). The expanding urbanization in the watershed has also increased sediment input into the Lake Washington watershed.

The Ship Canal and Lake Union are listed on the Ecology 303(d) list of impaired water bodies for exceeding water quality criteria for total phosphorus, lead, fecal coliform, and aldrin (Ecology 2009). In addition, portions of Lake Washington are on the 303(d) list for exceeding water quality criteria for fecal coliform, as well as the tissue quality criteria for 2,3,7,8-TCDD, PCBs, total chlordane, 4,4′-DDD, and 4, 4′-DDE in various fish species (Ecology 2009).

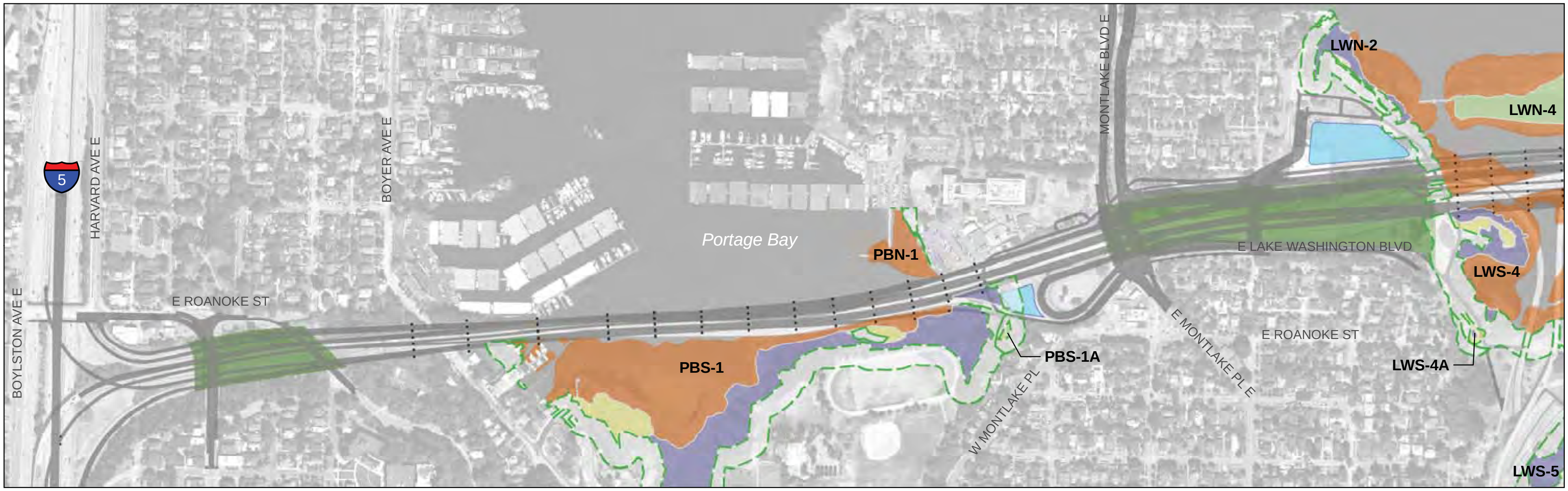
4.6 Wetland Habitat

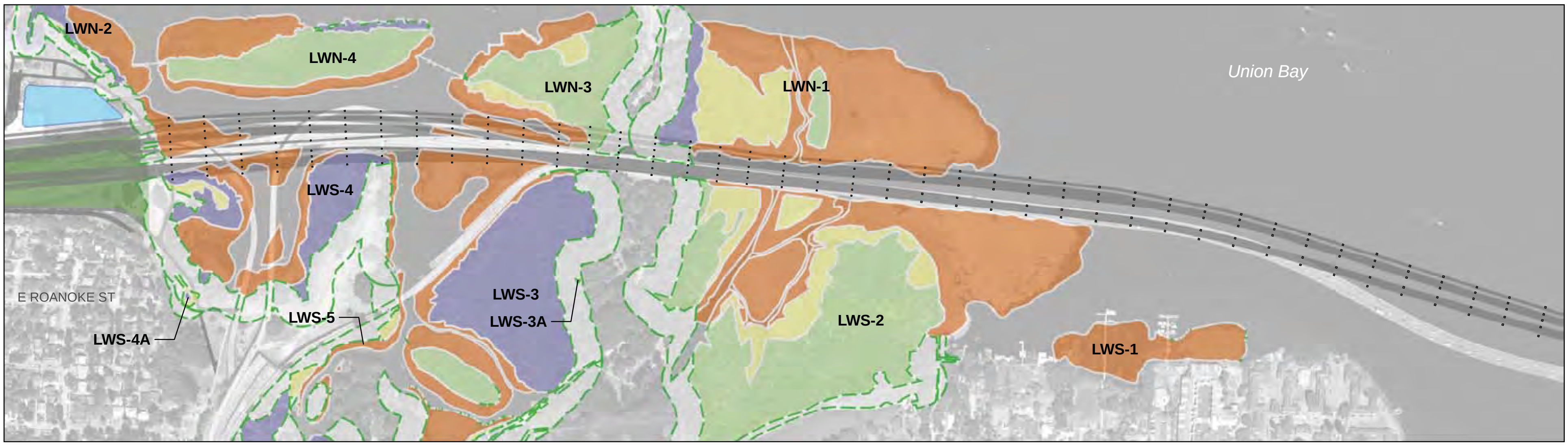
Wetland evaluations identified 15 wetlands in Portage Bay and Union Bay, three associated with Portage Bay and 12 associated with Union Bay. Lake Washington serves as the primary source of water for these wetlands. The managed water level of Lake Washington, as controlled at the Ballard Locks, influences the vertical fluctuation of water in these wetlands.

The three wetlands in Portage Bay occur along the southern shoreline of the bay. These wetlands contain forested, scrub-shrub, emergent, and aquatic bed vegetation communities. The Portage Bay wetlands provide moderate water quality improvement and habitat functions and low hydrologic functions. The 12 wetlands associated with Union Bay form one large wetland complex, which includes portions of the University of Washington campus and the Washington Park Arboretum. Like the Portage Bay wetlands, the Union Bay wetlands contain forested, scrub-shrub, emergent, and aquatic bed vegetation communities. These wetlands provide low to moderate water quality improvement, low hydrologic functions, and low to moderate habitat for a variety of wildlife. Wetlands in the project area are shown in Exhibit 4-2.

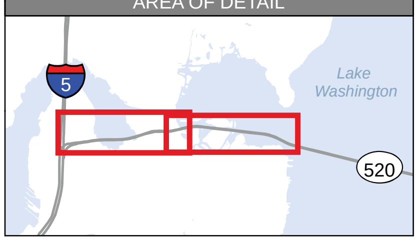
4.7 Upland Habitat

WSDOT identified three types of land cover in the action area: Urban Matrix, Open Water, and Parks and other protected areas (WSDOT 2009f). The Urban Matrix cover type (e.g., commercial and residential buildings with ornamental gardens, lawns, and scattered trees) is the most abundant land cover, covering approximately 52 percent of the action area. Following Urban Matrix, Open Water is the second most abundant land cover, covering approximately 44 percent of the action area. Less than 1 percent of Open Water is covered by bridges, and areas with this cover type provide ample habitat for a variety of water-oriented wildlife such as waterfowl. Parks and other protected areas represent approximately 6 percent of the total land cover in the action area. This land cover type includes upland deciduous forests, riparian forests, and forested, scrub-shrub, and emergent wetlands.





AREA OF DETAIL



- Column
- L2AB Wetland
- PEM Wetland
- PFO Wetland
- PSS Wetland
- Wetland Buffer
- Lid
- Proposed Edge of Pavement

N

0 200 400 800 Feet

Source: King County (2006) Aerial Photo, CH2M HILL (2008) GIS Data (Park). Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 4-2. **Wetlands in the Project Area**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

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4.8 Salmonid Habitat Function Zones

Eight zones have been identified in Lake Washington and the Ship Canal (Exhibit 4-3) to characterize the ecological conditions, salmonid habitat functions, and use of each zone by listed species. Use and timing of ESA-listed species in each zone is provided in Appendix E, Fish Use and Timing in the Project Area.

4.8.1 Habitat Function Zone 1 – Ship Canal West of Portage Bay

The Ship Canal is an 8.6-mile-long man-made navigation waterway connecting Lake Washington to Puget Sound in Seattle. Lake Washington was isolated from Puget Sound until 1903, when the construction of the Lake Washington Ship Canal created a connection from Lake Washington to Puget Sound through Lake Union. From west to east, the Ship Canal passes through Shilshole Bay, the Ballard Locks, Salmon Bay, the Fremont Cut, Lake Union, Portage Bay, the Montlake Cut, and Union Bay on the edge of Lake Washington. All successful juvenile outmigrants and adult returns must pass through this zone during their life cycle.

4.8.2 Habitat Function Zone 2 – Portage Bay

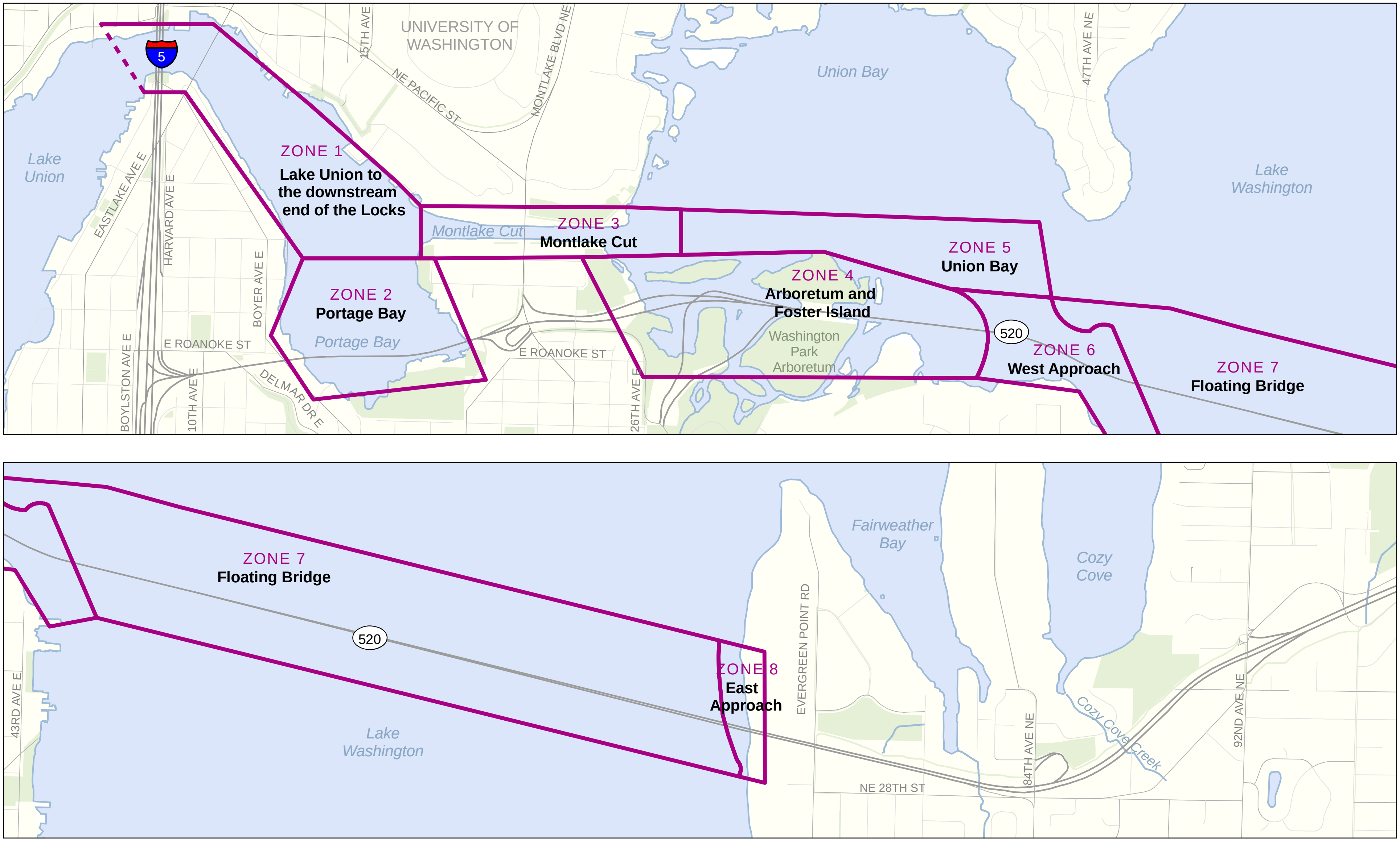
The project area crosses through the southern portion of Portage Bay, which is thought to be south of the primary salmonid migration route through the Ship Canal. This area is a shallow, quiescent bay with abundant aquatic macrophytes during the spring and summer months. It provides limited habitat for anadromous fish populations, which are believed to migrate relatively rapidly through this portion of the Ship Canal.

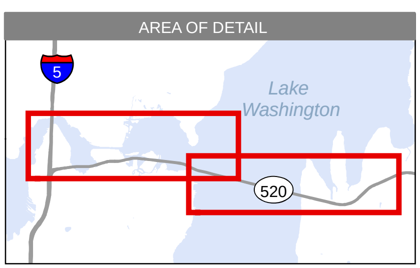
4.8.3 Habitat Function Zone 3 – Ship Canal at Montlake Cut

The Ship Canal at Montlake Cut is relatively shallow, warm, and heavily armored on both sides. The lack of suitable habitat makes fish residency times low; however, all outmigrating juveniles and returning adult salmonids must pass through this segment of the Ship Canal before entering Lake Union or Lake Washington. Construction activities in this area will be conducted primarily from upland areas, with some periodic support from barges and tugboats anchored or positioned in the Montlake Cut.

4.8.4 Habitat Function Zone 4 – Union Bay-Arboretum Waterways

This zone includes the Washington Park Arboretum, Foster Island, and Union Bay. The area is generally characterized by shallow, quiescent waterways where dense growths of macrophytes are abundant during the spring and summer months. This zone does not contain any anadromous salmonid natal streams. Much of this zone is thought to provide habitat for bass and other species that are tolerant of warmer waters and is not considered important or extensively used salmonid habitat.





Salmonid Function Zone
Stream
Park

N
0 500 1,000 2,000 Feet

Source: King County (2005) GIS Data (Streams and Streets), King County (2007) GIS Data (Water Bodies), CH2M HILL (2008) GIS Data (Parks). Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 4-3. **Project Scale – Salmonid Function Zones in Lake Washington**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

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4.8.5 Habitat Function Zone 5 – Union Bay

This area may be used by outmigrating juvenile Chinook salmon for extended time periods (multiple days). It may also provide rearing habitat and refuge for fish about to enter or just exiting the relatively hostile environment associated with the Ship Canal.

4.8.6 Habitat Function Zone 6 – West Approach

This zone occurs east of the dense macrophyte communities associated with Foster Island, out to the 10-meter-depth contour. This area is believed to be the primary migration route for Cedar River juvenile outmigrants and returning adults. Recent fish tracking studies (Celedonia et al. 2008b) suggest this area may be used by outmigrating juvenile Chinook salmon for extended time periods (multiple days) and may provide rearing habitat (primarily in the 2- to 6-meter depths). Fish travelling to or from the south end of Lake Washington generally pass underneath the bridge in this zone.

4.8.7 Habitat Function Zone 7 – Floating Bridge

The floating portion of the Evergreen Point Bridge resides in deeper water (greater than 10 meters deep) and is supported by floating pontoons. This zone is believed to provide limited habitat for the smaller juvenile salmonids, which are generally shoreline oriented; however, adult and larger juvenile salmonids may use this portion of the lake. In addition, juvenile salmonids may migrate into deeper waters at night or in pursuit of feeding opportunities because a preferred food item (zooplankton) tends to be more abundant offshore.

4.8.8 Habitat Function Zone 8 – East Approach

This zone occurs along the east shoreline of Lake Washington, which is thought to be of less importance to migrating juvenile and adult salmonids, as these are generally believed to pass through the action area closer to the western shoreline. It is likely that some shoreline-oriented salmonids use this area.

4.9 Mitigation Sites

Mitigation activities will be implemented to offset effects on aquatic habitat, wetlands, and parks as required by local, state and federal regulations. A total of 10 sites will be required to provide compensatory mitigation for these types of effects: 6 aquatic habitat sites, 3 wetland sites, and 1 park site. The environmental baseline conditions and descriptions for these sites are included with the description of mitigation activities in Sections 2.8.

5. STATUS OF SPECIES AND CRITICAL HABITAT IN THE ACTION AREA

The species addressed in this BA were identified on the basis of a review of the following information:

- Species lists obtained from the USFWS Web site on September 2, 2010 (Appendix A). The species identified by the USFWS are those that are known to occur or have the potential to occur in Grays Harbor County, Thurston County, Pierce County, or King County.
- A species list obtained from the NMFS Web site on September 2, 2010 (Appendix A). The species identified on the NMFS Web site are those that are known to occur or have the potential to occur in Washington state, including the action area.
- WDFW Priority Habitats and Species data, accessed July 6, 2010.
- Washington Department of Natural Resources Natural Heritage Program rare plant data, accessed July 6, 2010.

Based on an evaluation of the potential environmental effects of the project, this BA addresses one marine mammal and three fish species, along with designated critical habitat as appropriate (Exhibit 5-1). Information about the status and distribution of these species and designated critical habitat in the action area is presented in Sections 5.3 and 5.4.

Information about rare, sensitive, threatened, and endangered plant species and plant communities from the Natural Heritage Program indicates that no ESA-listed plant species are known to occur within the action area. Therefore, no plant species are addressed in this BA.

EXHIBIT 5-1.
ESA-LISTED SPECIES ADDRESSED IN THIS BIOLOGICAL ASSESSMENT

Species	Scientific Name	Federal Status	Critical Habitat
Killer whale (Southern Resident DPS)	*Orcinus orca*	Endangered	Designated
Bull trout (Coastal-Puget Sound DPS)	*Salvelinus confluentus*	Threatened	Designated
Chinook salmon (Puget Sound ESU)	*Oncorhynchus tshawytscha*	Threatened	Designated
Steelhead (Puget Sound DPS)	*Oncorhynchus* mykiss	Threatened	Under development
Bocaccio (Puget Sound/Georgia Basin DPS)	*Sebastes paucispinis*	Endangered	None designated
Yelloweye rockfish (Puget Sound/Georgia Basin DPS)	*Sebastes ruberrimus*	Threatened	None designated
Canary rockfish (Puget Sound/Georgia Basin DPS)	*Sebastes pinniger*	Threatened	None designated

DPS = distinct population segment
ESU = evolutionarily significant unit

Exhibit 5-2 lists species and designated critical habitat identified as potentially occurring in the action area that are not addressed in this BA. Exclusion of species from evaluation is based on at least one of the following:

- Lack of potential for effect (indicated by “no effect” in Exhibit 5-2)
- Lack of documented occurrence in the action area
- Lack of suitable habitat in the action area

Further explanation of the basis for exclusion of each species from the evaluation is provided in this section.

EXHIBIT 5-2.
SPECIES AND CRITICAL HABITAT NOT ADDRESSED FURTHER IN THIS BIOLOGICAL ASSESSMENT

Species	Scientific Name	Federal Status	Rationale for Exclusion
Invertebrates			
Oregon silverspot butterfly	*Speyeria zerene hippolyta*	Threatened	No suitable habitat or documented occurrence in action area
Sea Turtles			
Leatherback turtle	*Dermochelys coriacea*	Endangered	No effect
Loggerhead turtle	*Caretta caretta*	Threatened	No effect
Green turtle	*Chelonia mydas*	Threatened	No effect
Olive Ridley turtle	*Lepidochelys olivacea*	Threatened	No effect
Birds			
Western snowy plover	*Charadrius alexandrinus nivosus*	Threatened	No suitable habitat or documented occurrence in action area
Short-tailed albatross	*Phoebastria albatrus*	Endangered	No effect
Northern spotted owl	*Strix occidentalis caurina*	Endangered	No suitable habitat or documented occurrence in action area
Marbled murrelet	*Brachyramphus marmoratus*	Threatened	No effect
Marine Mammals			
Blue whale	*Balaenoptera musculus*	Endangered	No effect
Fin whale	*Balaenoptera physalus*	Endangered	No effect
Sei whale	*Balaenoptera borealis*	Endangered	No effect
Sperm whale	*Physeter macrocephalus*	Endangered	No effect
Humpback whale	*Megaptera novaeangliae*	Endangered	No effect
Steller sea lion	*Eumetopias jubatus*	Threatened	No effect
Terrestrial Mammals			
Canada lynx	*Lynx canadensis*	Threatened	No suitable habitat or documented occurrence in action area
Gray wolf	*Canis lupus*	Endangered	No suitable habitat or documented occurrence in action area
Grizzly bear	*Ursus arctos = U. a. horribilis*	Threatened	No suitable habitat or documented occurrence in action area

EXHIBIT 5-2.
SPECIES AND CRITICAL HABITAT NOT ADDRESSED FURTHER IN THIS BIOLOGICAL ASSESSMENT

Species	Scientific Name	Federal Status	Rationale for Exclusion
Fishes			
Chum salmon (Hood Canal summer-run DPS)	*Oncorhynchus keta*	Threatened	No effect
Green sturgeon (Southern DPS)	*Acipenser medirostris*	Threatened	No effect
Pacific eulachon	*Thaleichthys pacificus*	Threatened	No effect

DPS = distinct population segment

5.1 Sea Turtles

Four species of ESA-listed sea turtles—the leatherback turtle, the loggerhead turtle, the green turtle, and the olive Ridley turtle—are known to occur in U.S. Pacific coastal waters; however, none of these turtle species is known to nest along western U.S. shores (Conant et al. 2009; NMFS and USFWS 1998a, 1998b, 1998c, 2008). The primary threats to these species along the U.S. West Coast are incidental "take" from capture and entanglement in a variety of fishing gear. These include pelagic and demersal longlines, drift and set gillnets, bottom and midwater trawling, fishing dredges, pound nets and weirs, haul and purse seines, pots and traps, and hook and line gear. Sea turtles can also be injured or killed when struck by a boat, especially an engaged propeller. Recreational vessels, such as jet skis, also pose a danger due to collisions and harassment.

Activities associated with the project construction and mitigation sites will have no effect on sea turtle nest sites because none of these sea turtles nest along the Washington coast or in Puget Sound. The only project activity that may affect sea turtles is pontoon transport within existing shipping channels along the coast. Pontoon towing activities will be infrequent, of short duration, and conducted within established towing lanes by slow-moving vessels at speeds expected to be 4 knots or less, allowing turtles the opportunity to avoid the pontoons, tugboats, and any associated noise. Therefore, these species are not addressed further in this BA.

5.2 Birds

5.2.1 Short-Tailed Albatross

The short-tailed albatross occurs in waters throughout the North Pacific, primarily along the east coast of Japan and Russia and in the Gulf of Alaska. The species is known to occur in Pacific, Grays Harbor, Clallam, and Jefferson Counties in Washington; however, the species only breeds on two remote islands in the western Pacific. The severe decline in the short-tailed albatross population was caused by overexploitation for its feathers before and after the turn of the twentieth century. Although this threat no longer exists, the species is currently threatened by volcanic activity, extreme weather, small population size, a limited number of breeding sites, the presence of oil and other pollutants in its habitat, and commercial fishery bycatch.

Project activities will not affect breeding habitat and pontoon transport activities within existing shipping channels along the coast are not expected to have an effect on this species because of the infrequency of pontoon movement and the slow speeds at which the pontoon towing will occur. Therefore, this species is not addressed further in this BA.

5.2.2 Marbled Murrelet

The marbled murrelet occur along the Aleutian Islands and the coasts of Alaska, Washington, Oregon, and northern California (Carter and Erickson 1988). Population declines have been attributed to fragmentation and loss of nesting habitat (Csuti et al. 1997), reduced food availability (Burkett 1995) from overharvesting of fish (Ainley et al. 1995), and direct mortality associated with gill-net fishing, predation, urbanization, and the effects of oil spills (Fry 1995; Carter and Kuletz 1995WDW 1993a).

The marbled murrelet belongs to the diving seabird family (Alcidae). Marbled murrelets are found primarily in marine environments, but during the summer nesting season, they fly inland to nest, typically in low-elevation old-growth and mature coniferous forests within 50 miles of the coast (Hamer 1995; Hamer and Cummins 1991). Suitable habitat includes old-growth forests and mature forests with old-growth components (trees greater than 46 centimeters in diameter) with large moss-covered branches on the upper half of the tree (Ralph et al. 1995). Strong et al. (1996) found that most murrelets occurred within 1 mile of the shoreline, regardless of their ages. They consume a diversity of prey consisting of fish and invertebrates and will alternate food sources according to season and abundance (Federal Register, Volume 61, page 26258 [61 FR 26258]).

Critical habitat for the marbled murrelet was designated by USFWS in 1996 (61 FR 26256). Critical habitat factors include space for growth and normal behavior; nutritional or physiological requirements; cover or shelter; sites for breeding, reproduction, and rearing of offspring; and habitats that are protected from disturbance or are representative of the historical geographical and ecological distribution of a species. Recently, USFWS proposed revising critical habitat for marbled murrelets (71 FR 53838); however, to date, a final rule has not been issued. No designated critical habitat is located in the action area.

Marbled murrelets are potentially present in Grays Harbor during the fall, winter, and spring, and in other portions of the pontoon transport route at any time of year (Speich and Wahl 1995). Project activities at the moorage sites, in the marine environment, Puget Sound, and Lake Washington will not affect the marbled murrelet or its habitat. The project activities of pontoon towing along the pontoon transport route will be infrequent, of short duration, and conducted within established towing lanes by slow-moving vessels at speeds expected to be 4 knots or less, allowing murrelets the opportunity to avoid the tugboats and any associated noise. Therefore, this species is not addressed further in this BA.

5.3 Marine Mammals

Several ESA-listed marine mammal species could occur within the action area. Most of these species are not expected to be affected by the project and were excluded from further evaluation; they are discussed in Section 5.3.1. One marine mammal (the Southern Resident distinct population segment [DPS] of killer whales) may be affected by the proposed project activities; this species is discussed in Section 5.3.2.

5.3.1 Species Excluded from Further Evaluation

5.3.1.1 Blue Whale

Two stocks of blue whales inhabit U.S. waters in the North Pacific: western and eastern. Based on acoustic and whaling data, it is believed that the eastern stock winters off Mexico and Central America and feeds during the summer off the U.S. West Coast and, to a lesser extent, in the Gulf of Alaska and in central North Pacific waters (Stafford et al. 2001). Although the species is often found in coastal waters, blue whales are thought to occur more offshore than humpback whales, for example. Overall, it is clear that this species inhabits and feeds in both coastal and pelagic environments. Blue whales are frequently found on the continental shelf, such as in areas off the California coast (Calambokidis et al. 1990; Fiedler et al. 1998) and far offshore in deep water, such as in the northeastern tropical Pacific (Wade and Friedrichsen 1979). The primary threats currently facing blue whales are vessel strikes and fisheries interactions. Ship strikes were implicated in the deaths of at least four and possibly six blue whales off the California coast between 1980 and 1993 (Barlow et al. 1995a; Barlow et al. 1997). The average number of blue whale mortalities in California attributed to ship strikes was 0.2 per year from 1991 to 1995 (Barlow et al. 1997).

New studies have compiled information from around the world documenting collisions between ships and large whales (baleen whales and sperm whales) (Laist et al. 2001; Jensen and Silber 2003). Vessel types include mainly Navy vessels, container/cargo ships, whale-watching vessels, cruise ships, ferries, USCG vessels, and tankers (Jensen and Silber 2003). These vessels operate at faster speeds than the pontoons can be towed.

The only project activities that have the potential to affect blue whales are pontoon towing by tugboats and the noise generated by the tugboats. Towing activity along the pontoon transport route will be infrequent, of short duration, and conducted within established towing lanes by slow-moving vessels at speeds expected to be 4 knots or less, allowing blue whales the opportunity to avoid the tugboats and any associated noise. Therefore, blue whales are not addressed further in this BA.

5.3.1.2 Fin Whale

In recent years, fin whales have been observed year-round off central and southern California, with peak numbers in summer and fall (Dohl et al. 1983; Barlow 1995a; Forney et al. 1995), in summer off Oregon (Green et al. 1992), and in summer and fall in the Gulf of Alaska and the southeastern Bering Sea (Leatherwood et al. 1986; Brueggeman et al. 1990). Among the current potential threats to fin whales are collisions with vessels, entanglement in fishing gear, reduced prey abundance due to overfishing, habitat degradation, disturbance from low-frequency noise, and the possibility that illegal whaling or resumed legal whaling will cause removals at biologically unsustainable rates.

Typically, ship strikes occur in areas of high vessel traffic and/or high-speed vessel traffic. At least one, and probably more, fin whales were killed by collisions with ships off the California coast in the early 1990s (Barlow et al. 1997). Three fin whales were documented as killed by ship strikes off the California coast: one in 1997 and two between 2000 and 2005 (Carretta et al. 2006). Fin whales are much less often subject to whale watching in the eastern North Pacific than in the western North Atlantic. Thus, disturbance in the Pacific is more likely to come from the volume of industrial, military, and fishing vessel traffic off the Mexican, U.S., and Canadian coasts than from the deliberate approaches of whale-watching vessels.

The only project activities that have the potential to affect fin whales are pontoon towing by tugboats and the noise generated by the tugboats. However, it is expected that project tugboat activity and associated noise occurring along the transport route will not have an effect on fin whales because the towing events will be infrequent and of short duration, the vessels will be moving slowly (expected speed is 4 knots), and the associated noise can easily be avoided in the rare event that this species is present. Therefore, fin whales are not addressed further in this BA.

5.3.1.3 Sei Whale

Sei whales are distributed far out to sea in temperate regions of the world and do not appear to be associated with coastal features. The primary threats to sei whales are interactions with fishing gear and ship strikes. Limited information is available, but the offshore drift gillnet fishery is the only fishery that is likely to “take” sei whales from the eastern North Pacific stock; however, no fishery mortality or serious injuries have been observed. A sei whale found in Port Angeles in 2003 showed evidence of a ship strike, but the cause of death could not be determined (Douglas et al. 2008). Carretta et al. (2006) reported no documented ship strikes of sei whales along the Pacific coast of the western United States.

The only project activities that have the potential to affect sei whales are pontoon towing by tugboats and the noise generated by the tugboats. However, it is expected that project tugboat activity and associated noise will not have an effect on sei whales because the towing events will be infrequent and of short duration, the vessels will be moving slowly (expected speed is

4 knots), and the associated noise can easily be avoided in the rare event that this species is present along the marine tow routes. Therefore, sei whales are not addressed further in this BA.

5.3.1.4 Sperm Whale

In U.S. waters, three management units are recognized: California/Oregon/ Washington, Hawaiian, and Alaskan stocks (Carretta et al. 2006). Tag returns indicate that whales move between southern California and British Columbia (Rice 1974), which suggests that the California/Oregon/Washington population is separate from the Hawaiian population. Sperm whales are present off Oregon and Washington in all seasons except midwinter (December through February) (Green et al. 1992). Sperm whales show a strong preference for deep waters (Rice 1989), especially in areas with high sea floor relief.

The greatest threat to sperm whales is whaling, which still occurs in a few areas by natives using primitive methods, by the Japanese, and illegally. In addition to whaling, sperm whales may be affected by other shipping and fishing operations. Sperm whales have the potential to be harmed by ship strikes and entanglements in fishing gear, although these are not as great a threat to sperm whales as they are to more coastal cetaceans. Sperm whales spend long periods (typically up to 10 minutes; Jacquet et al. 1998) “rafting” at the surface between deep dives, which could make them vulnerable to ship strikes. Studies have compiled information from around the world documenting collisions between ships and large whales such as baleen whales and sperm whales (Laist et al. 2001; Jensen and Silber 2003). These studies found that sperm whales were struck 17 known times out of a total record of 292 strikes of all large whales, 13 of which resulted in mortality. Vessel types include mainly Navy vessels, container/cargo ships, whale-watching vessels, cruise ships, ferries, USCG vessels, and tankers (Jensen and Silber 2003). Given the current number of reported cases of injury and mortality, it does not appear that ship strikes are a significant threat to sperm whales (Whitehead 2003). Disturbance by anthropogenic noise may prove to be an important habitat issue in some areas of this species’ range, notably in areas of oil and gas activities or where shipping activity is high.

Project activities that include tugboats towing pontoons are unlikely to have an effect on sperm whales due to various factors. These include the species’ essentially exclusive use of pelagic, deep water habitats, the extremely low likelihood that they will “raft” along the pontoon transport route, and their ability to avoid slow-moving vessels. It is expected that project tugboat activity and associated noise along the transport route will not have an effect on sperm whales because the towing events will be infrequent and of short duration, the vessels will be moving slowly (expected speed is 4 knots), and the associated noise can easily be avoided in the rare event that this species is present. Therefore, sperm whales are not addressed further in this BA.

5.3.1.5 Humpback Whale

Since being listed as endangered in 1973, the humpback whale population is slowly recovering but likely remains below the numbers that existed before whaling began (Calambokidis and

Barlow 2004). Factors that may have contributed to their population declines or that may be limiting the recovery of the whales include the following:

- Vessel strikes
- Fisheries interactions
- Quantity and quality of prey
- Toxic chemicals that accumulate in top predators
- Anthropogenic noise
- Oil spills

Ship strikes of large whales cause mortalities worldwide, but there is uncertainty regarding the frequency and species involved. Douglas et al. (2008) examined 130 records (from 1980 through 2006) of large whale strandings in Washington state. Only one possible ship-struck humpback whale was recorded, despite concentrations of humpbacks feeding within shipping lanes in this region.

Humpback whales live primarily in coastal and continental shelf waters, although they sometimes feed around seamounts and migrate through deep water. Every year, they follow a regular migration route, feeding in temperate and polar climates during the summer, and mating and calving in tropical waters during the winter. Critical habitat for the humpback whale has not been designated or proposed.

The Washington coast generally hosts a small number of humpback whales in the summer; data show that an estimated 100 humpbacks occupying these waters annually (Douglas et al. 2008). The whales are mostly concentrated west and southwest of the Strait of Juan de Fuca entrance, between Juan de Fuca canyon and the outer edge of the continental shelf, where they spend their summers feeding (USACE 2006, pg. 30). While humpback whales are frequently observed off the Washington coast, they are infrequently observed in Puget Sound.

Project activities that include tugboats towing pontoons are unlikely to have an effect on humpback whales because the towing events will be infrequent and of short duration, the vessels will be moving slowly (expected speed is 4 knots), and the associated noise can easily be avoided in the rare event that this species is present. Therefore, humpback whales are not addressed further in this BA.

5.3.1.6 Steller Sea Lion

The Steller sea lion is the largest of the 14 species in the eared seal family (Otariidiae). Steller sea lions range along the North Pacific Rim from northern Japan to California (Loughlin et al. 1992). Although the species is not known to migrate, individuals disperse widely outside of the breeding season (late May through early July). Steller sea lions occurring in Washington belong to the eastern U.S. stock, which is listed as threatened (55 FR 50006). Factors that contributed to population declines or that may be limiting recovery include boat strikes, contaminants and pollutants, habitat degradation, illegal hunting/shooting, offshore oil and gas exploration, interactions with fisheries, and subsistence harvests. In contrast to the western U.S. stock, which has exhibited dramatic population declines since the 1970s, the eastern stock has remained relatively stable, with some population increases in the northern portion of the stock's range in southeast Alaska and British Columbia (Hill and DeMaster 1999).

Steller sea lions occur year-round in Washington waters, primarily along the outer coast from the Columbia River to Cape Flattery, as well as along the Vancouver Island side of the Strait of Juan de Fuca. Populations in Washington waters decline during the summer breeding season as they return to rookeries in California, Oregon, British Columbia, and southeast Alaska.

Steller sea lions feed in open-water habitat in nearshore areas, out to the edge of the continental shelf (Washington Department of Wildlife 1993b). Their diet consists of a variety of fish and invertebrates, predominately demersal and off-bottom schooling fish (Jones 1981) and less frequently other pinnipeds such as harbor seals (Pitcher and Fay 1982).

Steller sea lions are occasionally observed hauled out on buoys in Puget Sound, primarily around the San Juan Islands. The only documented haul-out site for Steller sea lions in southern Puget Sound is the Toliva Shoals buoy, near Fox Island (Jeffries et al. 2000). This haul-out site is approximately 10 miles (straight-line distance) from the CTC facility at the Port of Tacoma and approximately 17 miles from the Port of Olympia facility. Haul-out sites in Canadian waters within Puget Sound are located at Race Rock off Vancouver Island in the Strait of Juan de Fuca and near Vancouver Island in the Belle Chain Area near Saturna Island and at Trial Island (Jefferies et al. 2000).

Critical habitat has been identified for the Steller sea lion, and it is associated with breeding, haul-out, and foraging areas in Alaska, California, and Oregon (50 FR 226.12). No critical habitat has been designated in Washington.

Project activities that include tugboats towing pontoons are unlikely to have an effect on Steller sea lions because the towing events will be infrequent and of short duration, the vessels will be moving slowly (expected speed is 4 knots), and the associated noise can easily be avoided in the rare event that this species is present. In addition, pontoon outfitting will occur at existing construction facilities or in Lake Washington, well away from sea lion haul-out sites and other known habitat areas. Therefore, Steller sea lions are not addressed further in this BA.

5.3.2 Southern Resident Killer Whale

After a review of the status of the Southern Resident DPS of killer whales (*Orcinus orca*) (Krahn et al. 2004), NMFS listed the species as endangered on November 18, 2005 (effective February 16, 2006) (70 FR 69903). The Southern Resident killer whale (SRKW) DPS is genetically isolated and rarely interbreeds with other killer whale populations (Hoelzel et al. 1998; Barrett-Lennard 2000; Barrett-Lennard and Ellis 2001). Whales of the SRKW DPS also differ behaviorally from transient killer whales in that they rely almost exclusively on fish as a food source. Observations in northern Puget Sound indicate that salmon are preferred prey for killer whales, representing over 96 percent of the prey during the summer and fall (Ford and Ellis 2005). This study also indicated that Chinook salmon constitute over 70 percent of the identified salmonids taken in the summer and fall, although extensive feeding on chum salmon was also observed in the fall. While salmon appear to be a preferred prey item, 22 other species of fish and 1 species of squid (*Gonatopsis borealis*) are known to be eaten (Ford et al. 1998; 2000; Saulitis et al. 2000). Species such as rockfish (*Sebastes* spp.), Pacific halibut (*Hippoglossus stenolepis*), a number of flatfish, lingcod (*Ophiodon elongatus*), and greenling (*Hexagrammos* spp.) are likely consumed regularly by SRKWs (Ford et al. 1998).

5.3.2.1 Status and Abundance in the Action Area

The SRKW population is currently estimated at about 88 whales, a decline from estimated historical levels of about 200 during the mid- to late 1800s (NMFS 2008d, 2010a). After decreasing to 67 whales in 1971, the numbers have ranged between 80 and 100 animals since the 1980s (NMFS 2008d).

The factors limiting the numbers of SRKWs have not been clearly defined by scientific investigations. Likely causes include capture and removal for display in aquaria, the bioaccumulation of toxic chemicals (e.g., organochlorine compounds), and declines of Chinook salmon stocks, which serve as the main food source for SRKWs (Krahn et al. 2004).

NMFS identified the following activities that could result in violation of ESA Section 9 prohibitions against “take” of the SRKW DPS:

- Coastal development (e.g., dredging, land clearing and grading, and waste treatment) that may adversely affect SRKWs.
- Discharge of pollutants into areas used by SRKWs.
- Generation of noise levels or operation of vessels in a manner that disrupts foraging, resting, or care of young.
- Land/water use or fishing practices that result in reduced availability of prey species during periods when SRKWs are present.

5.3.2.2 Distribution in the Action Area

While both resident and transient forms of killer whales occur in Puget Sound, resident whales of the SRKW DPS are most commonly observed in Puget Sound (Wiles 2004). This group consists of three pods (J, K, and L) and is considered a stock under the Marine Mammal Protection Act. Whales of the J pod are seen year-round in the inland waterways of Puget Sound, the Strait of Juan de Fuca, and the Strait of Georgia (Wiles 2004; NMFS 2008d). From late spring through midwinter, the K and L pods are also present in these waters. Individuals from all three pods have also been seen, albeit infrequently, at all times of the year in coastal waters from central California north to Vancouver Island (Ford et al. 2000; NMFS 2008d). Whales of the SRKW DPS tend to remain outside of relatively confined bays or shallow water areas as they move through the central Puget Sound area.

From late spring to fall, most whales of the SRKW DPS can be found in the waters around the San Juan Islands, including Haro Strait, Boundary Passage, and the northeastern portion of the Strait of Juan de Fuca (Ford et al. 2000; Krahn et al. 2004). During this period, whales are also present in smaller numbers in Rosario Strait, the interior waters of the San Juan Islands, the southern portions of Georgia Strait and the Strait of Juan de Fuca, Admiralty Inlet, Puget Sound, and the outer coast. Individuals or groups from this population may also be seen at various locations in central Puget Sound each summer, typically for periods of a few days, but occasionally remaining in the area for more than a month. During early autumn, SRKW pods (especially the J pod) expand their movements into Puget Sound, likely to feed on returning adult chum and Chinook salmon (Osborne 1999). Considerably less is known about the wintertime movements of this stock. Whales from the J pod are commonly sighted in inshore waters in winter, while the K and L pods apparently spend more time offshore (Ford et al. 2000; Krahn et al. 2004).

The Whale Museum in Friday Harbor manages a long-term database of SRKW sightings and geospatial locations in inland waters of Washington. The data are largely opportunistic sightings from a variety of sources. Nevertheless, the animals are highly visible in inland waters and are widely followed by the interested public and research community. The Whale Museum reviews each sighting report and report context to include only reports of whales from the SRKW DPS. Transient whales, northern residents, and offshore whales are excluded. The data set does not account for level of observation effort by season or location; however, it is the most comprehensive long-term data set available to evaluate broad-scale habitat use by SRKWs in inland waters. For these reasons, NMFS relies on the number of past sightings to assess the likelihood of SRKW presence in a project area during a given month (NMFS 2010b).

Sighting data from this data set are reported as unique sighting days, which are defined as the cumulative number of days that SRKWs (individuals or groups) were sighted in a particular observation block during a particular month over the 19-year period. To eliminate the bias introduced by multiple sightings of the same whales in the same location on a single day, all of the sightings for a given day in one observation block are combined to count as one sighting. More than 400 observation blocks have been defined, with the size of the blocks varying geographically. In open water, the blocks are roughly 2 to 3 miles on each side.

Observation effort is greatest in the summer, when most whale-watching operations are active. In addition, the origination of a large number of whale-watching vessels from Victoria, British Columbia, may result in a bias for sightings in the northeastern portion of the Strait of Juan de

Fuca relative to the southern and western portions of the strait (NMFS 2006). Nevertheless, this is the most comprehensive long-term data set available on the distribution of SRKWs in inland waters, and it indicates areas of activity concentrations.

Based on a review of Whale Museum data from 1990 through 2008, SRKWs are extremely unlikely to occur in most portions of the proposed pontoon towing route during most months (NMFS 2010b). Guidance from the NMFS Northwest Region office defines SRKWs as extremely unlikely to occur in a particular area during a particular month if the Whale Museum data set includes a total of fewer than six sightings in that area during that month. None of the observation blocks that overlap the proposed towing route in the Strait of Juan de Fuca has more than five unique sighting days during any month.

Data from the Whale Museum indicate that SRKWs are extremely unlikely to occur in the central portion of Puget Sound (Admiralty Inlet south to Alki Point) from February through August. Sightings in this area increase during fall and winter. Of the 19 observation blocks that overlap the proposed pontoon towing route in this area, 1 block has six unique sighting days in September. This number increases to seven in October, seven in November, and nine in December, then decreases to five in January.

This annual pattern of distribution is similar for the portions of Puget Sound south of Alki Point, with the greatest numbers of unique sighting days during the late fall and winter months. Of the 13 observation blocks that overlap the proposed pontoon towing route in this area, 4 blocks have six or more unique sighting days during October. This number increases to eight in November and nine in December, then decreases to seven in January and two in February. From March through September, no observation blocks in the south sound have more than five unique sighting days.

5.3.2.3 Status of Critical Habitat

On November 29, 2006, NMFS designated critical habitat for the SRKW in Washington, consisting of approximately 2,560 square miles (6,630 square kilometers) of Puget Sound and the Strait of Juan de Fuca (71 FR 69054). Waters less than 20 feet (6.1 meters) deep relative to extreme high water are not considered to be within the geographical area occupied by SRKWs and are not included in the critical habitat designation.

Designated critical habitat does not include coastal and offshore areas in the Pacific Ocean or waters inside Hood Canal. Although coastal and offshore areas are part of the geographical area occupied by the species, there is not enough information regarding SRKW distribution, behavior, or habitat use in those areas to determine primary constituent elements (PCEs). There is also insufficient evidence of SRKWs in Hood Canal to include it within the geographical area occupied by the species.

NMFS has designated the following PCEs for SRKW critical habitat:

- Water quality to support growth and development
- Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth
- Passage conditions to allow for migration, resting, and foraging

Available information about the effects of sound disturbance on SRKW critical habitat is insufficient to allow NMFS to identify acoustic conditions as PCEs (71 FR 69055). However, NMFS will continue to consider sound in any future revisions of the critical habitat designation.

5.4 Fishes

Several ESA-listed species of fish are known to occur within the marine and/or freshwater portions of the action area. Most of these species are not expected to be affected by the project and were excluded from further evaluation; they are discussed in Section 5.4.1. Seven of the species (Coastal-Puget Sound bull trout, Puget Sound Chinook salmon, and Puget Sound steelhead, Bocaccio, canary rockfish, and yelloweye rockfish) may be affected by the proposed project activities and are discussed in the subsequent subsections.

5.4.1 Species Excluded from Further Evaluation

5.4.1.1 Hood Canal Summer-Run Chum Salmon

The range for the Hood Canal summer-run evolutionarily significant unit (ESU) of chum salmon does not include the Grays Harbor or Lake Washington portions of the action area; however, Hood Canal chum salmon may be located within the Puget Sound portion of the pontoon transport route.

Activities that include pontoon towing trips at slow speeds (expected speed is 4 knots) within established tow boat lanes are not expected to affect chum salmon or chum salmon habitat; therefore, this species is not addressed further in this BA.

5.4.1.2 Green Sturgeon

The southern DPS of green sturgeon was listed as threatened as of June 6, 2006 (71 FR 17757), based on low population levels and negative population trends. The decline of the southern DPS of green sturgeon has been the result of decreased spawning habitat, insufficient freshwater flow rates in spawning areas, pollutants (e.g., pesticides), bycatch of green sturgeon in fisheries, potential poaching (e.g., for caviar), entrainment by water projects, influence of exotic species, small population size, impassable barriers, and increased water temperatures (71 FR 17757). Green sturgeon are known to congregate during summer months in coastal estuaries such as Grays Harbor, Willapa Bay, and the Columbia River estuary. Subadult and adult green sturgeon generally use the Strait of Juan de Fuca and Puget Sound for the same purposes as Grays Harbor;

however, observations of green sturgeon are much less common in these areas than in other portions of the Washington coast (NMFS 2008a).

As noted above, this species is expected to be present in Grays Harbor, Washington marine waters, and Puget Sound. Project activities in these areas include mooring and transport of pontoons. None of these activities is expected to affect green sturgeon or related habitat; therefore, this species is not addressed further in this BA.

5.4.1.3 Pacific Eulachon

Eulachon are endemic to the eastern Pacific Ocean, ranging from northern California to southwest Alaska and into the southeastern Bering Sea. In the continental United States, most eulachon originate in the Columbia River basin. Other areas in the United States where eulachon have been documented are the Sacramento River, Russian River, Humboldt Bay, and the Klamath River in California; the Rogue River and Umpqua River in Oregon; and, infrequently, in coastal rivers and tributaries of Puget Sound, Washington (NMFS 2009a). Willapa Bay and Grays Harbor are considered priority areas for this species by the state of Washington. Data specific to the Grays Harbor area are limited to sparse harvest data and anecdotal evidence.

As noted above, this species is expected to be present in Grays Harbor, Washington marine waters, and Puget Sound. Project activities in these areas include mooring and transport of pontoons. None of these activities is expected to affect eulachon or related habitat; therefore, this species is not addressed further in this BA.

5.4.2 Puget Sound Chinook Salmon

5.4.2.1 Status and Abundance in the Action Area

Two natural Chinook salmon spawning populations (the north Lake Washington population and the Cedar River population) that occur in the action area 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). The University of Washington also produces Chinook salmon for research at a small hatchery on Portage Bay.

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. 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).

A substantial number of returning adult fish from the Issaquah Hatchery spawn naturally in the Lake Washington system, potentially affecting the genetic integrity of the native stocks. In 2003, approximately 50 percent of the spawners in WRIA 8 were hatchery-origin fish, with percentages as high as 75 percent in some stream systems (Shared Strategy for Puget Sound 2007). Preliminary genetic data indicate that the Chinook salmon spawning in Issaquah Creek and north Lake Washington tributaries are similar to the Green River Chinook salmon, which was the origin of the Issaquah Hatchery stock (WDFW and Puget Sound Treaty Tribes 2006). This suggests that any population differences in the Lake Washington system, if they historically existed, have been altered by straying hatchery fish spawning naturally. The extensive influence of hatchery production on natural stocks may have reduced the genetic diversity and fitness of naturally spawning populations, particularly the native Cedar River population (Shared Strategy for Puget Sound 2007).

During recent years, the Cedar River Chinook salmon run has declined about 10 percent per year; 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 5-3) (City of Seattle and USACE 2008).

EXHIBIT 5-3.
ESCAPEMENT OF NATURALLY SPAWNING CHINOOK SALMON INTO THE LAKE WASHINGTON BASIN

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	1269
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

While the north Lake Washington population escapements appear to be relatively consistent since 1998, between about 200 and 500 adults, the Cedar River escapements have fluctuated between 120 and 1,729 adult spawners (WDFW 2009). Although the numbers had previously shown a long-term negative trend in escapements and chronically low escapement values (WDFW 2004), a generally increasing trend has occurred since 1998 (WDFW 2009). In addition, the spawner escapement numbers in 2006 and 2007 (1,090 and 1,729, respectively) represent two of the three highest escapement estimates since 1981 (WDFW 2009).

The overall abundance levels of the north Lake Washington and Cedar River Chinook salmon populations raise concerns about the risk of extinction. The spatial structure is greatly reduced from historical conditions because habitat degradation has reduced spawning and rearing habitat available or suitable for Chinook salmon. However, the recent construction of the fish ladder at Landsburg Dam has reopened about 12 miles of historical habitat for Chinook spawning and rearing in the Cedar River (Shared Strategy for Puget Sound 2007). The overall population diversity also is greatly reduced from historical conditions because of the predominance of hatchery Chinook throughout the basin, particularly in the Lake Sammamish basin.

Ruckelshaus et al. (2006) concluded that the wild Cedar River Chinook population has largely been extirpated and that the Cedar River and north Lake Washington populations have largely been reestablished from hatchery strays and strays originating from other populations outside of the Lake Washington basin. Data also indicate that a high percentage of naturally spawning Chinook are hatchery strays. The residual amount of original genetic information carried into the current populations is most likely small, and the contribution of the two Lake Washington populations to the overall diversity of the entire ESU is probably small (NMFS 2008a).

The Cedar River Chinook population has the highest relative risk due to declining abundance trends, followed by the north Lake Washington population and the Issaquah population (Shared Strategy for Puget Sound 2007). However, the Cedar River Chinook population still remains significantly different from the other populations in WRIA 8, despite the apparent influence of hatchery production. This genetic diversity increases the probability of recovery or survival of Chinook salmon in WRIA 8.

One measure of a population’s productivity is the median population growth rate (lambda), calculated for long- and short-term trends. Long- and short-term trends are calculated on all spawners, and the short-term lambda is calculated with the assumption that the reproductive success of naturally spawning hatchery fish is equivalent to that of natural-origin fish (Good et al. 2005). A lambda of 1 represents a population that is generally replacing itself each year, and a lambda greater than 1 represents some annual growth. For salmon recovery purposes, the target goal lambda is 3.4 in order to increase abundance to a level that would remove the threat of extinction. The lambda for the north Lake Washington short-term trend is 1.07 (±0.07) (Good et al. 2005), indicating the population is just replacing itself. The short-term lambda for the Cedar River populations is estimated at 0.99±0.07, also indicating the population is probably just replacing itself. If this range of productivity were to continue, abundance could drop below theoretical minimum viable population thresholds (Shared Strategy for Puget Sound 2007).

5.4.2.2 Distribution in the Action Area

Small numbers of Chinook fry begin migrating into Lake Washington from the Cedar River in January, whereas most Chinook fry enter the lake in mid-May. Initially, the Cedar River Chinook fry tend to concentrate in the littoral zone at the south end of Lake Washington between February and mid-May, until they grow large enough to move offshore (Fresh 2000; Tabor et al. 2004c; Tabor et al. 2006). Therefore, the lakeshore area near the Cedar River mouth appears to be an important nursery area for juvenile Chinook salmon. Tabor et al. (2004c) found that the mean abundance of juvenile Chinook from February through May was positively related to proximity to the Cedar River mouth, but there is no difference by June. Juveniles migrate away from the Cedar River mouth and along the Lake Washington shorelines as they grow.

After entering the lake, the juvenile Chinook salmon rear in the shallow littoral zone (1 to 2 feet deep) as they gradually migrate to Union Bay and the Lake Washington Ship Canal. Juvenile Chinook salmon tend to prefer gradually sloping sand-silt substrate habitat less than 1.6 feet deep (Tabor et al. 2006). They also congregate at the mouths of small tributary streams, possibly attracted by flow, shallow-water depths, benthic invertebrate or terrestrial insect food sources, fine-particle substrate accumulated at the stream delta fans, or some combination of these factors (Shared Strategy for Puget Sound 2007). Juvenile Chinook salmon tend to increase their use of deeper-water habitat areas as they get larger, likely as a response to prey availability, reduced predation risks, and possibly more favorable water temperature conditions (Warner and Fresh 1998; Celedonia et al. 2008b).

Chinook fry typically rear in the lake from 1 to 4 months before migrating through the Ship Canal to Puget Sound (Seiler et al. 2004; Tabor et al. 2006). The larger fingerlings enter the lake between mid-May and June after spending up to 6 months rearing in the rivers and streams. Little information is available on the timing of north Lake Washington Chinook within the action area.

Recent observations in the Ship Canal indicate that young Chinook salmon tend to be relatively uniformly distributed over a range of depths in this area (Celedonia et al. 2008b).

Smaller juvenile Chinook salmon appear to prefer shallow areas with over-water cover, particularly during the day (Tabor et al. 2006) but tend to avoid areas with overhead cover as they grow (Tabor et al. 2004c). While riparian vegetation tends to be the preferred over-water cover habitat, docks and piers are sometimes used as substitute cover, particularly during the day (Tabor and Piaskowski 2002). The large number of piers and docks lining the Lake Washington shoreline is expected to substantially affect the natural behavior of juvenile Chinook salmon and other salmonids rearing and migrating through the lake.

Celedonia et al. (2008a) determined that the response of juvenile Chinook salmon to the Evergreen Point Bridge was at least partially dependent on whether they were actively migrating or holding. About two-thirds of actively migrating smolts appeared delayed by the bridge, while the remaining smolts appeared negligibly affected by the bridge. Delayed fish varied widely in the time of delay and distance traveled during delay. Nearly half (45 percent) of the delayed smolts took less than3 minutes to pass beneath the bridge after the initial encounter, travelling less than 33 meters along the edge of the bridge during this time. Conversely, many smolts that exhibited holding behavior, as opposed to active migration behavior, appeared to selectively choose to reside in areas near the bridge for prolonged periods. This behavior was distinctly different from the apparent bridge-induced delay observed in some actively migrating smolts. Holding fish often crossed beneath the bridge to the north and were later observed returning to and holding in areas immediately adjacent to the bridge’s southern edge (less than 20 meters from the edge of the bridge). The bridge did not appear to be a factor in delaying the transition to migration of holding fish.

Adult Chinook salmon typically return to Lake Washington in August and September, sometimes within days of returning to their natal rivers (City of Seattle and USACE 2008). The average time spent by adult Chinook in Lake Washington in 1998 was 2.9 days (Fresh et al. 1999). Therefore, the existing modified habitat conditions in Lake Washington and the Ship Canal may have a limited effect on returning adults, although the relatively short time spent in the lake may be related to the long-term trend of increasing water temperatures in late summer.

5.4.2.3 Status of Critical Habitat

NMFS published the final rule designating critical habitat for Puget Sound Chinook salmon in September 2005 (70 FR 52630). The rule identifies Lake Washington, including the action area, as designated critical habitat for Chinook salmon. This critical habitat includes Lake Washington, as well as the Ship Canal and Lake Union between the Ballard Locks and Lake Washington. The designation identified 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 Washington.

Critical habitat designations are based on the presence of 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. Descriptions of all six PCEs designated for Puget Sound Chinook salmon are provided in Appendix B, Species Life Histories and Critical Habitat.

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 the action area has been substantially modified by long-term anthropogenic activities. Freshwater rearing habitat through much of the Evergreen Point Bridge alignment 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. The shorelines of Union Bay and Portage Bay typically have gradually sloping shorelines with silt substrate and dense aquatic vegetation. The aquatic vegetation is dominated by the nonnative species of white water lily (*Nymphaea odorata*) or Eurasian watermilfoil (*Myriophyllum spicatum*). Much of the shallowest water also has dense growths of cattail. Various forms of native and nonnative riparian vegetation grow along portions of the shoreline unoccupied by the bridge, walking trails, or access points. Other 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.

Numerous factors are believed to affect the migration of salmonids through Lake Washington and the Ship Canal. Most of these factors are unlikely to be substantially affected by the presence of the existing Evergreen Point Bridge. Such factors include physiological development (smoltification) of migrating juvenile salmonids, overall water temperature of the lake and Ship Canal, and size and condition of the migrating fish. However, the existing bridge and in-water bridge structures do present unnatural conditions in the migration corridor, which have the potential to alter the short-term behavior of migrating fish. Alteration of migratory behavior could cause the fish to occupy or migrate through areas that are more or less productive than habitats they would otherwise occupy, require different levels of energy expenditure, or subject the fish to more or less viable survival conditions.

The bridge features suspected of affecting the migration behavior and potential survival rates of juvenile salmonids include the bridge shadow on the surface of the water during the day, the artificial lights from the bridge and bridge traffic at night, and the bridge support structures (columns) in the water that change the natural habitat for both the salmonids and their predators.

5.4.3 Puget Sound Steelhead

5.4.3.1 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. Allozyme analysis of steelhead sampled in the Cedar River in 1994 clusters them with winter steelhead in the Green, White, and Puyallup Rivers, including some Snohomish basin steelhead stocks (WDFW 2004).

Hard et al. (2007) observed that genetic analyses indicate that the Cedar River population is a distinct population that has undergone minimal hatchery introgression. Although extensive hatchery releases have occurred in the basin between 1915 and 1993, these hatchery steelhead planting operations ceased in 1993 (Washington Department of Fisheries et al. 1993). However, a small brood stock program in the Cedar River resulted in small releases (less than 15,000 fry) into the river in 2000 and 2001 (WDFW 2008). The adult returns in recent years have not been adequate to continue this brood stock program. A limited hatchery program utilizing the native winter steelhead stock was also initiated in 1997 as a supplementation program to assist in recovery of winter steelhead populations in the north Lake Washington tributaries.

Although WDFW believes there is little overlap in spawning between natural and hatchery stocks of winter steelhead throughout the ESU, Marshall et al. (2004) indicate that resident rainbow trout produce outmigrating smolts in the Lake Washington watershed, suggesting some degree of interbreeding between the two life history forms. However, 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 (2009) 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 (WDFW 2006). Based on these numbers, the relative risk of extinction for the Lake Washington winter steelhead population is considered very high.

5.4.3.2 Distribution in the Action Area

Juvenile steelhead migrating out of the Lake Washington watershed will pass through the action area using the general area as a migratory corridor. There is no available information that identifies the action area as a location specifically used by juvenile steelhead for rearing. Juvenile steelhead rear in fresh water, including Lake Washington, for several years before migrating to Puget Sound; therefore, they are expected to be less dependent on the shallow nearshore habitat in the lake than the smaller Chinook salmon fry.

Adult steelhead pass through the Ballard Locks to Lake Washington between December and early May (Washington Department of Fisheries et al. 1993). Spawning occurs throughout the Lake Washington basin, including the lower Cedar River, the Sammamish River and its tributaries, and several smaller Lake Washington tributaries (WDFW 2006). They spawn primarily in the main stem Cedar River from March through early June (Burton and Little 1997), although there are historical records of steelhead spawning in Cedar River tributaries such as Rock Creek.

5.4.3.3 Status of Critical Habitat

NMFS has not proposed or designated critical habitat for Puget Sound steelhead.

5.4.4 Coastal-Puget Sound Bull Trout

5.4.4.1 Status and Abundance in the Action Area

The draft Bull Trout Recovery Plan has identified Lake Washington as important foraging, migration, and overwintering (FMO) habitat (USFWS 2004). The Lake Washington FMO habitat consists of the lower Cedar River below Cedar Falls; the Sammamish River; Lake Washington, Lake Sammamish, and Lake Union; the Lake Washington Ship Canal; and all accessible tributaries. Amphidromous adult and subadult bull trout from nearby core areas may migrate through the marine environment into the Lake Washington FMO habitat. This FMO habitat is located within foraging and migratory distances of three core areas: Stillaguamish, Snohomish-Skykomish, and Puyallup Rivers. The use of Lake Washington by bull trout is presumed to be related to the abundance of these core area populations and their proximity to the action area (USFWS 2004).

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. There are, however, some coldwater springs and tributaries that may provide marginal spawning temperatures or thermal refuge areas for rearing or foraging during warm summer periods. These tributaries include Rock Creek (tributary of the Cedar River below the Landsburg Diversion) and Coldwater Creek (tributary of Cottage Lake Creek immediately downstream from Cottage Lake). Both Coldwater and Rock Creeks emanate from groundwater springs and flow through high-quality riparian forest areas. The upper reaches of Holder and Carey Creeks, two main branches of Issaquah

Creek, have good to excellent habitat conditions and may hold potential for bull trout spawning. Despite survey efforts by King County (Berge and Mavros 2001; King County 2002), no evidence of bull trout spawning or rearing has been found.

Despite limited spawning habitat, the Lake Washington watershed contains substantial forage fish and foraging habitat. A small number of subadult and adult bull trout have been observed in Lake Washington (King County 2000; Shepard and Dykeman 1977), although the origin of these fish is unknown. Potential sources include the Chester Morse Lake core area (population in the upper Cedar River), other tributary streams within the watershed, or other nearby core area populations.

5.4.4.2 Distribution in the Action Area

Little is known about the historical distribution and abundance of bull trout in the Lake Washington system. A 1-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.

Although bull trout may occasionally occur within the action area, there is no known regular occurrence of bull trout in the lake. There have been only a few reports of bull trout and Dolly Varden in the Lake Washington watershed. No bull trout observations have been documented between October and December, presumable because the fish are on or near their spawning grounds during this time (USFWS 2008a).

Several large native char (approximately 410 millimeters long) have been observed passing through the viewing chamber at the Ballard Locks, but only one was identified as a bull trout (Bradbury and Pfeifer 1992; USFWS 1998). Bull trout have been caught in Shilshole Bay and the Ballard Locks during late spring and early summer in both 2000 and 2001, with up to eight adult and subadult fish caught in Shilshole Bay below the locks between May and July in 2000. In 2001, five adult bull trout were captured in areas within and immediately below the Ballard Locks. One bull trout was captured within the large locks, one was captured in the fish ladder, and three adult bull trout were captured below the tailrace during the peak of juvenile salmon migration in mid-June (USFWS 2008a). Observations of bull trout near the Ballard Locks suggest the migration of bull trout from other core areas to Lake Washington.

Amphidromous adult and subadult bull trout likely occur in the action area throughout the year, most likely in spring and early summer during the outmigration of juvenile salmon. This observation is based on bull trout captured at the Ballard Locks and the Lake Washington Ship Canal between May and July. Bull trout likely use the action area for either foraging or migrating through the area to other marine or estuarine foraging habitats. Bull trout in the action area are anticipated to be from the core areas of the Stillaguamish, Snohomish-Skykomish, and Puyallup Rivers.

Amphidromous bull trout use marine waters as migratory corridors to reach seasonal habitats in nonnatal watersheds to forage and possibly overwinter (Goetz 2003). Marine FMO habitat includes portions of Puget Sound, particularly the highly productive nearshore and estuarine areas, with complex habitat structures and substantial nutrient inputs. The marine nearshore and estuary habitats are key to supporting this amphidromous life history form, providing important prey such as sandlances (*Ammodytes hexapterus*), surf smelts (*Hypomesus pretiosus*), Pacific herring (*Clupea pallasi*), and shiner perch (*Cymatogaster aggregata*) (WDFW et al. 1997). These amphidromous fish typically occur in nearshore marine waters from early spring through the late fall.

The current distribution of bull trout within Puget Sound marine waters is not completely known but has been documented from the Canadian border to at least Commencement Bay to the south (Fresh et al. 1979; Kraemer 1994; McPhail and Baxter 1996; King County 2002). The marine and estuarine residency period for bull trout is also poorly understood, as are their habitat preferences and foraging requirements, although the residence period could be timed to coincide with the spawning periods of forage fish (Kraemer 1994). Although the available information indicates that bull trout use primarily nearshore waters, this use may be biased due to the limitations of sampling in deeper offshore locations. This presumed habitat preference is reflected in the designated marine critical habitat, which extends from the shoreline to a depth of 33 feet below MLLW (75 FR 63898).

Subadults are thought to move between the lower river and the estuary throughout the year, but they overwinter primarily in fresh water, and most adults are believed to enter the estuary in February and March and leave the estuary between May and June to migrate upstream to their spawning grounds. Although bull trout have been documented moving between major river basins via marine waters, the patterns and extent of these migrations are not well known. High-priority habitat areas include those in proximity to known and potential spawning areas for marine forage fish and foraging habitats for subadult and adult bull trout. High-priority locations include Bellingham Bay, the lower Duwamish River and Elliott Bay, and Commencement Bay.

Primary bull trout FMO habitat within the Puyallup core area is believed to be the main stem reaches of the White, Carbon, and Puyallup Rivers. The amphidromous life history form is believed to use Commencement Bay and other marine nearshore habitats along Puget Sound. Urbanization and residential development and the marine port have significantly reduced habitat complexity and quality in the lower main stem rivers and associated tributaries and have largely eliminated intact nearshore foraging habitats for amphidromous bull trout within Commencement Bay.

Although bull trout could occasionally occur in the Olympia area, there is no documentation of amphidromous bull trout south of the Nisqually River area (Fresh et al. 1979; Kraemer 1994; McPhail and Baxter 1996; King County 2002). There is also no designated marine critical habitat in the Port of Olympia area. Therefore, their occurrence near the Port of Olympia pontoon construction site is expected to be insignificant.

5.4.4.3 Status of Critical Habitat

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, as well as the nearshore habitat in Puget Sound. This nearshore habitat extends from the mean higher high water (MHHW) elevation offshore to a depth of 33 feet below MLLW.The agency identified nine PCEs for Coastal-Puget Sound bull trout critical habitat (see Appendix B, Species Life Histories and 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.

Bull trout use Lake Washington and the Ship Canal primarily as a migration corridor (PCE 2). Except for the Ballard Locks, which may impede migration between Lake Washington and marine rearing areas, there are no other physical impediments to bull trout migration in the action area. However, temperature-related impediments may also be present in Lake Washington or the Ship Canal (PCE 5). Surface water temperatures of these water bodies typically exceed 20°C for substantial portions of the summer.

As stated above, bull trout forage in Lake Washington as they migrate to and from the marine environment. Availability of food in Lake Washington is generally good and considered properly functioning (PCE 3). The benthic habitat of Lake Washington likely provides adequate aquatic macroinvertebrates that support an abundant food base. The food base in Lake Washington 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.

Although substantial portions of the Lake Washington and Ship Canal shorelines are modified, these areas still provide habitat complexity and processes that establish and maintain these aquatic environments, to provide a variety of depths and structures that support bull trout foraging and rearing phases (PCE 4). 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.

Marine nearshore habitats within the Olympic Peninsula and Puget Sound critical habitat units contain only a subset of the identified physical or biological features for bull trout (PCEs 2, 3, 5, and 8). However, these habitats are important for conserving a diverse life-history expression and representative habitats. USFWS has designated over 440 miles of nearshore critical habitat in Puget Sound, including most of the eastern shoreline from Canada to the Nisqually River estuary, as well as a substantial portion (about 330 miles) of the Olympic Peninsula shoreline (75 FR 63898).

5.4.5 Puget Sound Rockfish

NMFS listed Puget Sound/Georgia Basin DPSs of yelloweye rockfish and canary rockfish as threatened species and bocaccio as an endangered species under the ESA on April 27, 2010 (75 FR 22276). The juvenile life history of these species includes larval and pelagic stages. Recreational and commercial harvest has been a major cause for decline of these rockfish species, with harvest levels peaking in the 1970s and 1980s. However, these peak harvest levels were due to increased fishing effort, and not to an increase in the abundance of rockfish (Palsson et al. 2009). Other threats that are believed to continue to affect the populations include habitat degradation by derelict fishing gear that continues to catch fish, chemical contaminants, low dissolved oxygen levels, and incidental catch from recreational and commercial fisheries (NMFS 2009e).

5.4.5.1 Status and Abundance in the Action Area

In the late 1970s bocaccio made up 89 percent of the Puget Sound recreational catch, with the majority of fish caught in the Tacoma Narrows area of south Puget Sound (NMFS 2009e). While there is little information available on the occurrence of bocaccio within the waterways of Commencement Bay or in the Port of Olympia area, one fish was reported in 1999 in the recreational catch in WDFW management area 11. There is also a report of bocaccio being observed (2 to 10 fish) at the Les Davis Pier Artificial Reef in Commencement Bay in 2001, which is the most recent reported identification of bocaccio in Puget Sound (NMFS 2009e).

While the marine habitat areas adjacent to the pontoon construction sites do not provide preferred habitat (deepwater rocky reef, shelf, and outcrop areas) for bocaccio and other rockfish, bocaccio occasionally occur in sand and mud substrate areas (NMFS 2009e). Therefore, the larvae and pelagic juveniles could be transported into these portions of the action area from the Tacoma Narrows and other preferred habitat areas by tidal and wind-driven currents. Female bocaccio fecundity ranges from 20,000 to over 2 million eggs, considerably more than many other rockfish species. Larvae and small juvenile rockfish may remain in open water for several months, being passively dispersed by tidal and wind-driven currents. If present, these younger life stages may settle in shallow water habitat before moving to deeper habitat areas as they grow. In the absence of specific information on the distribution of bocaccio in the action area, it is assumed that they could potentially occur in small numbers near the pontoon construction sites.

No information is available on the occurrence of canary rockfish within the nearshore marine portions of the project action area. These marine areas do not provide preferred habitat (deepwater rocky reef, shelf, and outcrop areas). Rockfish survey results in 1980 to 1989 and 1996 to 2001 reported canary rockfish at a frequency of 1.1 percent (sample size 8430) and 0.73 percent (sample size 550) in south Puget Sound, respectively (NMFS 2009e). Canary rockfish have also been caught in the past in the Tacoma Narrows recreational fishery, but there is no evidence of a reproducing population in this area (NMFS 2009e). If canary rockfish are reproducing in the Tacoma Narrows area, their larvae and pelagic juveniles could be transported to areas adjacent to the pontoon construction sites by currents, although there is no habitat within these portions of the action area known to attract juvenile canary rockfish.

Female canary rockfish fecundity ranges from 260,000 to 1.9 million eggs, considerably more than many other rockfish species. Larvae and small juvenile rockfish may remain in open water for several months, being passively dispersed by ocean currents. Therefore, it is assumed that larval or juvenile fish could potentially occur in small numbers.

Yelloweye rockfish occur more consistently in the recreational catch than bocaccio but at lower frequency than canary rockfish, but are still infrequently observed (typically 1 to 2 percent of the Puget Sound catch) (NMFS 2009e). The frequency of yelloweye rockfish in Puget Sound appears to have increased from 0.34 percent (sample size 8430) in 1980 to 1989 to 2.7 percent (sample size 550) in 1996 to 2001 (NMFS 2009e). Yelloweye rockfish have also been sighted consistently throughout Puget Sound (north and south) since 2001, although sightings are generally higher in the northern areas of Puget Sound. Yelloweye rockfish have been observed in scuba diver surveys, at an average frequency of 0.5 percent of dives in south Puget Sound (NMFS 2009e).

Female yelloweye rockfish produce between 1.2 and 2.7 million eggs, considerably more than many other rockfish species. Larvae and small juvenile rockfish may remain in open water for several months being passively dispersed by wind and tidal currents. No information is available on the occurrence of yelloweye rockfish within the nearshore marine portions of the project action area. As with the other rockfish species, these portions of the action area do not provide preferred habitat (deepwater rocky reef, shelf, and outcrop areas). Yelloweye rockfish are less likely to occur within the nearshore areas adjacent to the pontoon construction sites than the other two listed rockfish species; yelloweye rockfish are also found primarily in northern Puget Sound. There is also no habitat within these portions of the action area known to attract juvenile or adult yelloweye rockfish. However, in the absence of specific information, it is assumed that they could potentially occur in small numbers near the pontoon construction sites.

5.4.5.2 Distribution in the Action Area

Rockfish fertilize their eggs internally and the young are extruded as larvae, which exhibit a pelagic distribution, and often found near the surface of open water (Love et al. 2002). In these near-surface areas, larval rockfish are passively distributed by currents and wind. However, the relatively protected waters of Puget Sound may restrict the larval life stages from dispersing a substantial distance from their natal areas (NMFS 2009e).

Juvenile bocaccio and canary rockfish settle onto shallow nearshore water in rocky or cobble substrate with or without kelp at 3 to 6 months of age, and move to progressively deeper waters as they grow (Love et al. 2002). The highest densities of these species occur in areas of floating and submerged vegetation (NMFS 2010c). However, these habitat features are generally lacking in the vicinity of the CTC and Port of Olympia pontoon construction sites. Unlike bocaccio and canary rockfish, juvenile yelloweye rockfish do not typically occupy intertidal waters and are therefore very unlikely to be in the vicinity of these pontoon construction facilities. However, the near-surface distribution of the larval stages of all three rockfish species would likely occur in the commercial shipping lanes used to transport the pontoons from the construction sites to Lake Washington.

Sub-adult and adult yelloweye rockfish, canary rockfish, and bocaccio typically occupy waters deeper than 120 feet over moderate to extremely steep and complex substrates (Love et al. 2002). While adult yelloweye rockfish tend to remain near the bottom, and have limited home ranges, adult canary rockfish and boccacio have a wider range both laterally and vertically in the water column (Love et al. 2002). However, the adult life stage of these species is unlikely to occur in the relatively shallow, nearshore areas surrounding the pontoon construction sites, or near-surface habitat in the Puget Sound commercial shipping lanes.

Larval yelloweye rockfish, canary rockfish, or bocaccio could occur within the project action area, although they are readily dispersed by currents after they are born, making the concentration or probability of the presence of larvae in any one location extremely small (NMFS 2003). Similarly, the limited number of adult ESA-listed rockfish in Puget Sound further reduces the probability of larval presence and exposure to project activities.

5.4.5.3 Status of Critical Habitat

NMFS has not proposed or designated critical habitat for the Puget Sound/Georgia Basin DPSs of yelloweye rockfish, canary rockfish, or bocaccio.

6. EFFECTS ANALYSIS

This section describes the potential direct and indirect effects of the SR 520, 1-5 to Medina project on listed species and designated critical habitat. Direct effects include all immediate impacts (adverse and beneficial) from project-related actions, as well as disturbances that are directly related to project elements that occur very close to the time of the action itself. Indirect effects include those effects that are caused by or will result from the proposed action and are later in time but are still reasonably certain to occur (50 CFR 402.02). Indirect effects from land use are addressed separately; this analysis is provided in Appendix H.

The effects of the project on EFH were analyzed as required by the Magnuson-Stevens Fishery Conservation and Management Act. The EFH assessment is provided in Appendix C.

The discussion of direct and indirect effects includes the potential mechanisms of effect (“stressors”) from project activities on listed species as well as the species responses to those stressors. The discussion of stressors is organized according to the following primary project elements:

- Pontoon and anchor construction and delivery
- Roadway and bridge construction
- Project operation
- Mitigation measures
- Effects on designated critical habitat
- Indirect effects
- Cumulative effects

Each section initially focuses on the effect of each potential stressor on the physical, chemical, and biological conditions of the environmental baseline. The section then provides an analysis of species exposure (intensity, frequency, duration, etc.) to each stressor and the resulting species response to each stressor and provides conclusions in terms of the effect of the stressors on each species.

For the roadway and bridge portions of the analysis, the discussion is organized more specifically around primary geographic zones of the project (e.g., Portage Bay, Union Bay, and the west approach), and where the project elements intersect with the aquatic habitat. The project elements and resultant stressors in each zone are evaluated on an annual basis throughout the life of their construction (“temporary” effects), concluding with the proposed full-build condition (“permanent” effects). The analyses of species exposure and response consider both the effects by construction year and the long-term presence of the proposed structures.

Subsequent sections discuss effects on designated critical habitat, effects of interdependent and interrelated actions, , and cumulative effects.

Effects were analyzed using the results of site inspections, the views of recognized experts and regulators on the species at issue, information from literature reviews, professional knowledge and experience, reviews of engineering drawings and technical specifications, and discussions with project engineers. The analysis of effects includes the use of the best scientific and commercial data available pursuant to 50 CFR 402.14(d).

Effect determinations for the species are provided in Section 7.

6.1 Pontoon and Anchor Construction and Delivery

The project pontoons and anchors will be constructed at existing and permitted facilities in Puget Sound. Two pontoon construction sites will be used: one in the Port of Olympia and one in the Port of Tacoma. These facilities will continue to operate under existing permitting conditions and implement appropriate BMPs to minimize or eliminate environmental effects. After construction, the pontoons may be temporarily moored at these or other commercial facilities for a variable amount of time before being towed to the project area in Lake Washington.

Pontoons constructed as part of the Pontoon Construction Project at the Grays Harbor casting basin facility will also be delivered to the project area. These pontoons may undergo additional outfitting, and be temporarily moored at, these or other commercial facilities for a variable amount of time before being towed to the project area in Lake Washington.

6.1.1 Port of Olympia

Pontoon construction at the Port of Olympia facility will occur in previously developed areas and is consistent with current activities at the site. The pontoon construction activities include the implementation of appropriate BMPs to minimize or eliminate potential construction effects on natural resources in the area. They will not alter existing upland environmental conditions within the area, including stormwater quality, stormwater quantity, and shoreline habitat. Because the pontoons will be constructed on the upland portions of the facility with perimeter containment BMPs, pontoon construction will not affect existing aquatic conditions, including water quality, sediment quality, substrate, bathymetry, water current patterns, macroalgae, or benthic epifauna.

The pontoons will be stored in the upland portion of the site until they are launched. This upland storage period will range from a few days to over 200 days. Once launched, the pontoons will be towed directly to Lake Washington or to temporary storage, if required.

If any temporary storage is required, it will occur in existing industrial berths that are typically occupied by large vessels (see Sections 2.5.3, 2.10.3.13, and 6.1.3 for additional details on use of existing facilities). Therefore, moorage of the pontoons in existing industrial berths is not expected to affect existing aquatic conditions (e.g., water quality, macroalgae, and benthic fauna) given the historical and current use patterns of these areas. Furthermore, there is limited use of these areas by forage fish and migrating juvenile salmonids.

The pontoons will be launched into Budd Inlet by rolling or lifting them onto a submersible barge, which will be moved to deep water and submerged, allowing the pontoons to float. Two launch cycles, consisting of eight launch dates, are expected to be needed to launch the 21 pontoons constructed at the Port of Olympia site. The expected launch schedule will extend for about 12 months, from August 2013 to August 2014. The launching process does not include flooding and dewatering a pontoon casting basin; therefore, no fish stranding or associated fish handling activities will occur. While listed fish species may be present in the vicinity of the Port of Olympia facility, the launching process is not expected to adversely affect these species or designated critical habitat. Neither the construction of pontoons at the Port of Olympia facility nor the storage of pontoons at the facility or industrial berths is expected to affect the existing environmental conditions in the action area, listed species, or any designated critical habitat.

6.1.2 Port of Tacoma

Pontoon construction at the CTC facility and the adjacent Port of Tacoma site are consistent with current activities at these sites. Only minor alteration of existing upland environmental conditions is expected to occur, but pontoon construction will not require any in-water work. Therefore, with adequate BMP implementation, pontoon construction will not affect aquatic conditions adjacent to construction facilities.

Pontoon storage will occur within upland portions of the site until launching. The upland storage periods are expected to range between 22 and 288 days for individual pontoons. Once launched, the pontoons would be towed directly to Lake Washington. If temporary storage is required, it will occur at existing industrial berths, similar to those used for the pontoons from the Port of Olympia facility. There is limited use of these areas by forage fish and migrating juvenile salmonids.

Listed fish species may be present in the portion of the action area near the CTC facility. Neither the construction of pontoons at the CTC facility nor the storage of pontoons in industrial berths is expected to affect the existing environmental conditions in the area. Therefore, no effects are anticipated on existing environmental conditions in the area or on any designated critical habitat.

When a pontoon is ready for transport and the casting basin has been sufficiently flooded to float the pontoon, tugboats will pull the pontoons out of the casting basin and into the launch channel. Once within the launch channel, the pontoons will be cabled to a tugboat and pulled into Blair Waterway and prepared for transport to Lake Washington.

Although pontoon launching may result in the stranding of listed fish species in the casting basin while it is being dewatered, the casting basin is designed to facilitate the removal of any stranded fish. To minimize this potential effect, all pumps or outlets, if used to convey water to or from the site to fish-bearing waters, will be screened in accordance with NMFS standards. Listed fish species may still enter the casting basin during an incoming tide, while the gates are open during passive basin filling and pontoon removal. The fish are expected to leave the basin with the outgoing tide.

During infrequent periods of higher low tide (i.e., when the low tide is higher than the base elevation of the basin), the basin may not be fully drained when the gates close. Listed fish species may become stranded in the basin. These trapped fish will be carefully removed according to WSDOT protocols for fish handling (WSDOT 2009a) and will be released into the Blair Waterway. Fish handling may result in short-term direct effects on individuals, including injury or mortality.

Four pontoon launch cycles, consisting of a total of seven launch dates (i.e. gate openings) are anticipated to launch the 17 supplemental stability pontoons constructed in the CTC basin, between August 2012 and May 2014. One additional launch cycle, consisting of three launch dates, will also occur at this facility, to launch the six pontoons constructed at the adjacent Port of Tacoma site. This additional launch cycle is expected to occur between May and June 2014. No outfitting activities will be needed for these supplemental stability pontoons; therefore, they will be towed directly to Lake Washington, typically within several days.

6.1.3 Pontoon Outfitting

The available information on the timing and location of potential pontoon outfitting are detailed below. As new information becomes available, it will be provided as an update to the consultation or consultation will be reinitiated if necessary.

Pontoon outfitting will occur at available port locations in Puget Sound and/or within the limits of construction on Lake Washington once the pontoons are anchored in their final positions. See Section 6.2.5 for a discussion of pontoon-related construction on Lake Washington. Outfitting could take up to 4 months. Once outfitting is completed at the Puget Sound locations, the pontoons will be towed to the Ballard Locks and into Lake Washington for immediate use (Section 6.1.4). The following site selection criteria apply to potential commercial outfitting locations:

- Only existing deepwater berths with appropriate infrastructure.
- No improvements and no in-water work would be required at these locations.

Given the above site selection criteria and application of identified BMPs (Section 2.10.3.13), outfitting of pontoons at such existing facilities or industrial berths is not expected to have measurable effects on listed species, their prey base, or designated critical habitat.

6.1.4 Pontoon Transport and Delivery

The following subsections discuss the potential effects from the preparation and transport of pontoons from the existing Grays Harbor or Puget Sound construction facilities to the Puget Sound outfitting locations and subsequently to Lake Washington. The pontoon delivery process will involve towing 33 existing pontoons from Grays Harbor, and 44 supplemental stability pontoons from the Puget Sound pontoon construction sites. The pontoons are expected to be towed from Grays Harbor from March through October. Towing along the outer coast and the Strait of Juan de Fuca is unlikely during the winter months (November through February) because of the increased risk of inclement weather. Open-ocean towing will be permitted only during periods of 7-foot seas (i.e., 7-foot significant wave height) or less that are diminishing in forecast (the maximum predicted wave height in 7-foot seas is 13 feet).

Assuming that the pontoons are towed individually, and that intermediate outfitting sites are used, up to 154 pontoon tows over a period of about 24 months will occur. This will result in an average of about six or seven pontoon tows per month, which is only a small fraction of the existing tows or overall commercial vessel traffic typically occurring in Puget Sound. Statictics for Puget Sound vessel transit suggest that approximately 1,500 to 2,000 tugboat towing events occur each month and approximately 15,000 commercial vessel transits (PSHSC 2010). The 154 project pontoon towing events represent less than 0.5 percent of the approximately 36,000 towing events expected to occur during the 24-month construction period and less than 0.05 percent of the likely commercial vessel trips occurring in Puget Sound.

Pontoon transport has the potential to affect the species and habitat addressed in this analysis by the potential transport of invasive species from Grays Harbor and by vessel activity. These mechanisms are discussed further below.

6.1.4.1 Grays Harbor Invasive Species

As part of the Pontoon Construction Project, 33 pontoons will be constructed within the Grays Harbor facility. If the 33 pontoons are not immediately required for emergency repair, they will be moored at a deepwater location in the south channel of Grays Harbor.

The moorage site at Grays Harbor is located in water approximately 24 to 65 feet deep at MLLW and dominated by silt and/or sand substrate with no submerged aquatic vegetation or areas of macroalgae. The amount of area covered by pontoons will be approximately 24 acres. Removing pontoons from moorage within Grays Harbor is not expected to affect the existing environmental conditions of the action area, listed species, or any designated critical habitat. The plate anchors used to moor the pontoons will be left in place. Each anchor consists of a plate that is vibrated to 30 to 60 feet below the sediment surface by a vibratory pile driver. Once the follower is removed, only the anchor chain penetrates the surface sediment layer. Although this system minimizes the effects during installation, there is no feasible method for removing the plates, and they are not expected to affect listed species.

The pontoons, buoys, and anchor chains will provide a variety of attachment surfaces for biofouling organisms. The attachment surfaces include the sides of the pontoons on the exterior of the rafts, sides of the pontoons on the interior of the rafts, bottoms of the pontoons, anchor chains, anchor buoys, and sites where anchor chains are attached to the pontoons. Conditions for attachment and growth of a biofouling community may differ among these surface types.

For example, current velocity at the pontoon surface and the resulting drag forces may differ between the more sheltered interior surfaces of the rafts and the surfaces on the exterior of the rafts or the bottom surfaces of pontoons. Light levels will vary between the sides of the pontoons that are exposed to light and the bottom surfaces that are in shade.

Generally, the degree of fouling and the composition of biofouling communities are related to the following:

- Available wetted surface area and complexity of the wetted surface
- Sources (and distance to sources) of propagules (seeds, larval stages, spores, or tissue fragments that establish new individuals) to colonize the surfaces
- Time in the water and moorage residence time
- Pontoon maintenance
- Environmental conditions such as current velocity, substrate, depth, water temperature, and salinity

Both native and nonnative organisms in Grays Harbor make up the biofouling community that will potentially colonize the pontoons. The types of these organisms will be similar to the biological communities associated with piles, concrete bridge supports, marina floats, and vessel hulls in areas with similar conditions within Grays Harbor or adjacent estuaries (Cohen et al. 2001).

An underwater video of existing piles near the moorage site shows a community of barnacles, mussels, and bryozoans, with some polychaete worms and amphipods (based on videography by ICF Jones and Stokes 2009). Typical biofouling communities documented in Willapa Bay include green algae, filamentous diatoms, Pacific oysters (*Crassostrea gigas*), mussels, clams, amphipods, nestling clams, grastropods, sponges, hydroids, anemones, barnacles, tunicates, and polychaete worms (Cohen at al. 2001).

Non-indigenous biofouling taxa documented as established in Grays Harbor and other west coast estuaries represents another potential pool of organisms that might colonize the pontoons. Only a few of these non-indigenous taxa are considered invasive species. Many of the taxa, while nonnative, have been present in Puget Sound and other west coast estuaries for decades (e.g., manila clams and Pacific oysters).

Although many non-indigenous taxa occur in Grays Harbor or nearby estuaries, the moorage site is not near concentrated areas of suitable biofouling habitat, such as rocky or cobble substrates, marinas, docks, large aquaculture operations, seawalls, or bridges. The dynamic, silty/sandy benthic substrate in the area of the moorage site is unlikely to support populations of biofouling organisms. Finally, the moorage site is in a relatively open area with strong currents and is unlikely to entrain and retain planktonic larvae.

If moored for 6 months or more, the pontoons will be cleaned before transport to avoid the risk of introducing nonnative species into Puget Sound. Buoys and anchor chains used in moorage at Grays Harbor will be disassembled after moorage is disconstinued and will not be reused as part of this project. Therefore, the risk of introducing invasive species to Puget Sound by means of pontoon transport is discountable.

6.1.4.2 Vessel Activity

Vessels used for pontoon transport may create underwater disturbance. Vessels activity may have the potential to cause behavioral responses in listed species. Examples of behavioral responses include changes in diving duration or swimming direction. Vessels engaged in pontoon transport will not generate disturbance levels that exceed the injury thresholds for ESA-listed fish or marine mammals. Pontoon transport will occur within existing shipping channels, which are characterized by high levels of use by commercial and recreational vessels. Disturbance associated with transport activities, therefore, is likely to be indistinguishable from baseline levels.

In addition, several factors are expected to diminish the potential severity of the effects of vessels engaged in pontoon transport. Some studies suggest that the continuous sounds characteristic of marine vessel operation are less likely to alter animal behavior than pulsed sounds (i.e., brief noise pulses whose peak levels are much higher than those of most continuous or intermittent noises) (Feist et al. 1992; Richardson et al. 1995). Vessel activity at any particular location will be transient, limited to the period when vessels are close enough to be audible. If any animals are present in these areas, the duration of their exposure will be limited to the brief period when the vessels are nearby. Lastly, the species addressed in this analysis are wide-ranging and may travel long distances as part of their normal daily movements. Pontoon towing routes are not near any known foraging areas for listed species. Any changes in behavior of these species due to project-related disturbance will likely be localized and temporary and are not expected to have lasting effects. Therefore, vessel activities are unlikely to disrupt normal species behavior, and the potential for effects associated with pontoon transport is expected to be insignificant.

It is extremely unlikely that vessels engaged in pontoon transport, as well as the pontoons themselves, would strike and injure killer whales given the slow towing speeds (4 knots). Records of collisions between killer whales and vessels are rare, despite existing high volumes of vessel traffic in the marine waters of Washington state. NMFS (2008d) found records of two collisions, and probably a third, that resulted in killer whale fatalities in recent decades. In a study of 130 large whale strandings in Washington state from 1980 through 2006, Douglas et al. (2008) found no evidence of collisions with killer whales. Of 292 collisions documented by Jensen and Silber (2003) between vessels and large whales worldwide, most involved slow-moving species such as finback and blue whales; only one involved a killer whale. This collision occurred in the Strait of Georgia in 1973 and involved a commercial ferry travelling in excess of 15 knots, resulting in the injury of a killer whale calf. The same study found that vessel speeds between 13 and 15 knots are correlated with the greatest number of strikes.

During pontoon transport, the following measures will be implemented to minimize the potential for vessel strikes of marine mammals:

- Transport of pontoons (and materials if barged) will occur within existing shipping channels.
- Vessel speeds and operations will be minimized to avoid striking listed marine mammals (the expected speed is 4 knots).

With the implementation of these minimization measures, and in consideration of the small number of vessel strikes relative to the large number of large vessel trips in Washington state waters, the potential for vessel strikes of SRKWs is discountable.

6.2 Roadway and Bridge Construction

This section addresses the construction and long-term presence of the roadway and bridge elements that have the potential to affect listed species or their habitats. Each subsection is discussed in the context of the geographic subareas, as shown in Exhibit 2-1.

6.2.1 Portage Bay Bridge

This section addresses effects that will result from the following activities and conditions:

- Construction of the new fixed-span structure and associated temporary structures
- Removal of the existing Portage Bay Bridge and temporary structures
- Long-term presence of the proposed new Portage Bay Bridge

Project elements and construction activities in this area are described in Sections 2.2 and 2.3. Exhibit 6-1 summarizes the spatial and temporal extent of those project elements and related construction activities necessary to complete the construction of the proposed Portage Bay Bridge.

EXHIBIT 6-1.
SPATIAL AND TEMPORAL EXTENT OF PROJECT ELEMENTS IN PORTAGE BAY

Project Element	Total Number	Frequency	Total Duration	In-Water/Over-Water Area
Work bridge/falsework pile installation	1,300	Up to 32 per day	Up to 10 months	Up to 5,500 square feet
Work bridge deck	2	Approx. 10,000 square feet per day	Up to 10 months	Up to 4 acres
Cofferdams	6	3 per construction year for 2 years	Up to 20 months	Approx.14,000 square feet total
Mudline footings	3	N/A	14 months	12,495 square feet total
Drilled shafts	65 in water	2 to 4 days per shaft	Approx. 21 months	2,800 square feet

EXHIBIT 6-1.
SPATIAL AND TEMPORAL EXTENT OF PROJECT ELEMENTS IN PORTAGE BAY

Project Element	Total Number	Frequency	Total Duration	In-Water/Over-Water Area
Bridge superstructure	14 spans	Varies	Approx. 60 months	7.6 acres
Materials transport	N/A	Daily	Ongoing	N/A
Column demolition	89	Approx. 2 to 3 week	Approx. 8 months	1,440 square feet
Pile removal	1,300	Approx. 4 to 6 per day	Approx. 6 months	Up to 5,500 square feet
Cofferdam removal	6	3 per construction year for 2 years	Approx. 2 months	Approx. 1,500 square feet

N/A = not applicable

The project elements and associated construction activities described in Sections 2.2 and 2.3 are expected to result in the following mechanisms of effect or types of stressors on listed species and/or designated critical habitat:

- Water quality degradation
- Noise
- Habitat alteration
- Fish handling

These stressors from activities in the Portage Bay Bridge area are discussed in detail below. The potential effects on listed salmonids (species response to stressors) in the Portage Bay area are discussed in Section 6.2.1.5. Stressors are reported both cumulatively by construction year ("temporary" effects) and for the final proposed condition ("permanent" effects).

6.2.1.1 Water Quality Degradation

Potential water quality effects during the proposed activities include increased turbidity, reduced concentrations of dissolved oxygen, introduction of poluutants, resuspension of contaminated sediments, and the introduction of construction debris. The following discussions detail these effects.

Turbidity

Project construction in and near aquatic habitat could result in increased turbidity. Upland construction and staging activities will disturb the substrate in shoreline areas, resulting in some potential for sediments to be introduced to the aquatic environment. However, implementation of appropriate BMPs (described in Section 2.10) will eliminate or minimize this potential. Any turbidity caused by upland activities will remain localized, and BMPs will be maintained, repaired, or augmented to minimize or eliminate turbid runoff.

The construction elements in the Portage Bay Bridge area include in-water work activities, which are identified as sources of turbidity that may result in exposure of listed salmonids. Exhibit 6-2 represents the current estimate of work in terms of the number of construction elements by construction year.

EXHIBIT 6-2.
PROJECT ACTIVITIES LIKELY TO INCREASE TURBIDITY IN PORTAGE BAY

	Peak Values per Construction Year					
Turbidity Sources	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
No. of existing columns removed	N/A	45	45	N/A	N/A	N/A
No. of piles driven	900	200	N/A	N/A	200	N/A
No. of piles removed	N/A	N/A	N/A	650	N/A	650
No. of shaft casings installed	42	39	N/A	26	N/A	N/A
No. of shaft templates removed	42	21	N/A	14	N/A	N/A
No. of cofferdams installed	N/A	3	N/A	3	N/A	N/A
No. of cofferdams removed	N/A	3	N/A	3	N/A	N/A
Total	**984**	**311**	**45**	**696**	**200**	**650**

N/A = not applicable

Short-term increases in turbidity may occur during all aspects of in-water construction (i.e., pile driving and removal and cofferdam and shaft installation and removal) during each of the six in-water construction periods.

The greatest potential for sediment suspension will result from construction elements that remove structures (columns, piles, cofferdams, and shaft templates). This is expected to mobilize adjacent sediment particles upwardly into the water column, as opposed to installation activities during which the forces would be directed into the substrate.

Although construction year 1 represents the highest number of potential turbidity sources, turbidity is expected to be at its highest during construction years 4 and 6, during which approximately 650 piles will be removed each year. No pile driving is expected to occur during those years; therefore, the disturbance from pile-driving noise will not be concurrent with the disturbance from pile-removal turbidity.

The substrate sediments in the Portage Bay area are generally characterized by normally consolidated deposits of organic soils with inclusions of silty clay ranging from 50 to 80 feet deep (WSDOT 2009h). As such, most of the particulate matter potentially introduced to the water column is expected to be organic material. Approximately 50 percent of the proposed work in Portage Bay will be confined to areas within the littoral zone (areas typically less than about 15 feet deep), where there is an abundance of aquatic macrophytes. Therefore, the root mass associated with these macrophyte communities is expected to reduce the potential for sediment suspension into the water column to some degree.

The spatial extent of increased turbidity is expected to be limited by the nature of the proposed construction activities, the shallow water installation locations, the lack of currents in Portage Bay (the construction area is within the southern portion of the bay, away from the Lake Washington Ship Canal, and is sheltered from the prevailing winds), and the implementation of BMPs such as floating booms, which were implemented during the SR 520 test pile project.

Monitoring results from the SR 520 test pile project during pile removal demonstrated that increased turbidity typically occured within approximately 100 feet of the pile installation and removal, with turbidity beyond that distance rarely exceeding 3 nephelometric turbidity units (NTUs) above background and not exceeding 3 NTUs above background at 150 feet (WSDOT 2010c).

Operation of unconfined bubble curtains appeared to mobilize sediments from immediately below the lower bubble ring. Although this created measurable increases in turbidity, the increases were small (2 to 3 NTUs above background level) and relatively uniform across the areas monitored (approximately 3 NTUs at 50 feet and approximately 2 NTUs at 150 feet). This is likely because the action of the bubble curtain also dispersed any sediment that the curtain mobilized. However, pile-driving activities alone (without a bubble curtain) appeared to result in no measurable increase in turbidity during the installation activity in Portage Bay.

Removal of the confined bubble curtain created a noticeable turbidity event. A turbid plume was noticeable in the underwater video immediately adjacent to the pile and measured as approximately 25 NTUs by monitoring equipment located 50 feet from the activity. This turbidity dissipated to near the levels that existed before the activity within 30 to 40 minutes.

Removal of installed piles appeared to increase turbidity in most cases. Whereas in one case, turbidity reached approximately 25 NTUs above background level at 50 feet, turbidity at 100 feet rarely exceeded 5 NTUs above background level. Turbidity tended to return to background levels approximately 30 to 40 minutes after the construction activity ceased. For pile removal, this is the relatively brief period when the pile is being pulled from the sediment and placed on the materials barge. Turbidity during the initial stages of vibratory removal was minimal and almost undetectable, even with video camera observations.

Propeller wash from tugboat activity also has some potential to increase turbidity. Scour depth is variable depending on the type of substrate, the clearance between the propeller tip and the substrate, the power of tugboat engines, and the amount of thrust applied. Tugboat activity within Portage Bay will be limited to areas deeper than 10 feet, thereby limiting the risk of substrate disturbance to these depths, with decreasing risk with increasing depth. Additionally, because most construction activities will occur from work bridges, tugboat use will be more limited in Portage Bay compared to other areas of the project area that will requiring construction from barges such as the west approach area.

Increased turbidity, as described above, is expected to occur episodically throughout the time frame of the construction and demolition activities in Portage Bay, throughout a total of up to 42 months consisting of six approximately 7-month in-water construction periods. The higher intensity effects of turbidity (see above) are expected to occur during the extraction activities proposed in construction years 4 and 6.

The in-water activities are expected to result in only localized, intermittent, and short-term increases in turbidity. Additionally, the timing and duration of the proposed construction and demolition activities during the in-water construction period, along with the implementation of appropriate BMPs (Section 2.10) should limit the potential exposure of listed salmonids.

The potential effects of turbidity on listed salmonids in the Portage Bay area are discussed in Section 6.2.1.5.

Dissolved Oxygen

An increase in turbidity can cause a decrease in dissolved oxygen. Depletion of dissolved oxygen could correlate directly with the instances of turbidity increases described above. During the SR 520 test pile project, observed short-term increases in turbidity did not result in any detectable change in dissolved oxygen measurements taken at the 50- or 100-foot ranges from the pile-driving activity (WSDOT 2010c). Also, because projected increases in turbidity are anticipated to be similarly localized, intermittent, and short term, WSDOT expects that dissolved oxygen concentrations in the aquatic environment will not be affected by project activities.

Pollutants

If pollutants are present in sediments, they could be suspended in the water column by actions that cause turbidity. The result sof two sediment-related studies in Portage Bay indicate that relatively low concentrations of pollutants such as metals, PCBs, PAHs, and phthalates are present in sediment (Cubbage 1992; Moshenberg 2004). However, because the existing sediment quality data are limited and the samples were not collected from areas anticipated to be directly affected by project construction, the risk of encountering contaminated sediments during construction is unknown. Regardless, the potential for pollutants in the sediment where construction activities will occur is considereda potential risk for pollutant introduction into the water column. The intensities and concentrations of potential pollutant introduction cannot be predicted, although it would be limited to periods of increased turbidity. In other words, the risk from pollutants sorbed to sediments will subside as the sediments settle out of suspension. BMPs associated with turbidity control are expected to effectively minimize the risks of listed species exposure to contaminants.

Additionally, sediment testing of excavation spoils (e.g. from drilled shafts or coffer dams) will be required prior to their disposal. The results of these analyses will be used to determine if adjustments to the proposed project BMPs would be needed to minimize or eliminate the introduction of contaminants into the water column.

Another in-water activity that could alter water quality is underwater concrete cutting. Concrete dust has some potential to increase localized pH. However, concrete dust is considered to be insoluble (0.1 percent maximum solubility) in water (Chandler 2008); therefore, localized increases in pH are expected to be negligible and likely to be rapidly buffered by the large volume of Portage Bay.

Fuel leaks, spills, etc. have the potential to introduce pollutants into the aquatic environment. The implementation of perimeter control (curbs and toe boards) and catchment measure (tarps and platforms) BMPs described in Section 2.10 is expected to minimize or eliminate this risk. In addition, WSDOT will submit an SPCC plan before beginning work. If any inadvertent spills or releases occur, the slack water conditions in this area will allow effective spill isolation and cleanup.

Physical Debris

The implementation of perimeter control (curbs and toe boards) and catchment measure (tarps and platforms) BMPs described in Section 2.10 is expected to minimize or eliminate the potential risk of introducing physical debris into the aquatic environment during construction activities.

6.2.1.2 Noise

Potential noise during the proposed activities includes terrestrial construction noise and underwater construction noise (vessel operations and pile driving).

Terrestrial Construction Noise

Impact pile driving will produce the loudest noise levels of all the project activities on land. This noise will not be transmitted into the water; therefore, it will not affect the aquatic environment or listed fish species.

Underwater Construction Noise

Three proposed in-water activities in the Portage Bay area will have the potential to increase underwater noise levels, potentially affecting listed species: vessel operations, vibratory pile driving, and impact pile driving.

Vessel Operations

The operation of tugboats or self-propelled work barges will produce in-water disturbance. The ambient noise measurements in Portage Bay are typically in the range of 135 to 139 dB_{RMS}; however, levels may at times be as high as 145 dB_{RMS} or higher (Laughlin 2009). Monitoring during the SR 520 test pile project documented background noise level of 135 dB (120 dB_{RMS}), which included non-pile-driving construction noise related to small boat and barge activity (Illingsworth and Rodkin 2010). Operation of tugboats and work barges is likely to result in noise levels comparable to those noted during these non-pile-driving periods, which are both less than the behavior effects threshold for fish that has been established for impact pile driving (150 dB_{RMS}), and composed of a substantially different sound signature (e.g., distribution of sound energy levels across variable frequencies) than impact pile driving for which the 150 dB_{RMS} sound level threshold has been established. Therefore, the disturbances generated by project-related vessels are expected to be within the range of baseline conditions.

Pile Driving

The effects of pile driving were determined using empirical site-specific data established by the results of a test pile project conducted by WSDOT in various locations in the project area. Data used for this analysis related to incident sound levels, and BMP sound reduction levels are reported in Illingworth and Rodkin (2010); the full analysis is provided in Appendix D. In Portage Bay, a single-strike incident sound level of 199 dB_{PEAK} and a sound reduction level of 30 dB from BMP application are assumed. The proposed pile-driving activities for Portage Bay and the distances within which potential effects on listed salmonids in the Portage Bay area will result are summarized in Exhibits 6-3, 6-4a, and 6-4b.

EXHIBIT 6-3.
PILE-DRIVING ACTIVITIES AND DISTURBANCE DISTANCES IN PORTAGE BAY FOR POTENTIAL EFFECTS ON LISTED SALMONIDS

Elevated Noise Source	Peak Values per Construction Year					
	2013	2014	2015	2016	2017	2018
Timing	Oct.–Apr.	N/A	Oct.–Apr.	N/A	Oct.–Apr.	N/A
Total no. of piles	900	N/A	200	N/A	200	N/A
Maximum piles per day	32	N/A	16	N/A	16	N/A
Estimated driving days	28	N/A	13	N/A	13	N/A
Strikes per pile	500	N/A	500	N/A	500	N/A
Strikes per day	16,000	N/A	8,000	N/A	8,000	N/A
Strike duration per pile (minutes)	20	N/A	20	N/A	20	N/A
Strike duration per day (minutes)	640	N/A	320	N/A	320	N/A
Total ensonified area (acres) – 206 dB_{PEAK}[1]	N/A	N/A	N/A	N/A	N/A	N/A
Total ensonified area (acres) – 187 dB_{SEL}[1]	1.9	N/A	0.8	N/A	0.8	N/A
Total ensonified area (acres) – 183 dB_{SEL}[1]	1.9	N/A	0.8	N/A	0.8	N/A
Total ensonified area (acres) – 150 dB_{RMS}[1]	10.2	N/A	6.6	N/A	6.6	N/A

[1] Per work bridge constructed in calendar year; Assumptions: 187 dB_{SEL} and 183 dB_{SEL} distance = 2 meters from the pile (270 square feet per pile). 150 dB_{RMS} distance = 22 meters from the pile (0.7 acre per pile).
dB = decibels
N/A = not applicable
RMS = root mean square
SEL = sound exposure level

Pile-driving activities in Portage Bay will include both vibratory and impact driving. Only impact pile-driving activities are expected to produce sound levels that could adversely affect listed species. In Portage Bay, the range within which the cumulative sound exposure level

(SEL) will remain greater than the injury threshold for juvenile and subadult/adult fish (183 and 187 dB, respectively) increases logarithmically with increasing numbers of pile strikes, up to about 5,000 pile strikes in a day, and remains at that range for any additional strikes per day. For both juvenile and subadult/adult fish (less than or greater than 2 grams, respectively), the maximum expected range within which the SEL will exceed the threshold for the expected number of pile strikes is about 2 meters (about 7 feet) for a 30-inch-diameter pile, which will result in an area of approximately 270 square feet surrounding a single pile. The range within which elevated sound levels will exceed the behavioral disturbance threshold (150 dB_{RMS}) is 22 meters (about 72 feet) from the pile (or about 0.7 acre per pile). Exhibits 6-4a and 6-4b show the extent of the pile-driving thresholds by construction year.

Pile driving will be most extensive during construction year 1, with the installation of up to 900 piles. Assuming a rate of installation of 16 to 32 piles per day, 28 to 56 days of pile driving will be expected over the approximately 7-month in-water construction period. For subsequent construction years (years 3 and 5), 13 to 25 days of pile driving can be expected for the installation of up to 200 piles per year, assuming a similar rate of installation.

The potential effects of pile driving on listed salmonids in the Portage Bay area are discussed in Section 6.2.1.5.

6.2.1.3 Habitat Alteration

Potential habitat alterations that will result from the proposed project activities include riparian habitat disturbance and displacement, benthic habitat disturbance and displacement, shading, changes in structural complexity, artificial lighting, and changes in localized limnology.

Riparian Habitat Disturbance and Displacement

Project activities in the Portage Bay area will result in both the disturbance and the displacement of riparian habitat, which consists of wetlands and upland vegetated buffer areas. Portage Bay has an area of freshwater marsh habitat and naturally sloped shoreline, while the remainder of the shoreline is developed, with little natural riparian vegetation. Construction activities will result in the clearing or filling of less than 0.38 acre of wetlands and the clearing or filling of 0.81 acre of buffer habitat (see Sections 4.5 and 4.6 for a description of riparian and wetland conditions in Portage Bay). Clearing or filling of riparian zones, as well as alteration of vegetation, could reduce the capacity of the riparian zone to filter pollutants, protect lake shores, and provide fish habitat.

Disturbance of riparian areas could cause some localized alteration of the adjacent aquatic habitat, such as minor changes in shading patterns and a possible reduction in allochthonous (organic material) input. Any localized effects on suitable habitat for listed species are expected to be buffered by existing communities of dense invasive macrophytes along much of the shoreline.

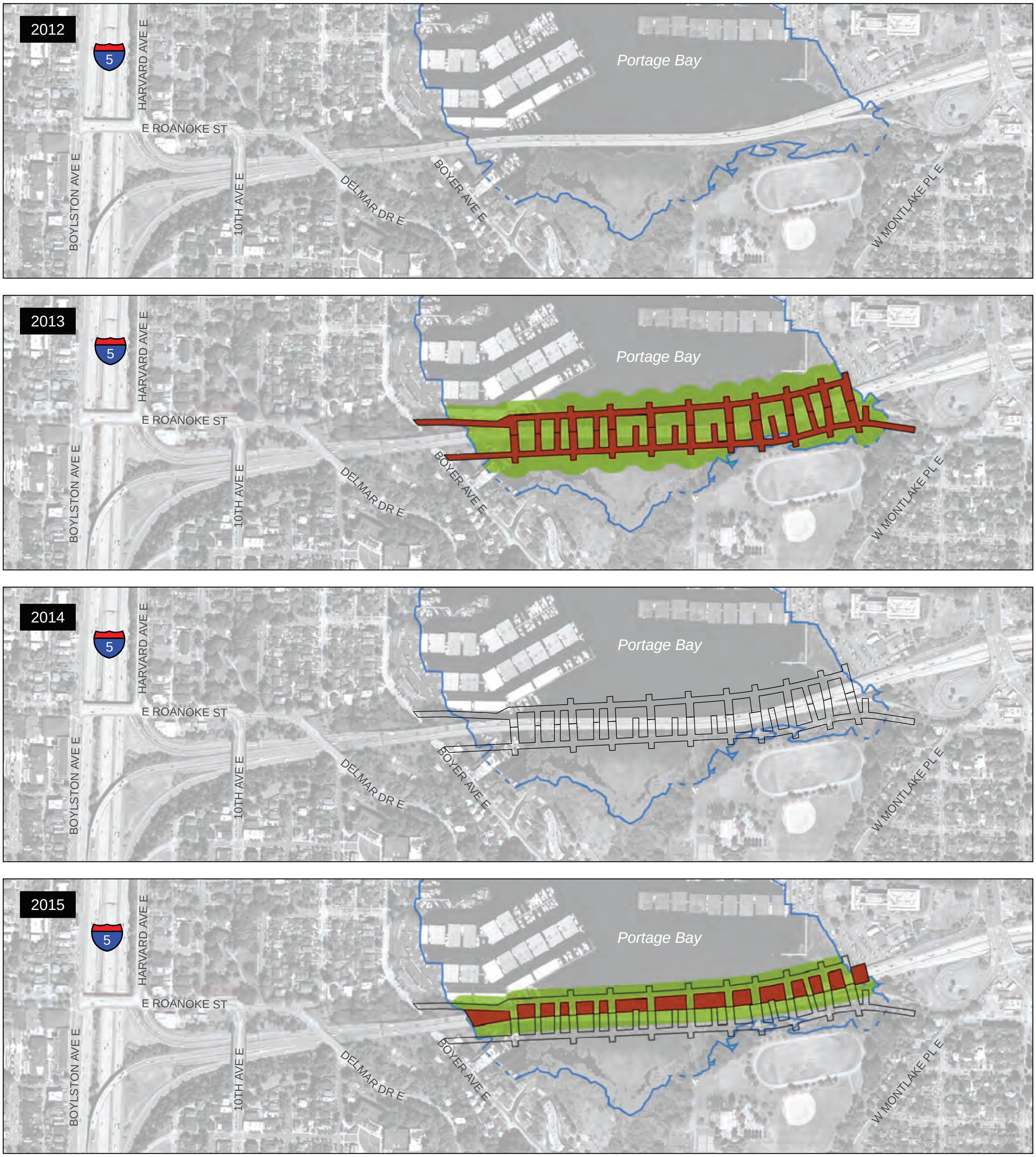
During periods of construction activity, BMPs for erosion and sedimentation control are expected to offset the loss of water quality functions provided by riparian habitat (see Section 2.10 for additional information on water quality BMPs). Any loss of hydrologic and water quality functions is expected to be offset after project construction, when the disturbed areas are either stabilized with restored vegetation or built to specification with stormwater management facilities. In addition, compensatory mitigation will be provided as part of the proposed project for all wetland and upland vegetated buffer displacement.

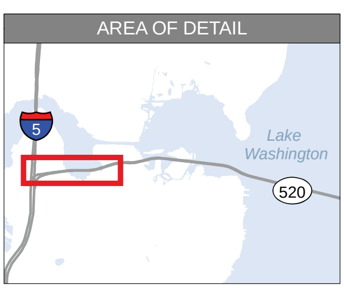
Therefore, riparian habitat disturbance and displacement is not expected to adversely affect listed salmonids.

Benthic Habitat Disturbance and Displacement

The substrate sediments in the Portage Bay area are generally characterized by normally consolidated deposits of organic soils with inclusions of silty clay to water depths ranging from 50 to 80 feet (WSDOT 2009g). The Portage Bay benthic habitat in the vicinity of the proposed in-water disturbance (particularly pile driving) consists of vegetated shallows dominated by nonnative white water lily (*Nymphaea odorata*) and Eurasian watermilfoil (*Myriophyllum spicatum*).The potentially affected benthic habitat crosses through the southern portion of the bay, which is south of the primary salmonid migration route through the Ship Canal.

Construction of the work bridges and falsework will result in variable disturbance of about 2,750 to 5,500 square feet of substrate area due to piling in varying locations throughout the construction year. Construction years 2 and 3 represent the periods of greatest substrate displacement due to piling, which includes the potential disturbance and displacement of native and nonnative aquatic vegetation. These habitat areas are expected to recover relatively quickly after the support piles are removed. Construction years 2 through 6 will have varying, but similar, amounts of substrate disturbance (up to 18,958 square feet) as different combinations of existing, temporary, and proposed structures will be present during the progression of work.





Ordinary High Water Mark

Ordinary High Water Mark (Not Surveyed)

WorkBridge

Work Bridge and Falsework Construction in Progress

N

0 250 500 1,000 Feet

Potential Fish Behavior/Injury Thresholds

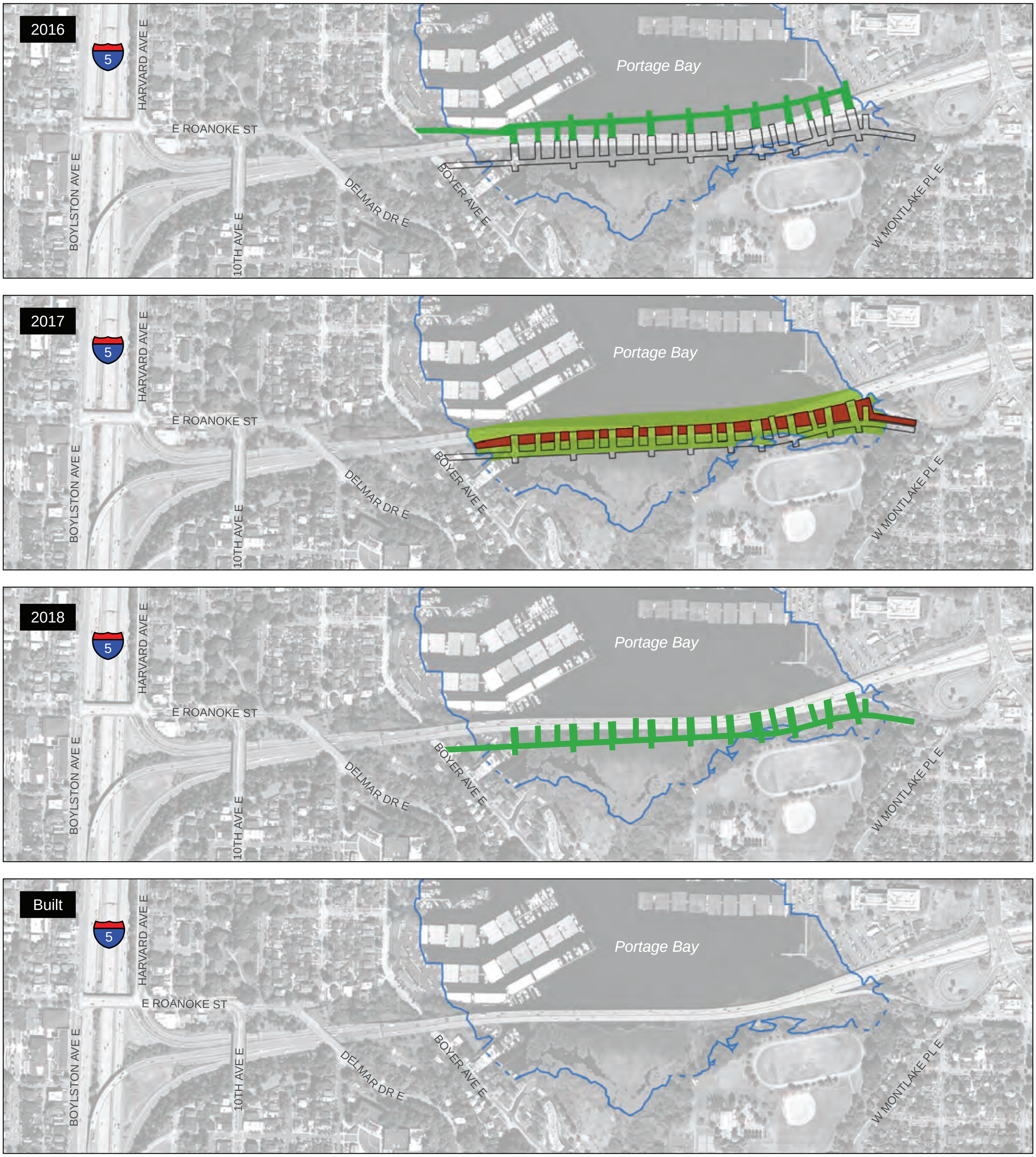
150 dB RMS

183/187 db SEL

Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 6-4a. **Annual Pile-Driving Noise in Portage Bay**

SR520, I-5 to Medina: Bridge Replacement and HOV Project



- Ordinary High Water Mark
- Ordinary High Water Mark (Not Surveyed)
- Work Bridge
- Work Bridge Removal (Vibratory Removal)
- Falsework Construction in Progress

Potential Fish Behavior/Injury Thresholds

- 150 db RMS
- 183/187 db SEL

Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

N 0 250 500 1,000 Feet

Exhibit 6-4b. **Annual Pile-Driving Noise in Portage Bay**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

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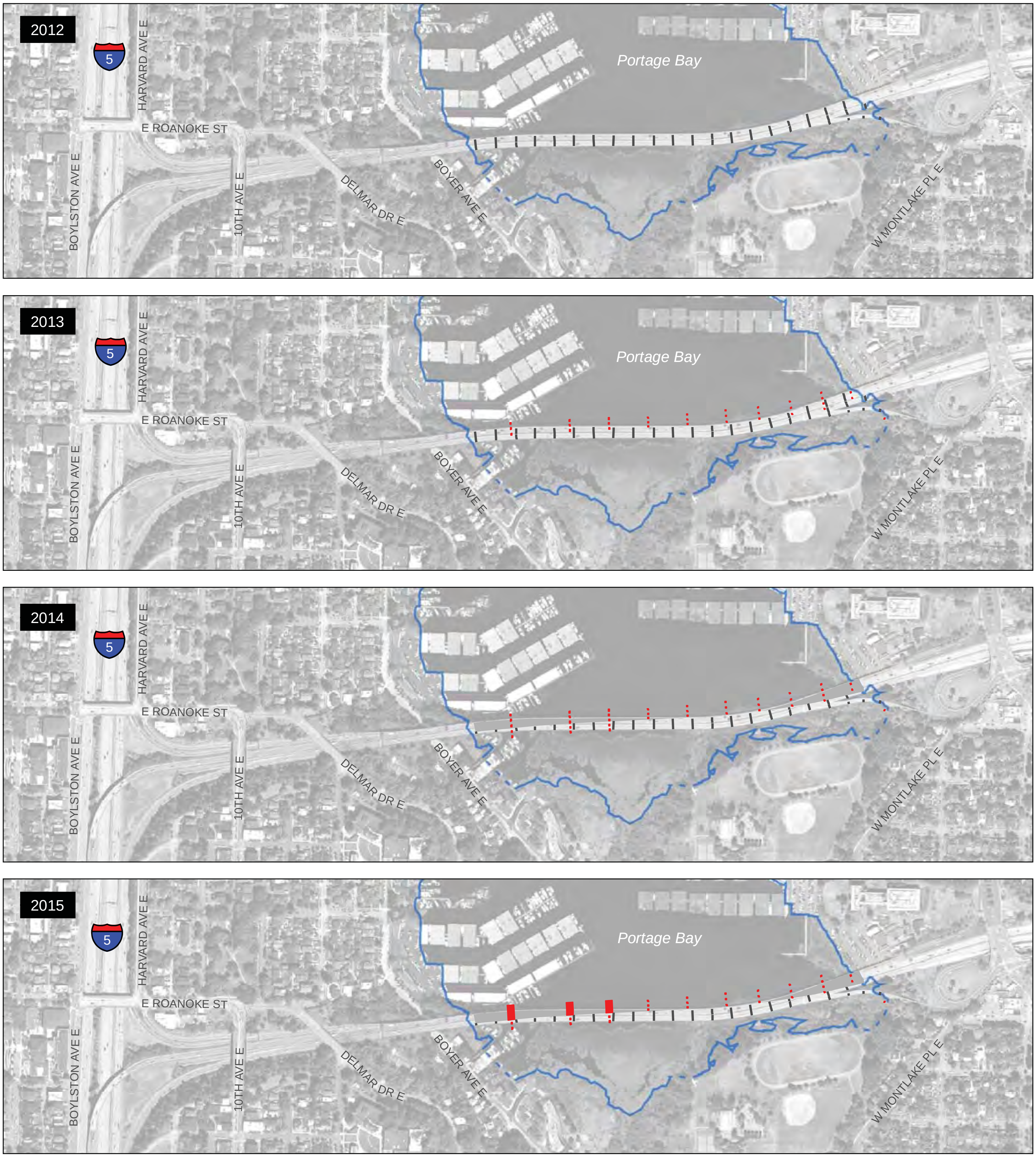
Both mudline footings and drilled shafts will intersect with the substrate in Portage Bay. The project calls for the installation of 35 drilled shafts that will permanently occupy about 2,800 square feet of benthic substrate and three mudline footings that will permanently occupy about 12,495 square feet of benthic substrate. These shafts and footings will result in the permanent displacement of about 15,295 square feet of substrate habitat. Temporary substrate displacement will be up to 28 percent greater as the mudline footings are being constructed as a result of the surrounding cofferdams. Demolition of the existing bridge will remove up to 90 columns that currently occupy approximately 1,440 square feet of benthic substrate. Descriptions of these physical structures and their functions are provided in Section 2.2. Exhibit 6-5 summarizes the expected extent of cumulative and final benthic habitat disturbance and displacement in the Portage Bay area that will be caused by these structures. A year-by-year description of constuction activities related to these structures is included in Section 2.6.2. Exhibits 6-6a and 6-6b show the extent of benthic habitat displacement by construction year.

EXHIBIT 6-5.
EFFECTS OF SUBSTRUCTURE ELEMENTS ON SUBSTRATE IN THE PORTAGE BAY AREA, BY CONSTRUCTION YEAR

	Peak Values per Construction Year (square feet)						
Substrate Displacement Source	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Final**
Existing columns	1,440	1,440	720	N/A	N/A	N/A	N/A
Piles [a]	4,500	4,500	5,500	2,250	3,250	3,250	N/A
Columns/shafts [b]	2,100	3,780	4,900	2,800	2,800	2,800	2,800
Cofferdams	N/A	8,238	N/A	5,492	N/A	N/A	N/A
Mudline footings	N/A	N/A	7,497	7,497	12,495	12,495	12,495
Total	**8,040**	**17,958**	**18,617**	**18,039**	**18,545**	**18,545**	**15,295**

[a] Assumes all piles are in water (i.e. below the ordinary high water mark), although work bridges will extend above ordinary high water.
[b] Does not include drilled shafts beneath mudline footings; acounts for temporary widening shafts.

N/A = not applicable



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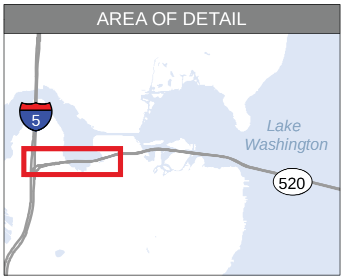

Existing Piers

Ordinary High Water Mark

Ordinary High Water Mark (Not Surveyed)

Bridge Substructure - Permanent Fill

Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

N

0 250 500 1,000 Feet

Exhibit 6-6a. **Annual Benthic Habitat Displacement in Portage Bay**

SR520, I-5 to Medina: Bridge Replacement and HOV Project

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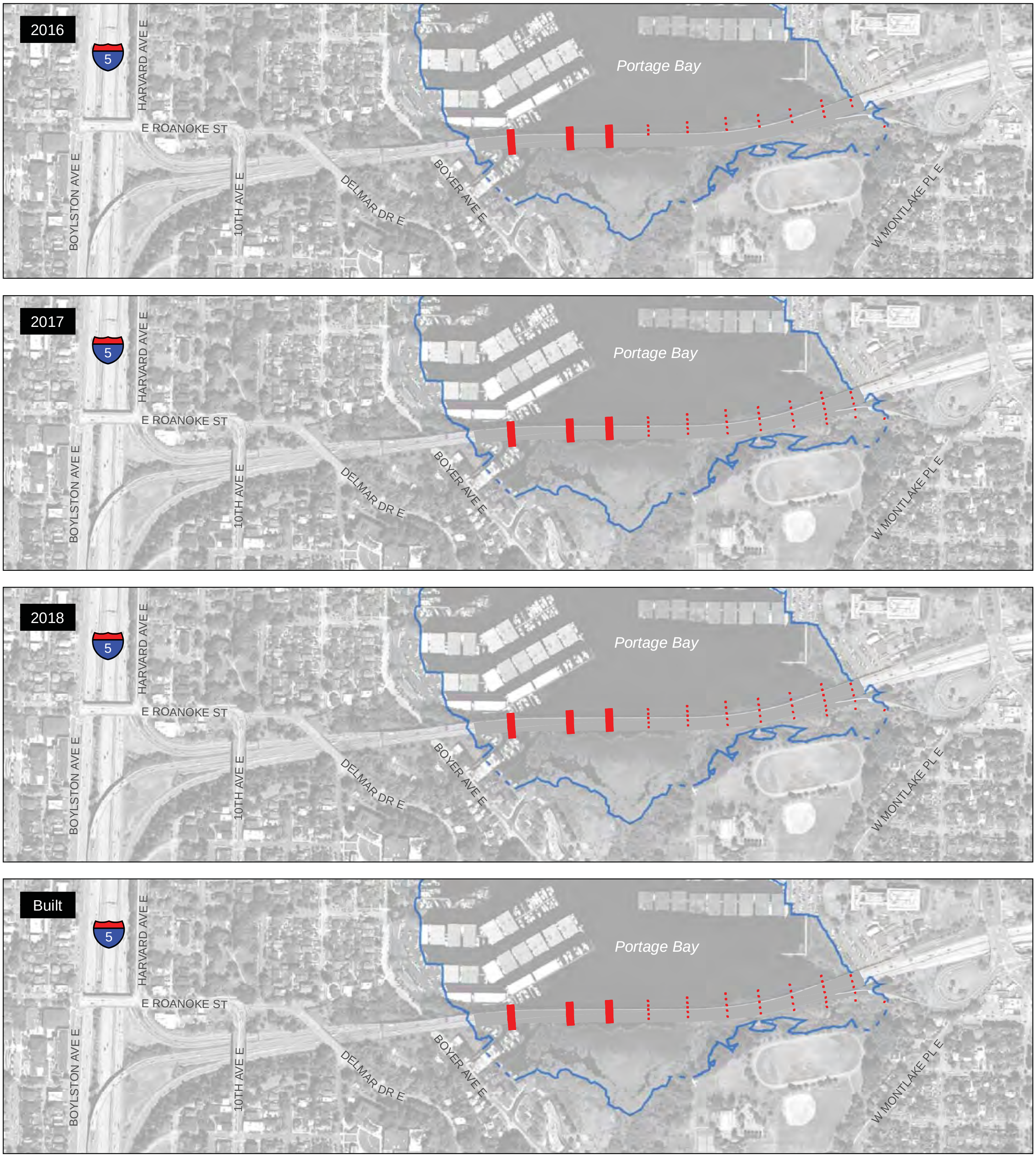
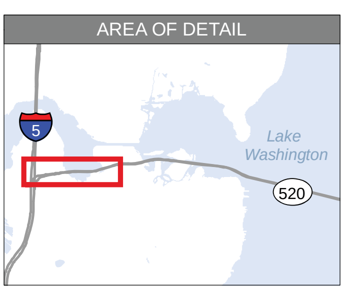




Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

N

0 250 500 1,000 Feet

- Ordinary High Water Mark
- Ordinary High Water Mark (Not Surveyed)
- Bridge Substructure - Permanent Fill

Exhibit 6-6b. **Annual Benthic Habitat Displacement in Portage Bay**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

Shading

The placement of permanent over-water structures will alter the intensities and patterns of in-water shading. Shade effectively creates a different habitat type that contrasts with the adjacent aquatic environment (lacking shade). In particular, the transition between light and shade (edge effect) is considered a potential influence on fish behavior and habitat selection. The shadow cast by an over-water structure affects both the plant and animal communities below the structure.

Factors that influence in-water shade intensities include the width and over-water height of new bridge decks, light diffraction (bending of light around an object) around the structures, light refraction (change in speed and direction of light when travelling from one medium to another, e.g., from air to water) in water, and the spatial alignment of the structures in relation to the path of the sun. To evaluate the effect of shading, the total area of over-water cover was used to provide a year-by-year comparison of the variable shade conditions as project construction proceeds. Exhibit 6-7 provides a summary of these values.

EXHIBIT 6-7.
OPEN-WATER AREA SHADED BY TEMPORARY AND PERMANENT BRIDGE STRUCTURES IN PORTAGE BAY, BY CONSTRUCTION YEAR

	Peak Values per Construction Year (acres)						
Shading Source	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Final**
Existing bridge deck area	3.1	3.1	2.1	2.1	N/A	N/A	N/A
Work bridge area	4	4	4	4	2.0	2.0	N/A
New bridge deck area [a]	1.8	1.8	5.0	3.2	3.2	7.6	7.6
Total	**8.9**	**8.9**	**11.1**	**9.3**	**5.2**	**9.6**	**7.6**

[a] Includes temporary bridge widening.
N/A = not applicable

In construction year 1, increases in shade will begin with the construction of approximately 4 acres of construction work bridges and 1.8 acres of bridge deck associated with the temporary widening of the existing structure. The overall amount of over-water shade will increase to a peak of about 11.1 acres in construction year 3, until the portions of the existing bridge and temporary structures are removed.

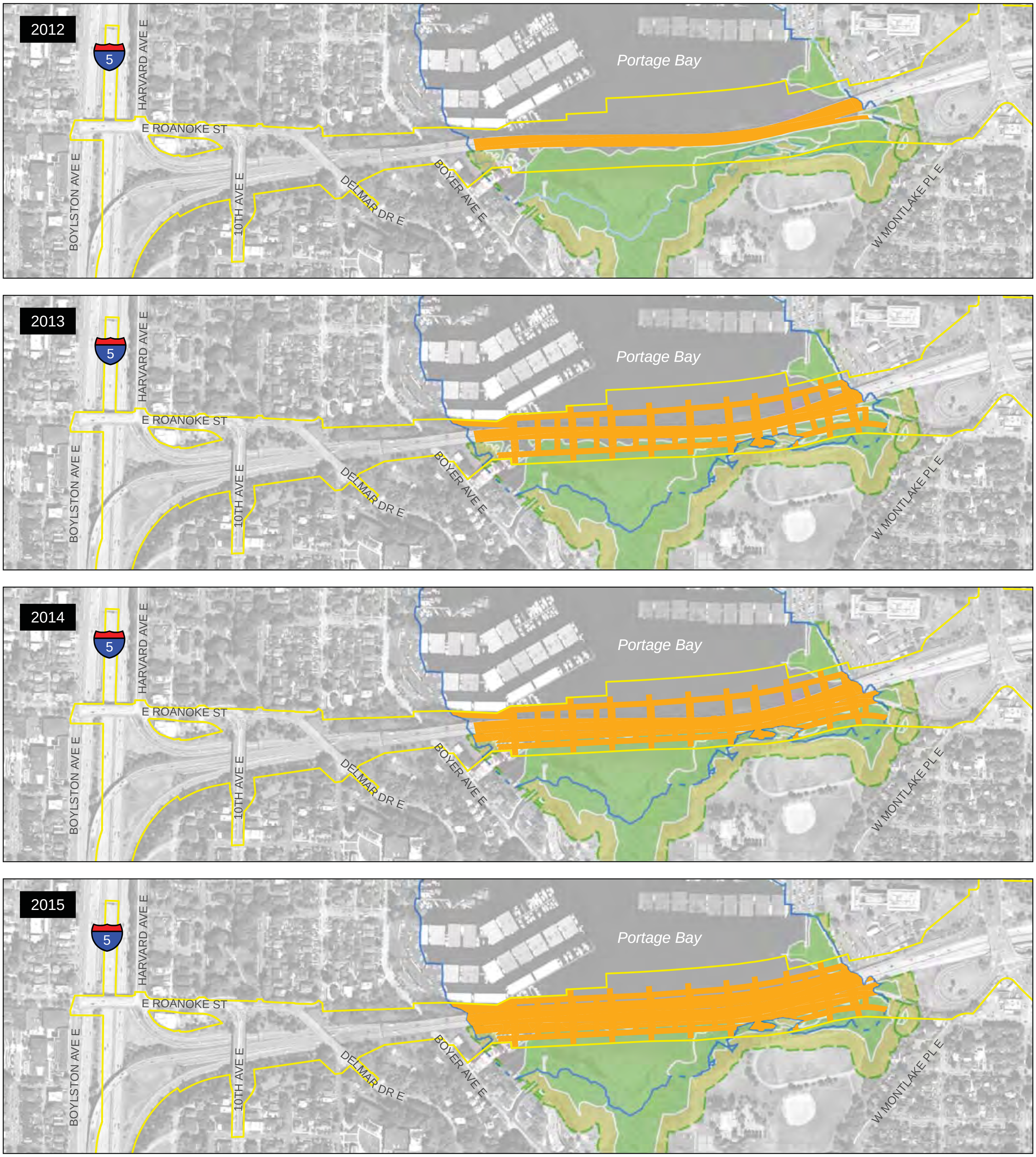
The amount of project-generated shade over the waters of Portage Bay will gradually decrease in years 4 and 5 as a result of the removal of the existing structure and portions of the construction work bridge. The amount of shade will then increase again in year 6 due to the combination of the construction work bridge structure and the construction of the new structure, finally settling at about 7.6 acres when construction is completed. Exhibits 6-8a and 6-8b show the extent of shade by construction year.

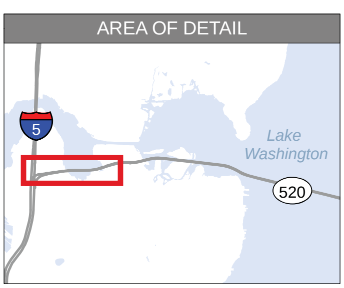
The project will result in an increase of 4.5 acres of shade relative to the baseline condition. The bridge configuration will range between 105 and 143 feet wide, compared to 61 to 75 feet for the existing bridge. The new Portage Bay Bridge will be approximately 62 to 16 feet above the water surface elevation, moving from west to east; this is 7 to 11 feet higher (moving west to east) than the existing Portage Bay structure, which will allow more ambient light under the new structure.

The construction work bridges will be only about 5 feet above the water surface, will allow less ambient light underneath than the existing and proposed bridge structures, and will likely produce the greatest degree of light-to-shadow contrast (edge effect) compared to those structures. Some portion of the work bridges will be shaded by the existing and proposed structures (those under and on the north side of the existing and proposed structures). Depending on the solar angle, this will negate the shadow caused by the higher structures (effectively lessening the total amount of over-water cover) for the time that they are in place.

The effect of shade from the permanent structure will be greatest in the eastern portion of the bay where the new bridge will be the widest and lowest. The edge effect of the bridge’s shadow will be greatest primarily on the north side of the structure due to the very limited amount of available habitat south of the structure. The areas with the highest degree of shading effect (i.e., due to the work bridges and in the eastern portion of Portage Bay) are likely to result in reduced aquatic vegetation density. Any reduction in aquatic vegetation due to the work bridges will be temporary, and the effects are expected to diminish within a few years after the removal of the structures.

The potential effects of shading on listed salmonids in the Portage Bay area are discussed in Section 6.2.1.5.





- Ordinary High Water Mark
- Ordinary High Water Mark (Not Surveyed)
- Limits of Construction
- Shading
- Wetland
- Wetland Buffer

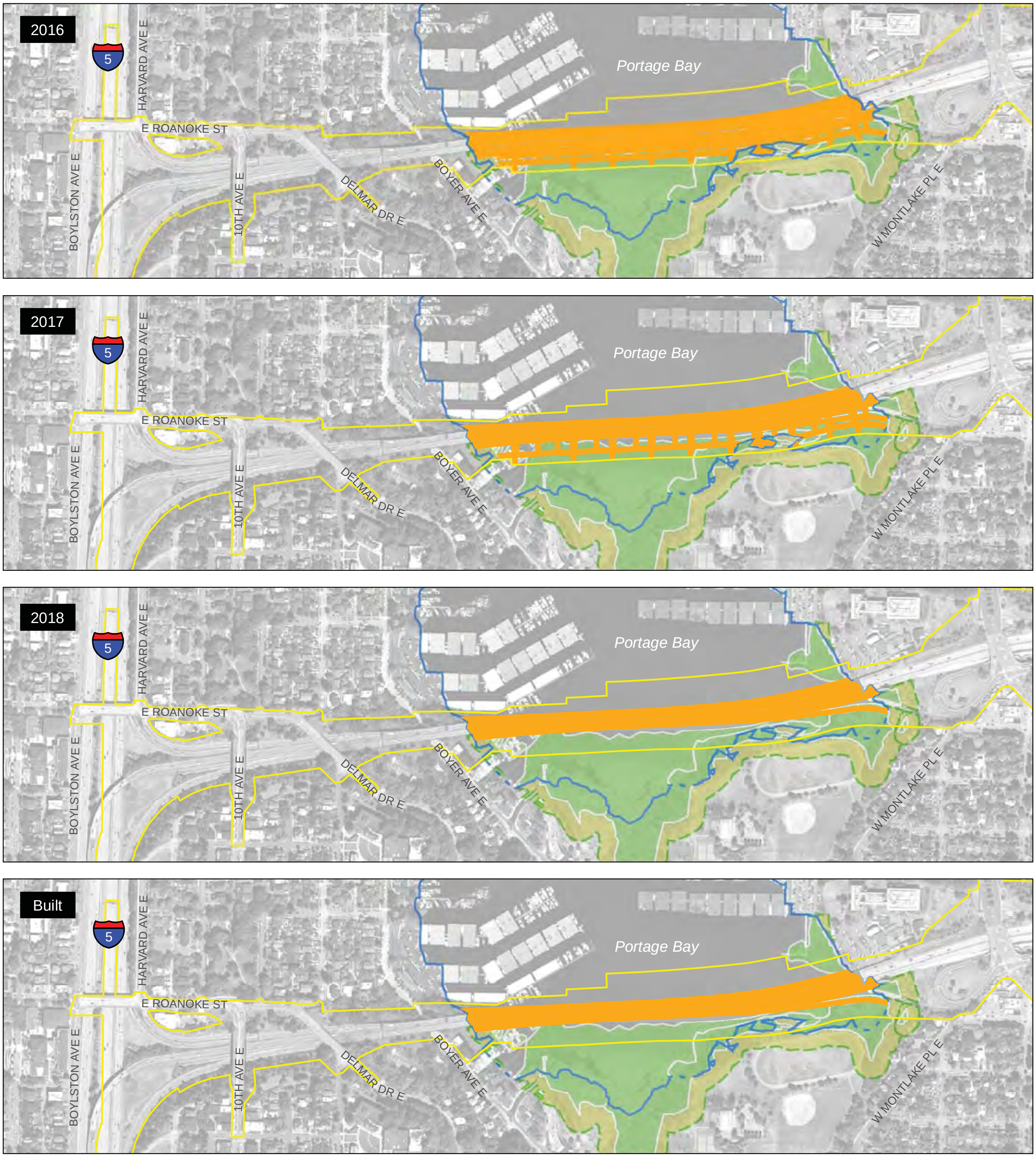
Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

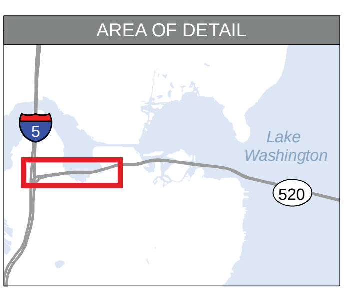
N

0 250 500 1,000 Feet

Exhibit 6-8a. **Annual Shade in Portage Bay Area**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project





- Ordinary High Water Mark
- Ordinary High Water Mark (Not Surveyed)
- Limits of Construction
- Shading
- Wetland
- Wetland Buffer

Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

N

0 250 500 1,000 Feet

Exhibit 6-8b. **Annual Shade in Portage Bay Area**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

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Alteration of Structural Complexity

The placement of temporary and permanent in-water structures will alter the structural complexity of the aquatic habitat. The effects of these structures on benthic habitat are discussed above; this section addresses habitat within the water column.

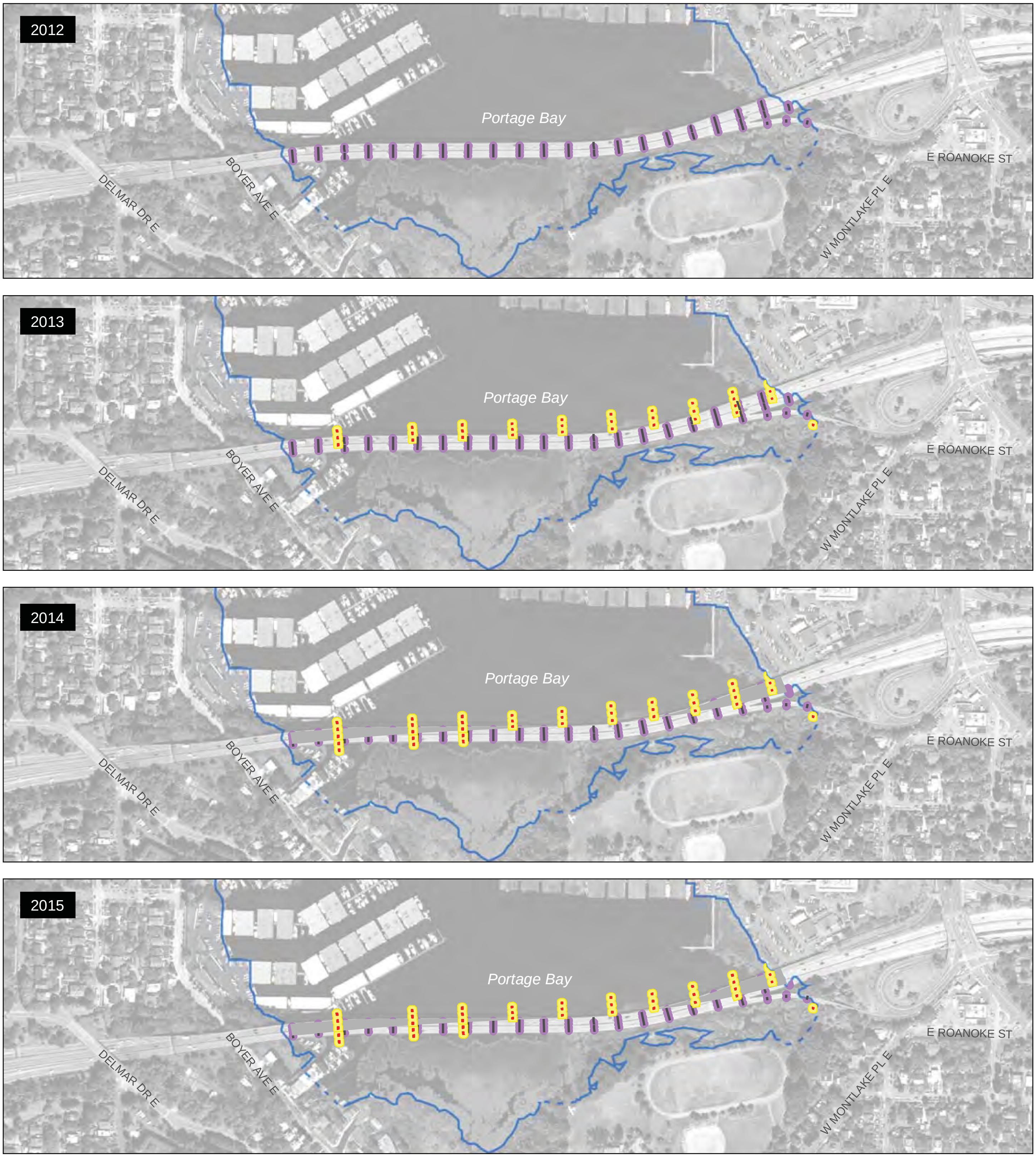
Habitat complexity influences the behavior and distribution of fish, both listed salmonids and predators of salmonids. Each of the vertical structures is considered to represent potential predator habitat. Project-related factors that influence in-water structural complexity are primarily the amount of in-water structure per unit area and the spatial alignment of the structures in relation to one another, such as the distance between shafts (or columns) and the distance between piers (span length). Exhibit 6-9 provides quantities of permanent and temporary in-water structures.

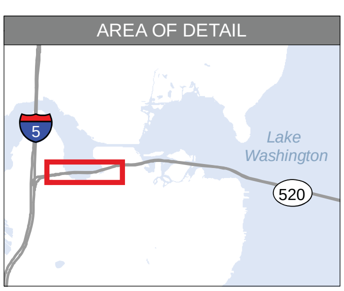
EXHIBIT 6-9.
CHANGES IN STRUCTURAL COMPLEXITY (IN-WATER COLUMNS AND PILES) IN PORTAGE BAY, BY CONSTRUCTION YEAR

	Peak Values per Construction Year						
Structural Complexity Source	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Final**
No. of existing bridge columns [a, b]	89	89	45	N/A	N/A	N/A	N/A
No. of work bridge piles [c]	900	900	1,100	450	650	650	N/A
No. of new bridge shafts/columns [a, d]	42	28	28	50	50	50	50
Total	**1,031**	**1,017**	**1,173**	**500**	**700**	**700**	**50**

[a] Includes temporary bridge widening.
[b] Column spacing = 7 to 9 feet; span length = 100 feet; columns per acre = 28.7.
[c] Pile spacing = 18 feet; span length = 40 feet; piles per acre = 275.
[d] Column spacing = 32 to 42 feet; span length = 116 to 300 feet; columns per acre = 6.6.
N/A = not applicable

The construction of the work bridges will result in a temporary increase in structural complexity in the Portage Bay area due to the presence of 550 to 1,100 steel piles in the shallow-water nearshore habitat at any one time. This increase in structural complexity will begin with the installation of the work bridges during construction year 1 and continue through the entire construction time frame. The highest degree of structural complexity will occur during construction years 1, 2, and 3, when some elements of all the existing and proposed structures are in place and construction of the northern half of the new Portage Bay substructure has been completed. Ultimately, the new Portage Bay Bridge will consist of 50 vertical in-water structures, a net reduction of 49 structures. Exhibits 6-10a and 10b indicate the extent of fixed-bridge vertical structures and surrounding areas, shown as potential predator habitat, by construction year. Refer to Exhibits 6-4a and 6-4b for the spatial extent of work bridges, which also represents the piles associated with the work bridges.





- Existing Piers
- Ordinary High Water Mark
- Ordinary High Water Mark (Not Surveyed)
- Potential Predator Habitat - Existing
- Potential Predator Habitat - Proposed
- Permanent Bridge Column

Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

N

0 125 250 500 Feet

Exhibit 6-10a. **Potential Predator Habitat in Portage Bay by Construction Year**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

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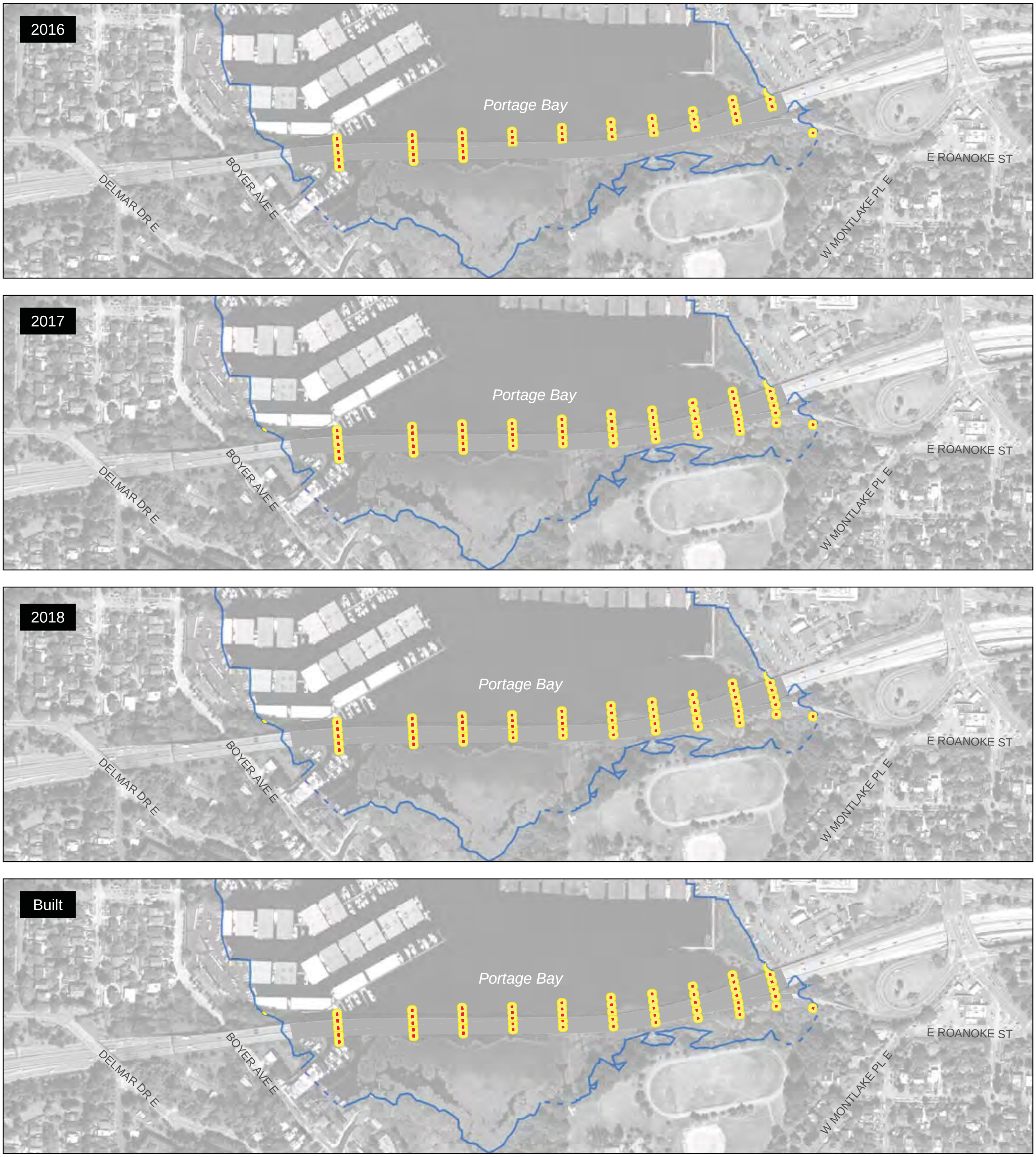
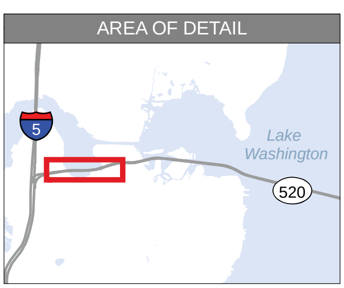




Ordinary High Water Mark

Ordinary High Water Mark (Not Surveyed)

Potential Predator Habitat - Proposed

Permanent Bridge Column

Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

N

0 125 250 500 Feet

Exhibit 6-10b. **Potential Predator Habitat in Portage Bay by Construction Year**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

The proposed Portage Bay structure will have fewer and more-widely-spaced shafts and piers than the existing structure. A total of 12 column piers are proposed, with 5 columns at each pier, for a total of 50 in-water columns or shafts, compared to the 76 in-water columns currently supporting the Portage Bay Bridge. Whereas the existing Portage Bay structure has approximately 100-foot span lengths (distance between piers) with approximately 7 to 9 feet between columns, the proposed structure will have 300- to 116-foot span lengths (moving from west to east) with approximately 32 to 42 feet between shafts and columns. The two westerly span lengths in Portage Bay will be 300 feet long; the one easterly span length will be 116 feet long, and the remaining eight span lengths will range between 200 and 150 feet. This design will result in lower overall structural complexity than the baseline conditions. The resultant effects of changes in structural complexity in the Portage Bay area will begin immediately after the completion of the new structure and will continue for the design life of the bridge.

The potential effects of changes in structural complexity on listed salmonids are discussed in Section 6.2.1.5.

Artificial Lighting

Artificial lighting during construction activities has the potential to affect aquatic habitat conditions in Portage Bay, potentially serving as an attractant to listed species as well as their predators. This could potentially alter normal behavior patterns of listed species and increase predation on listed species.

During construction, nighttime lighting will be used only in concentrated work and stockpile areas, and some low-intensity navigation lighting will also be installed on some portions of the work bridges. Construction activities expected to occur at night include the following:

- Travel lane closures for any work performed from 9:00 p.m.–5:00 a.m to ensure worker safety.)
- Construction activity in winter months (October through March, until 7:00 p.m.)
- Work bridge deck placement
- Girder placement
- Resupply of construction staging areas (e.g., delivery of steel, rebar, and decking materials)
- Final structure outfitting (e.g., signal, signage, and striping)

Therefore, the effects of construction lighting will be variable, both spatially and temporally, as the construction progresses. Areas of concentrated light from on- or over-water work are expected to be 200 feet or less at any one location. Typical BMPs include the following:

- Shielding the lights with visors, louvers, shields, or screens to minimize light spillage
- Directing the lights away from the water whenever practical

- Minimizing the use of lights in areas other than the immediate work zones, when lighting is not needed for safety

After construction is completed in Portage Bay, roadway lighting will be provided for operation of the facility, as described in Section 2.7.2.

The potential effects of artificial lighting on listed salmonids in the Portage Bay area are discussed in Section 6.3.1.

Effects on Localized Limnology

Limnological conditions in the Portage Bay Bridge area are influenced by shading and primary productivity. Wind-driven currents are expected to play a lesser role than in other portions of the lake because Portage Bay is sheltered from the prevailing winds (from the west and the south).

The addition of over-water and in-water structures during construction and the resulting net increase in the amount of over-water and in-water structure from the new Portage Bay Bridge span may result in localized effects on limnological processes. Any such effects are expected to result largely from altered shading patterns. Increased shading may create minor reductions in water temperature.

6.2.1.4 Fish Handling

Some handling of listed salmonid species may occur during construction activities in the Portage Bay area. The installation of cofferdams is the only construction activity that will potentially require fish removal or handling. WSDOT fish handling and exclusion protocols will be implemented to minimize any potential effects (WSDOT 2009a). The drilled shaft casings are not expected to trap any fish because they will be slowly lowered to the bottom. Although efforts will be made to remove any fish trapped inside the cofferdams, some fish may remain stranded. These fish may not survive the effects of drilling and installation of the shafts and columns.

The potential effects of fish handling on listed salmonids in the Portage Bay area are discussed in Section 6.2.1.5.

6.2.1.5 Species Response to Stressors

This section considers the spatial and temporal overlap of the presence of listed salmonids with the associated stressors in Portage Bay (i.e., species exposure) and the expected responses by these species. The exposure of an organism is largely determined by its life history, behavior, and habitat uses. Exhibit 6-11 summarizes the expected use of the Portage Bay habitat by listed salmonids.

EXHIBIT 6-11.
EXPECTED OCCURRENCE OF ANADROMOUS FISH SPECIES IN PORTAGE BAY (ZONE 2), BY LIFE HISTORY STAGE

ZONE 2: PORTAGE BAY													
Species	**Life History Stage**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Chinook salmon	Adult						Low	Low	Low	Low	Low		
	Residual	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal
	Juvenile				Low	Low	Low	Low	Low				
Steelhead	Adult	Low	Low	Low	Low	Low	Nominal						Nominal
	Residual	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal
	Juvenile		Nominal	Nominal	Nominal	Low	Low	Low	Nominal				
Bull trout	Subadult	Nominal	Nominal	Nominal	Low	Low	Low	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal

Nominal presence
Low presence
High presence

Because of the similar life history and habitat requirements of the three ESA-listed salmonids addressed in this analysis, this effects discussion focuses on Chinook salmon as an umbrella species, with distinctions made for steelhead and bull trout as appropriate in their respective subsections. The same approach was used for subsequent analyses in this BA.

Puget Sound Chinook Salmon

Several potential stressors associated with project construction and operation in Portage Bay will have limited or no potential for affecting the physical, chemical, or biological environment in Portage Bay and are, therefore, not expected to adversely affect adult or juvenile Chinook salmon. These potential stressors are summarized in Exhibit 6-12.

EXHIBIT 6-12.
NON-ADVERSE EFFECT STRESSORS IN THE PORTAGE BAY AREA

Stressor	Rationale
Dissolved oxygen related to water quality	Dissolved oxygen is not expected to be affected by the proposed project activities; exposure risk is considered discountable.
Pollutants related to water quality	Pollutants are not known to be present at substantial concentrations; exposure risk is considered discountable with application of BMPs.
Physical debris related to water quality	BMPs will prevent introduction of physical debris into the aquatic environment; exposure risk is onsidered discountable.

EXHIBIT 6-12.
NON-ADVERSE EFFECT STRESSORS IN THE PORTAGE BAY AREA

Stressor	Rationale
Terrestrial construction noise	Terrestrial noise transmission is not expected to exceed ambient underwater noise levels; exposure risk is considered discountable.
Vessel operations related to underwater construction noise	Noise caused by vessel operations is not expected to exceed existing underwater noise levels; exposure risk is considered discountable.
Riparian habitat disturbance and displacement	Localized shading patterns and reduction in organic litter input will not result in significant disruption of behavior or injury of listed species. Nearshore communities of nonnative macrophytes provide marginal habitat for listed species. Effect on species is considered insignificant.
Benthic habitat disturbance and displacement	Primary productivity and forage base are not limiting. Reduction in benthos-derived productivity will not result in significant disruption of behavior or injury of listed species. Effect on species is considered insignificant.
Limnological processes	Short-term alterations of temperature or phytoplankton production will not result in significant disruption of behavior or injury of listed species. Effect on the species is onsidered insignificant.

BMP = best management practice

Certain aspects of the proposed action are likely to adversely affect adult and juvenile Chinook salmon in the Portage Bay area, either through a modification of normal behavior or through direct injury or mortality. These stressors are the following:

- Water quality degradation from construction activities
- Underwater noise from impact pile driving
- Shading (note that discussions of shading and alteration of structural complexity are combined in the discussion below)
- Alteration of structural complexity (note that discussions of shading and alteration of structural complexity are combined in the discussion below)
- Artificial lighting
- Fish handling

Water Quality Degradation from Construction Activities

The primary mechanism by which the project would degrade water quality is by suspending sediments and increasing turbidity. Suspended sediments may have some potential to introduce associated pollutants into the water column, and the intensity of potential effects from such pollutants are expected to be correlated with the intensity of the turbidity increase.

Project-generated turbidity may be at its highest during construction years 4 and 6; approximately 650 piles will be removed each year. Timing restrictions and the use of BMPs will minimize the potential exposure of Chinook salmon to this turbidity. No exposure to increased turbidity more than 150 feet from the source is expected because of required adherence to state water quality standard for the turbidity mixing zone and the results from preliminary pile-driving investigations, demonstrating that the water quality standard for turbidity can be achieved.

Within 150 feet of the source activity, fish exposed to increased turbidity are expected to exhibit variable responses based on the intensity of the turbidity and the duration of exposure. Direct effects of increased turbidity on salmonids can include altered physical and physiological conditions. The primary physical effects consist of gill abrasion by suspended sediments. Particle size and angularity are important factors in the effect of suspended sediment on young salmon. The finer, more abrasive particles may clog or erode gill filaments.

Physiological effects include stressors on the physical health and fitness of salmonids as a result of detrimental effects on blood chemistry and osmoregulatory functions (Servizi 1990).

Moderate turbidity can improve foraging for salmonids, whereas higher turbidity can reduce the foraging rates. Gregory and Northcote (1993) found that intermediate turbidity (35 to 150 NTUs) provided the highest observed feeding rates in juvenile Chinook salmon. Gregory (1993) reported reduced foraging rates for young Chinook salmon at turbidity greater than 150 NTUs, but feding continued at turbidities as high as 850 NTUs.

Distance of prey capture and prey capture success have both been found to decrease significantly when turbidity increased (Berg and Northcote 1985). Whereas turbidity can have a measurable effect on the feeding efficiency of salmonids, similar reductions in efficiencies are expected for species that prey on salmonids.

High turbidity can also delay adult migration, although turbidity alone does not seem to affect ultimate homing. Delays in spawning migration and associated energy expenditure may reduce spawning success and, therefore, population size (USFWS 2008a). Information concerning the effects of turbidity on adult migrations is based on riverine habitats, not lake systems. In Portage Bay, localized increases in turbidity high enough to affect adult migrations will likely result in adults migrating around the turbidity plume.

Any exposure durations are likely to be limited due to (1) the ephemeral nature of the turbidity plume, and (2) adherence to the in-water construction period to minimize likelihood of salmonid presence. In most cases of exposure, it is expected that increased turbidity will elicit an avoidance response. Any physical trauma caused by turbidity will occur only to fish exposed within a few feet of the activity for an extended period of time, and any physiological effects are expected to increase the avoidance response. Given that turbidity increases are expected to be less than 100 NTU within 50 feet of any disturbance, and that increased turbidity should subside within 3-40 minutes (WSDOT 2010c), exposed fish are expected to only exhibit signs of stress temporarily.

Given the small area of the lake habitat affected at any one time (within a 150-foot radius of turbidity-causing activity), the expected limited use of the existing habitat by listed salmonids, and the temporary duration of expected turbidity plumes, only a few Chinook salmon are likely to be adversely affected by increased turbidity. Of those affected, even fewer are likely to be juvenile fish.

In conclusion, although the extent of expected harm and harassment of Chinook salmon due to increased turbidity is not insignificant or discountable, several factors suggest that exposure risk will be moderated:

- Construction activities that may cause increased turbidity will occur during the 7-month in-water construction period from mid-August through April.
- Because of the timing of in-water work, Chinook salmon adults are more likely than juveniles to be present during project activities that cause turbidity. However, the average time spent by adult Chinook salmon in the Lake Washington system in 1998 was 2.9 days (Fresh et al. 1999). Because Portage Bay constitutes a small portion of the Lake Washington system, the average time spent by adult Chinook salmon in Portage Bay is anticipated to be less than 2.9 days.
- Adult and juvenile Chinook salmon migration occurs primarily within the northern portion of Portage Bay, near or within the Ship Canal. The most intensive turbidity-causing activities will occur in the southern portion of Portage Bay, more than 150 feet away from the migration corridor. Monitoring data during the SR 520 test pile project demonstrated that increased turbidity will be constrained to an area within approximately 150 feet of the construction activity (WSDOT 2010c).
- The use of BMPs (Section 2.10) is expected to minimize the size of the area affected by turbidity-causing activities.

Underwater Noise from Impact Pile Driving

In-water pile driving in Portage Bay will occur over an approximately 7-month period (September through April) during three of the six proposed construction years—years 1, 2, and 4 (Exhibit 6-3). During construction year 1, up to 900 piles will be driven, with up to 200 or less driven during subsequent years.

Small numbers of Chinook fry begin migrating into Lake Washington from the Cedar River in January, and most Chinook fry enter the lake in mid-May, outside the in-water construction period. A majority of the adult Chinook salmon typically return to the lake in August and September, in the early part of the in-water construction period.

Impact pile driving is known to injure and/or kill fish, as well as cause temporary stunning and alterations in behavior. Fish with swim bladders, including salmonids, are more susceptible to barotraumas (injuries caused by pressure waves, such as hemorrhage and rupture of internal organs) from impulsive sounds than fish without swim bladders. Death from barotrauma can be instantaneous or delayed by up to several days after exposure (NMFS 2009b).

Pile-driving activities can also elicit a variety of behavioral responses. In general, there is much uncertainty regarding the response of fish to sources of underwater sound. Broadly, the effects of elevated underwater sound pressure levels on organisms range from no effect to death. Over this continuum of effect, there is no easily identifiable point at which behavioral responses transition to physical effects (USFWS 2008a).

Most bioacoustic specialists consider temporary hearing damage (temporary threshold shifts) to be physiological fatigue and not injury (Popper et al. 2006). However, an organism that is experiencing a temporary threshold shift may suffer consequences of not being able to detect biologically relevant sounds such as approaching predators or prey or mates attempting to communicate. Mesa (1994) examined predator avoidance ability and the physiological response of Chinook salmon subjected to various stressors. The test fish were agitated to cause disorientation and injury. When equal numbers of stressed and unstressed fish were exposed to predators, there was significantly more predation of stressed fish (USFWS 2008a).

The practical spreading loss model (Appendix D) indicates that noise associated with pile driving in Portage Bay will attenuate to less than the 150 dB_{RMS} sound level behavioral threshold for fish disturbance at a distance of about 22 meters (72 feet). The cumulative SEL will exceed the injury threshold at about 2 meters (7 feet) for a 30-inch pile. This represents a total area surrounding the proposed work bridges of 0.7 acre and 270 square feet, respectively.

Pile driving is the in-water construction activity in Portage Bay that is most likely to influence the behavior of adult salmonids. Because pile driving is likely to occur during spawning migrations, adult salmonids could be exposed to elevated SELs while migrating through the described threshold zones; however, this is considered discountable given their migration preferences, their expected rate of travel, and the small distance of the SEL injury zone (2 meters). A slightly larger potential may exist for exposure to noise equal to or greater than the behavioral modification threshold. Elevated noise levels could elicit a startle response, potentially altering migration rate or migration route.

Similar responses are expected by residual Chinook salmon or juveniles that may be exposed to elevated sound levels. These life stages are expected to occur in much lower numbers than the numbers of adults during the proposed impact pile-driving activities. Timing restrictions on impact pile driving may reduce the probability of exposure to discountable levels.

In conclusion, individuals that are present within 22 meters (approximately 72 feet) of pile-driving activities may exhibit a disruption of normal behavior; individuals present within 2 meters (approximately 7 feet) of multiple pile strikes may sustain some form of physical injury.

Although the extent of expected harm and harassment of Chinook salmon due to noise from impact pile driving is not insignificant or discountable, several factors suggest that exposure risk will be moderated:

- Chinook salmon, while not prevented from entering the area of noise effects, are expected to be present in low numbers during impact pile driving (pile-driving activities are expected to occur during a 7-month period from September through April, which is outside the juvenile migration period).

- Because of the timing of pile driving, adult Chinook salmon are more likely to be present in the pile-driving area than juveniles. However, the average time spent by adult Chinook salmon in Lake Washington in 1998 was 2.9 days. Portage Bay is a small portion of the Lake Washington system; consequently, the average time spent by adult Chinook salmon in Portage Bay is anticipated to be much less than 2.9 days. Therefore, the exposure of adult Chinook slamon to pile driving activities, if any, is expected to be limited.
- The use of a bubble curtain is expected to substantially minimize the size of the area affected by sound levels in excess of the disturbance threshold. Based on the SR 520 test pile project, behavioral changes and injury will occur only relatively near the point of noise origin (within 22 and 2 meters, respectively) because of the type of substrate and surrounding land forms (Illingworth and Rodkin 2010). Adult and juvenile Chinook salmon migration mainly occurs in the northern portion of Portage Bay near or within the Ship Canal. The most intensive pile-driving activities will occur in the southern portion of Portage Bay, away from the migration corridor and the potential area of behavioral changes or injury.

Shading and Alteration of Structural Complexity

Because of the greater relative importance of the habitat, Chinook salmon responses to changes in over-water shading and in-water structural complexity are discussed in greater detail in the description of habitat alterations in the west approach area (Section 6.2.4.3). During the 6-year construction time frame, the amount of shade created by the project elements will range from approximately 11 acres in year 3 to slightly more than 5.5 acres in year 5, with the project resulting in a final permanent shading of 7.59 acres (Exhibit 6-7)—an increase of approximately 4.6 acres over baseline conditions. However, the new Portage Bay structure will be approximately 7 to 11 feet higher and will contain 39 fewer columns than the existing structure. The higher structure will produce narrower, more diffuse, shadows than the existing structure, and the reduced number of columns used to support the new structure will decrease the shade cast within the under-structure environment.

As Exhibit 6-9 shows, during construction years 1, 2, and 3, more than 1,000 in-water piles, columns, and other structures (up to 1,217) will be present, increasing the structural complexity of the Portage Bay area. At project completion, there will be approximately 50 in-water columns; which will be fewer and more widely spaced (approximately double in distance) than those of the existing structure.

Effects on Migratory Behavior

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. The available 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).

Adult Salmonid Response

The existing data do not indicate that the existing Portage Bay Bridge has a detrimental influence on the migration behavior of adult salmonids in Lake Washington or the Ship Canal. These fish are expected to move quickly through the Ship Canal (Portage Bay) and into Lake Washington, seeking deeper and colder water. Although they will not be prevented from entering Portage Bay and encountering the temporary and long-term structures, WSDOT does not anticipate a significant disruption of normal migration behavior for adult Chinook salmon.

Juvenile Salmonid Response

The existing data do not suggest that juveniles have extended residence time in Portage Bay. The edge effect created by the shadow of the Portage Bay structure is not expected to influence movement into more or less productive habitat because it is located exclusively in the littoral zone in the south end of the bay.

Similarly, the edge effect of shade is not expected to result in any migration delay because individuals will not need to cross under the structure on their outmigration. For individuals that exhibit a paralleling behavior (Celedonia et al. 2008a, 2008b, 2009), the edge on the north side of the structure may limit forays into less favorable habitat underneath and along the south side of the Portage Bay Bridge. Therefore, a significant disruption in normal migration behavior of juvenile Chinook salmon due to the presence of structures in Portage Bay is not expected.

In conclusion, although the extent of expected harm and harassment of Chinook salmon due to increased shade and structural complexity is not insignificant or discountable, several factors suggest that the effects on migration patterns will be moderated:

- Existing data do not indicate that the existing Portage Bay Bridge has a detrimental influence on the migration behavior of adult or juvenile salmonids within the Lake Washington system (including Portage Bay).
- Although the new Portage Bay structure will be wider, it will be higher and contain fewer columns than the existing structure. This will produce more diffuse shadows than the existing structure, reducing the intensity of shading and overall structural complexity per unit area.
- Adult and juvenile Chinook salmon migration occurs primarily near or within the Ship Canal, away from the proposed Portage Bay Bridge.

Effects on Predator-Prey Interactions

Adult Salmonid Response

The available information does not indicate that the existing bridge structure has an influence on the predator-prey interactions of adult salmonids in Lake Washington or the Ship Canal (including Portage Bay). The physical characteristics and location of the new structure are sufficiently similar to those of the existing structure that they are not likely to have a different influence on the predator-prey interactions for adult salmonids.

Juvenile Salmonid Response

The available data, discussed in Appendix G, suggest that smallmouth bass may exhibit a habitat selection preference for areas with higher structural complexity and vertical habitat elements such as columns and piles. A similar selection preference may be observed in Portage Bay associated with the proposed temporary and long-term structures. Assuming that the habitat used in the study described in Appendix G (west approach) was selected because of the concentration of outmigrating juveniles, a lower level of selection for the Portage Bay Bridge can be expected.

The new Portage Bay Bridge will represent an improvement over the baseline condition because the bridge will be higher (although wider) and have fewer and more-widely-spaced in-water structural elements, thereby reducing the overall complexity per unit area. If predatory fish select the habitat associated with the new Portage Bay Bridge, juveniles that migrate along, or hold near, the edge of the structure will be vulnerable to predation.

Some very limited proportion of outmigrating juvenile Chinook salmon may exhibit a holding behavior, resulting in increased residence time around the Portage Bay Bridge. Those fish exhibiting holding behavior or migrating near the proposed structural elements may experience direct injury or mortality by predation, if predators also select that habitat.

In conclusion, although the extent of expected harm and harassment of Chinook salmon due to increased shade and structural complexity will not be insignificant or discountable, several factors suggest that the effects on associated predator-prey relations will be moderated:

- The new Portage Bay Bridge will represent an improvement over the baseline condition because the bridge will be higher (although wider) and have fewer and more-widely-spaced in-water structural elements, thereby reducing the overall complexity per unit area.
- Existing data do not indicate that the existing Portage Bay Bridge has an influence on predator-prey relations associated with adult salmonids.
- Adult Chinook salmon migration occurs primarily away from the proposed Portage Bay Bridge and within deeper waters.
- Juvenile Chinook salmon migration occurs primarily in the northern portion of Portage Bay, away from the proposed bridge.

Artificial Lighting

Construction lighting associated with building approximately the eastern half of the new Portage Bay Bridge has the greatest potential for affecting juvenile Chinook salmon; however proposed over-water lighting in Portage Bay will occur where juvenile salmonid use is limited. Lighting may affect the distribution of fish, their prey items, or the ability of fish to detect prey items at night.

Construction lighting is expected to result in effects on listed salmonids that are similar to those of operational lighting, which are discussed in detail in Section 6.3.1.

Fish Handling

Some handling of listed salmonid species may potentially occur during construction activities in Portage Bay. The installation of cofferdams (in years 2 and 4) is the only construction activity that will potentially require fish removal or handling. Drilled shaft casings are not expected to trap any fish because they will be slowly lowered to the bottom.

The capture and handling of fish, including ESA-listed species, may result in their injury or death. Mortality may be immediate or delayed. Handling stress, trauma from seines and dip nets, impingement on block nets, and electroshocking may result in some injury and death. Injury and death due to handling stress is less common when seines or dip nets are used. Adverse effects due to stranding, block nets, and electroshocking are more likely to occur. The actual numbers of fish affected by capture and handling is difficult to anticipate.

Although the extent of expected harm and harassment of Chinook salmon due to handling is not insignificant or discountable, several factors will contribute to impact minimization and reduced risk of exposure:

- WSDOT fish handling and exclusion protocols will be implemented to minimize any potential effects (WSDOT 2009a).
- Adult and juvenile Chinook salmon migration occurs primarily in the northern portion of Portage Bay, near the Ship Canal, away from the proposed cofferdam installation and/or drilled shaft activities.
- Construction will occur during the in-water construction period to minimize the presence of juvenile salmonids in the action area.

Puget Sound Steelhead

The potential effects of the project activities in the Portage Bay area on Puget Sound steelhead are expected to be similar to but substantially less probable and less severe than the effects on Chinook salmon. Adult steelhead tend to migrate during the winter (November to March), in much lower numbers than Chinook salmon, and their migration tends to be spread out over the prolonged migration period. Juvenile steelhead tend to migrate out of the lake in generally the same time frame as Chinook salmon, with most of the migration occurring between May and

July. The primary difference is the larger size of the steelhead in the lake, which indicates that they usually rear for a year in their natal stream, are less likely to show a preference for nearshore habitat, and are less likely to be affected by the short and long-term changes in the habitat conditions.

Generally, any adverse effects on Chinook salmon resulting from project activities could also affect steelhead. However, based on the older age classes and larger size of migrating juvenile steelhead and the generally lower numbers of steelhead in the system, potentially adverse effects on steelhead will be more limited than those on Chinook salmon.

In conclusion, although the extent of expected harm and harassment of steelhead during project activities is not insignificant or discountable, several factors will contribute to impact minimization and a reduced risk of exposure:

- Steelhead, while not prevented from entering the Portage Bay area, are expected to be present in low numbers during the in-water construction period (September through April), which is mostly outside the juvenile migration periods.
- Adult steelhead migration will occur primarily in the northern portion of Portage Bay, away from the most intensive pile-driving impact areas. Adult steelhead are likely mobile enough to avoid areas of lesser effects.
- There is limited available information that identifies Portage Bay as a location specifically used by juvenile steelhead for rearing. Steelhead rear for several years before migrating to Puget Sound; therefore, they are expected to be less dependent on the shallow nearshore habitat in the lake/Portage Bay.
- The use of BMPs (Section 2.10) is expected to minimize the size of the area affected by turbidity-causing activities.
- The use of a bubble curtain during pile driving is expected to minimize the size of the area affected by sound levels in excess of the disturbance threshold.

Coastal-Puget Sound Bull Trout

Generally, effects on Chinook salmon could also apply to bull trout. The potential mechanisms of effect on bull trout due to the project activities in Portage Bay are expected to be similar to those for Chinook salmon; however, the effects are less likely because of the low abundance of the bull trout and the timing of their use of habitat in Portage Bay. The potential effects will also be less intense because only adult and subadult life stages are expected to be exposed to them.

Bull trout may occasionally occur within the action area, especially the saltwater portions downstream of the Ballard Locks; however, there have been only a few reports of bull trout/Dolly Varden in the Lake Washington watershed (including Portage Bay) upstream of the locks. No bull trout observations have been documented between October and December, which is the beginning of the in-water construction period. Additionally, it is only the subadult and adult life stages of bull trout that are likely to make forays into the Portage Bay portion of the project area and experience any type of exposure to project-related effects. Although anadromous adult and subadult bull trout may occur in the action area anytime, they are most likely to be present in spring and early summer, associated with increased prey abundance of outmigrating juvenile salmonids. Timing information is based on bull trout captured at the Ballard Locks and the Ship Canal between May and July, which occurs outside the in-water construction period.

Adult and subadult bull trout are expected to exhibit some different life history traits in Lake Washington than either Chinook salmon or steelhead; therefore, some differences in potential bull trout responses to stressors are expected. These responses are summarized below.

In in addition to the stressors listed in Exhibit 6-12, the following stressors associated with Portage Bay are not expected to result in adverse effects on bull trout:

- **Shading and structural complexity.** Bull trout are not dependent on the Portage Bay area as a migratory corridor, and the subadult and adult forms of bull trout have limited susceptibility to predation. The patterns of overwater shading and in-water structural complexity are not expected to result in a significant disruption of normal behavior or increased predation.

- **Construction lighting.** Foraging by subadult or adult bull trout may be improved somewhat artificially illuminated conditions; however, a significant disruption in foraging behavior is not expected. Additionally, due to the timing of habitat use (late spring), the potential for bull trout exposure to artificially illuminated conditions during construction would be lower than that for the other listed salmonids.

- **Fish handling.** Bull trout are not expected to be using the habitat in Portage Bay during in-water construction activities, and the probability of their presence during cofferdam installation is extremely low. Exposure risk is considered discountable.

- **Effects to prey base –** Although project-related stressors are expected to have some adverse effects on ESA-listed fish, and potentially other forage fish species, the abundance of prey resources is not expected diminish so as to significantly affect bull trout behavior or survival.

Potentially adverse effects on bull trout and their responses to the stressors are summarized as follows:

- **Turbidity.** Individuals exposed to turbid conditions may experience gill abrasion, reduced foraging potential, or exhibit avoidance behaviors.

- **Pile driving.** Individuals exposed to pile-driving noise are expected to experience some disruption of normal behavior (e.g., startle or avoidance response) within 22 meters; however, a cumulative SEL injury effect within 2 meters is considered discountable.

In conclusion, although the extent of expected harm and harassment of bull trout during project activities is not insignificant or discountable, several factors will contribute to impact minimization and a reduced risk of exposure:

- Bull trout, while not prevented from entering the Portage Bay area, are expected to be present in low numbers, if at all, during the in-water construction period (September through April).
- If any bull trout are present, the individuals are expected to be adult or subadults, both of which are likely mobile enough to alter their route to avoid impact areas.
- The use of BMPs (Section 2.10) is expected to minimize the area affected by construction activities.

6.2.2 Bascule Bridge in the Montlake Cut Area

This section addresses effects that will result from the following activities and conditions:

- Construction of the new bascule bridge structure and associated temporary structures
- Long-term presence of the new bascule bridge

Project elements and construction activities are described in Sections 2.2 and 2.3. Exhibit 6-13 summarizes the spatial and temporal extent of those project elements and the related construction activities.

EXHIBIT 6-13.
SPATIAL AND TEMPORAL EXTENT OF PROJECT ELEMENTS IN THE MONTLAKE CUT AREA

Project Element	Total Number	Frequency	Total Duration	In-Water/ Over-Water Area
Barge moorage	6 moorage events	All moorage events over a 3- to 4-week period	48 hours per each event	Not calculated
New bridge deck	2 leaves	N/A	Permanent	Increase of 0.2 acre

N/A = not applicable

The project elements and associated construction activities described in Sections 2.2 and 2.3 are expected to result in the following mechanisms of effect or types of stressors on listed species and designated critical habitat:

- Water quality degradation
- Noise
- Habitat alteration

The potential project-related effects on the Montlake Cut area are discussed in detail below. The potential effects on listed salmonids in the Montlake Cut area related to this analysis are discussed in Section 6.2.2.4.

6.2.2.1 Water Quality Degradation

Proposed activities in the Montlake Cut will occur almost exclusively in uplands or will be contained on barges. Upland activities are not expected to affect water quality, becasue they will be isolated from the water by cofferdams installed upland of the OHWM. In addition, because the Montlake Cut is a deep waterway that is lined with retaining walls/riprap and used primarily for vessel passage, operation of tugboats and barges to assist with placement of the bridge leaf spans is not expected to affect water quality (i.e., to increase turbidity by disturbing sediments).

6.2.2.2 Noise

Potential noise during the proposed activities includes terrestrial construction noise and underwater construction noise (vessel operations).

Terrestrial Construction Noise

Terrestrial construction noise in Montlake Cut is expected to be similar to noise in other portions of the action area (Section 6.2.1.2), except that impact pile driving will not be used in this area.

Underwater Construction Noise

For the bascule bridge construction, vessel operations are the only proposed in-water activity that has the potential to affect listed species.

The operation of tugboats and, potentially, self-propelled work barges will produce in-water disturbance. The Montlake Cut is used primarily for vessel passage. Operation of tugboats and work barges is likely to generate noise levels comparable to those generated by other vessels that routinely operate in the area. Noise levels generated by the project-related vessels are therefore expected to be within the range of baseline conditions and are not expected to affect the aquatic environment or listed species.

6.2.2.3 Habitat Alteration

Potential habitat alterations include shading and artificial lighting. Because of the lack of work proposed below the OHWM for the Montlake Cut area, no disturbance or displacement of riparian or benthic habitat is anticipated. Also, wetlands will not be disturbed during the construction of the bascule bridge.

Shading

The placement of permanent over-water structures will alter in-water shading intensities and patterns, potentially causing changes in riparian and aquatic habitats. Exhibit 6-14 lists factors that will potentially affect shade in the Montlake Cut area.

EXHIBIT 6-14.
OPEN-WATER AREA SHADED BY EXISTING AND PROPOSED BRIDGE STRUCTURES IN THE MONTLAKE CUT AREA, BY CONSTRUCTION YEAR

Shading Source	2016	2017	2018	Final
Existing bridge deck area	0.2 acre	0.2 acre	0.2 acre	0.2 acre
New bridge deck area	N/A	0.2 acre	0.2 acre	0.2 acre
Total	**0.2 acre**	**0.4 acre**	**0.4 acre**	**0.4 acre**

N/A = not applicable

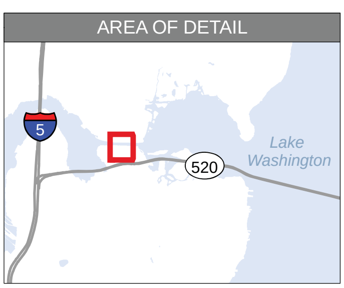
An increase in shade will not occur until near the end of construction year 2, with the construction of the new bascule bridge spans. The project will result in 0.4 acre of permanent over-water cover—an increase of 0.2 acre over the baseline condition in the Montlake Cut. Exhibit 6-15 shows the extent of shade from the proposed bascule bridge.

The potential effects of shading on listed salmonids in the Montlake Cut area are discussed in Section 6.2.2.4.

Artificial Lighting

Artificial lighting during project construction has the potential to affect aquatic habitat conditions and listed species in the Montlake Cut. BMPs will be similar to those discussed for Portage Bay (see Section 6.2.1.3).

Construction lighting is expected to result in effects on listed salmonids that are similar to those of operational lighting, which are discussed in detail in Section 6.3.1.



Ordinary High Water Mark
Permanent Shading
Proposed Edge of Pavement
Park

N

0 50 100 200 Feet

Source: King County (2006) Aerial Photo, CH2M HILL (2008) GIS Data (Park). Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 6-15. **Effects of Shading by the Bascule Bridge**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

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6.2.2.4 Species Response to Stressors

This section addresses the spatial and temporal overlap of the presence of listed salmonids with the associated stressors of the bascule bridge in the Montlake Cut area (i.e., species exposure) and the expected responses by these species. The exposure of an organism is largely determined by its life history, behavior, and habitat uses.

Puget Sound Chinook Salmon

Several potential stressors associated with project construction in the Montlake Cut area will have limited or no potential to affect the physical, chemical, or biological environment in the Montlake Cut and will not disrupt normal behavior or otherwise injure adult or juvenile Chinook salmon. The potential stressors that will not adversely affect adult or juvenile Chinook salmon are summarized in Exhibit 6-16.

EXHIBIT 6-16.
NON-ADVERSE EFFECT STRESSORS IN THE MONTLAKE CUT AREA

Stressor	Rationale
Turbidity related to water quality	Construction activities are not anticipated to create turbidity; exposure risk is considered discountable.
Physical debris related to water quality	BMPs will prevent introduction of physical debris into the aquatic environment; exposure risk is considered discountable.
Construction noise	Terrestrial noise transmission is not expected to exceed ambient underwater noise; exposure is considered insignificant.
Vessel operations related to underwater construction noise	Noise caused by vessel operations is not expected to exceed existing baseline underwater noise; exposure is considered insignificant.

BMP = best management practice

Certain aspects of the proposed action are likely to adversely affect adult and juvenile Chinook salmon in the Montlake Cut either through a modification of normal behavior or through direct injury or mortality. These stressors are the following:

- Shading
- Artificial lighting

Shading

The project will result in 0.4 acre of permanent over-water cover in the Montlake Cut area—an increase of 0.2 acre over the baseline condition. The existing bascule bridge spanning the Montlake Cut, less than 50 feet west of the proposed new bridge, accounts for the existing 0.2 acre of over-water cover. The Montlake Cut is a relatively deep waterway (approximately 30 feet deep), and the sides of the cut are armored with concrete or riprap. The existing and proposed bridges are located about 36 to 45 feet above the water surface.

Chinook salmon responses to changes related to over-water shading are discussed in detail in the description of habitat alterations in the west approach area (Section 6.2.4.3). As noted there, over-water structures can affect the migratory and predator-prey behavior of Chinook salmon.

Adult Chinook salmon tend to migrate through the Montlake Cut quickly, suggesting that the existing bascule bridge structure does not have a measurable effect on the migration behavior of adult salmonids in the Montlake Cut (Fresh et al. 1999; Fresh 2000). The physical characteristics and location of the new structure are sufficiently similar to those of the existing structure that they are not likely to have a different influence on adult salmonids. Outmigrating juvenile salmonids may respond to the edge effect created by the bridge shadow, potentially altering their migration behavior. Because of the height of the bridge above the water, the light-dark transition is not expected to be intense, potentially reducing the risk of shade-influenced behavior modification.

The new bascule bridge will provide increased shaded areas that might be used by predator species (e.g., smallmouth bass), which could affect juvenile salmonids. However, the steep shoreline in this east-to-west channel, results in partial or complete shade for most of the day. Combined with the overall height of the overhead bridge structures, the new bridge is not expected to result in a substantial effect on fish behavior. In addition, the depth of the Montlake Cut and the unnatural armoring of the banks provide little if any habitat for salmonid predators or holding habitat for juvenile salmonids.

Artificial Lighting

As noted previously, the Montlake Cut is a deep waterway with artificially armored banks. These conditions provide limited habitat for fish; therefore, it is expected that juvenile salmonids will migrate through this area fairly quickly. The potential effects of construction lighting on listed salmonids is expected to be similar to that of operational lighting, which is discussed in detail in Section 6.3.1.

Puget Sound Steelhead

The potential effects of project activities in the Montlake Cut on Puget Sound steelhead are expected to be similar to but less probable and less severe than the effects on Chinook salmon. Adult steelhead are not expected to be affected by project activities in this area. Juvenile steelhead migrate out of the lake in generally the same time frame as Chinook salmon, most of the migration occurring between May and July. Juvenile steelhead are older and larger than juvenile Chinook at the time of outmigration. Their larger size could reduce the potential effects of predation on juvenile steelhead in comparison to juvenile Chinook. Regardless, any adverse effects on juvenile Chinook salmon could also apply to juvenile steelhead.

Coastal-Puget Sound Bull Trout

The potential effects of the project activities in the Montlake Cut area on bull trout are expected to be similar to but substantially less probable than the effects on Chinook salmon. Bull trout may occasionally occur in this area; however, there have been only a few reports of bull trout/Dolly Varden in the Lake Washington watershed (including the Montlake Cut). In addition, there have been no reports of juvenile bull trout in Lake Washington or the Montlake Cut; therefore, juveniles are expected to occur very rarely in these areas. Fuethermore, observations of adult and subadult bull trout have not been documented between October and December, which is the beginning of the in-water construction period. Although anadromous adult and subadult bull trout may occur in the Montlake Cut area anytime, they will most likely be present in spring and early summer. This conclusion is based on bull trout captured at the Ballard Locks and the Ship Canal between May and July, a period that is outside the in-water construction period.

Based on the low probability of bull trout occurrence in the action area, and the larger size and behavior traits of adult and subadult life history stages that may be present, effects on bull trout are expected to be insignificant.

6.2.3 Union Bay

This section addresses effects that will result from the following activities and conditions:

- Construction of the new fixed-span structure and associated temporary structures
- Removal of the existing Union Bay span and ramp structures, as well as the temporary structures
- Long-term presence of the proposed Union Bay structure.

Project elements and construction activities for Union Bay are described in Section 2.3. Exhibit 6-17 summarizes the spatial and temporal extent of those project elements and the related construction activities.

EXHIBIT 6-17.
SPATIAL AND TEMPORAL EXTENT OF PROJECT ELEMENTS IN UNION BAY

Project Element	Total Number	Frequency	Total Duration	In-Water/Over-Water Area
Work bridge pile installation	1,100	Up to 16 per day	Approx. 14 months	Up to 5,500 square feet
Work bridge deck	2	Approx. 5,000 square feet per day	Approx. 14 months	Up to 7.6 acres
Drilled shaft	104 in water	2 to 4 days per shaft	Approx. 24 months	8,320 square feet
Bridge superstructure	12 spans	Varies	Approx. 36 months	8.4 acres
Materials transport	N/A	Daily	Ongoing	N/A
Column demolition	186	Approx. 3 to 5 per week	Approx. 13 months	Approx. 3,000 square feet
Pile removal	1,300	Approx. 4-6 per day	Approx. 10 months	Up to 5,500 square feet

N/A = not applicable

These project elements and the associated construction activities described in Section 2.3 are expected to result in the following mechanisms of effect or types of stressors on listed species and designated critical habitat:

- Water quality degradation
- Noise
- Habitat alteration
- Fish handling

The potential project-related stressors in Union Bay are discussed in detail below. Stressors are reported both cumulatively by construction year ("temporary" effects) and for the final proposed condition ("permanent" effects). The potential effects on listed salmonids are discussed in Section 6.2.3.6.

6.2.3.1 Water Quality Degradation

Potential water quality effects during the proposed activities include increased turbidity, decreased concentrations of dissolved oxygen, and introduction of pollutants and/or construction debris. Potential water quality effects in Union Bay will be similar to those discussed for Portage Bay (Section 6.2.1.1).

Turbidity

Project construction in and near aquatic habitat could result in increased turbidity. Upland construction and staging activities will disturb the substrate in shoreline areas, creating some potential for sediments to be introduced to the aquatic environment. However, implementation of appropriate BMPs will eliminate or minimize this potential risk (BMPs are described in Section 2.10). Any turbidity caused by upland activities will remain localized, and BMPs will be maintained, repaired, or augmented to eliminate turbid runoff.

The construction elements listed in Exhibit 6-18 include in-water work activities for the Union Bay area, which are sources of turbidity that may result in exposure of listed salmonids to turbid conditions. Exhibit 6-18 represents the current estimate of work for each of the construction elements, by construction year.

EXHIBIT 6-18.
PROJECT ACTIVITIES LIKELY TO INCREASE TURBIDITY IN UNION BAY

Turbidity Source	Peak Values per Construction Year					
	2013	**2014**	**2015**	**2016**	**2017**	**2018**
No. of existing columns removedl	97	N/A	89	N/A	N/A	N/A
No of piles driven	500	N/A	600	N/A	N/A	N/A
No. of piles removed	N/A	N/A	N/A	500	N/A	600
No. of shaft casings installed	60	N/A	44	N/A	N/A	N/A
No. of shaft templates removed	60	N/A	44	N/A	N/A	N/A
Total	**717**	**0**	**777**	**500**	**0**	**600**

N/A = not applicable

Turbidity may be increased during all aspects of in-water construction (i.e., existing column removal, pile driving and removal, shaft installation and removal) during each of the six construction years in which in-water work will occur (Exhibit 6-18), although no activities are anticipated that will produce long-term changes in turbidity.

The greatest potential for sediment suspension will result from construction elements that remove existing or temporary structures. This is expected to mobilize adjacent sediment particles upwardly into the water column, as opposed to installation activities during which the forces would be directed into the substrate.

Turbidity may be at its highest during construction years 4 and 6, when approximately 500 to 600 piles will be removed. Pile removal is likely to cause more turbidity than the installation of piles and columns because of the nature of the work required to extract piles as opposed to driving them. No pile driving is expected to occur during construction years 4 and 6; therefore, disturbance from pile-driving noise will not be concurrent with disturbance from pile-removal turbidity in those years. Construction years 2 and 5 will be entirely devoid of potential turbidity-generating sources.

During project construction, the removal of existing or temporary structures is expected to mobilize adjacent sediments upwardly into the water column and cause a series of short-term, localized turbidity plumes (see Exhibit 6-18). Because of the shallow water (less than 10 feet deep) conditions throughout Union Bay, no tugboat activity is expected to occur, eliminating any potential for increased turbidity due to propeller wash disturbance of the substrate. The work in these shallow-water areas will be conducted from the work bridges, including the construction and removal of the work bridge piles.

The substrate sediments in Union Bay are generally characterized by very dense silty, gravelly sand overlain by varying thicknesses of organic muck (WSDOT 2009g). The depths of organic soils vary from a few feet to up to 60 feet. All of the proposed work in Union Bay will be confined to relatively shallow-water areas, where there is an abundance of aquatic macrophytes. The root mass associated with these macrophyte communities is expected to reduce the potential for sediment suspension into the water column.

As in Portage Bay, the spatial extent of increased turbidity is expected to be limited by the nature of the proposed construction activities, the shallow-water installation locations, the lack of water currents in this portion of Lake Washington, and the implementation of BMPs such as floating booms or turbidity curtains. A setailed discussion of the potential extent of turbidity resulting from project activities is provided in Section 6.2.1.1.

The total temporal extent of increased turbidity is expected to be episodic throughout the duration of the construction and demolition activities in Union Bay, a total of 30 months over the course of six 8-month in-water construction periods. The higher intensity effects of turbidity are expected to occur during the extraction activities proposed in construction years 4 and 6.

As a result, in-water activities will result in localized, intermittent, and short-term increases in turbidity. Additionally, the timing and duration of proposed construction and demolition activities during the in-water construction period, along with the implementation of appropriate BMPs, will reduce the potential exposure of listed salmonids. The potential effects of turbidity on listed salmonids are discussed in Section 6.2.1.5.

Dissolved Oxygen

Changes in dissolved oxygen concentrations due to increases in turbidity are discussed in Section 6.2.1.1.

Pollutants

There is no indication of contaminated sediments in the construction zones in Union Bay. The implementation of perimeter control (curbs and toe boards) and catchment measure (tarps and platforms) BMPs described in Section 2.10 is expected to minimize or eliminate the potential for pollutants to be introduced to the aquatic environment during construction activities.

Physical Debris

The implementation of perimeter control (curbs and toe boards) and catchment measure (tarps and platforms) BMPs described in Section 2.10 is expected to minimize or eliminate the potential risk of introducing physical debris from construction activities.

6.2.3.2 Noise

Potential noise during proposed activities includes terrestrial construction noise and underwater construction noise (vessel operations and pile driving).

Terrestrial Construction Noise

Terrestrial construction noise in Union Bay is expected to be similar to that in Portage Bay (see Section 6.2.1.2).

Underwater Construction Noise

Several in-water activities proposed in Union Bay will have the potential to increase underwater noise levels, potentially affecting listed species. Three primary elements of the project have the potential to result in noise effects: vessel operations, vibratory pile driving, and impact pile driving.

Vessel Operations

As in Portage Bay, noise levels generated by the potential use of project-related vessels in Union Bay are expected to be within the range of baseline conditions (see Section 6.2.1.2).

Pile Driving

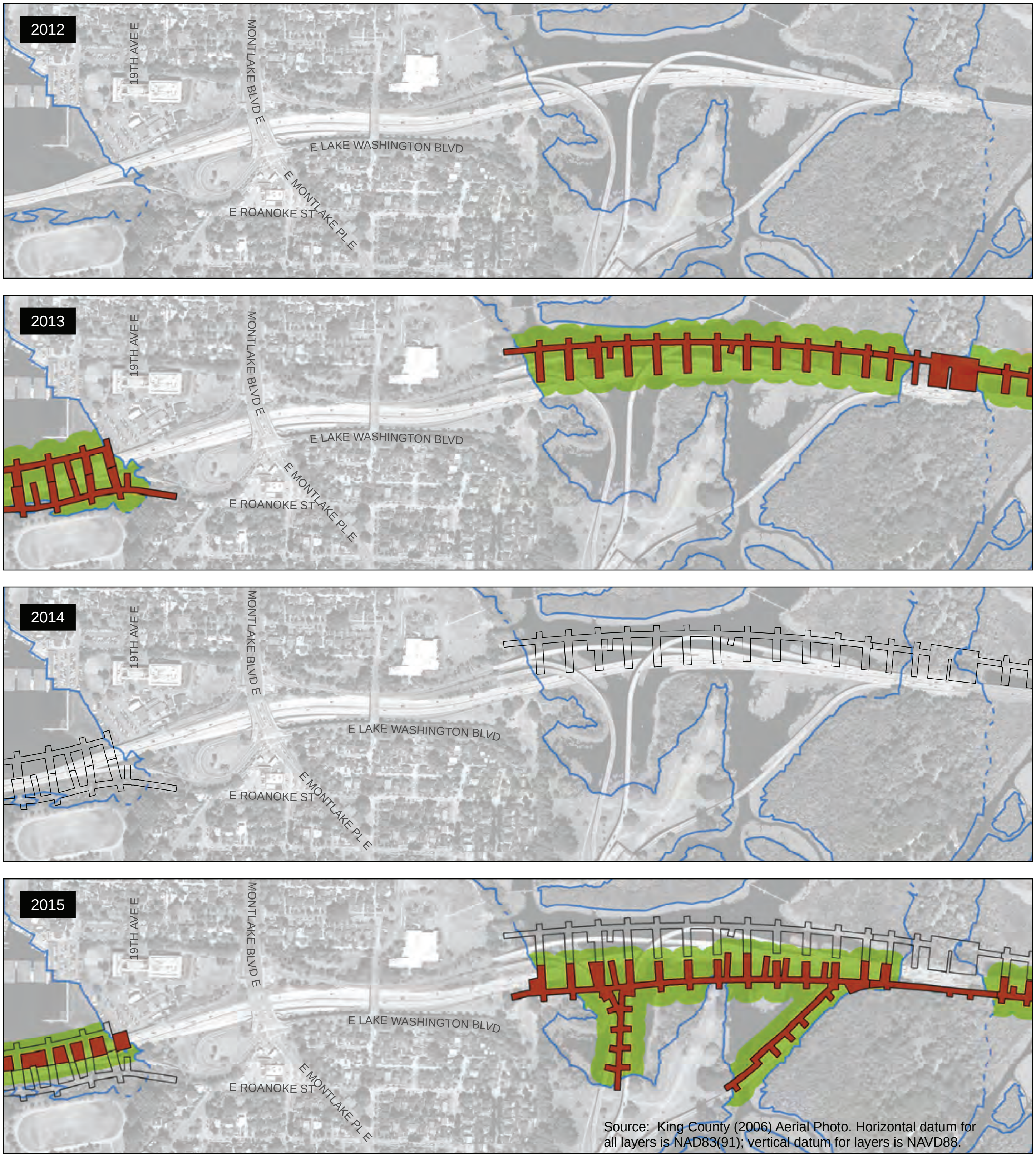
The proposed pile-driving activities in Union Bay and the distances for causing potential effects on listed salmonids are summarized in Exhibit 6-19. Pile-driving activities in Union Bay will include both vibratory and impact pile driving. Only impact pile-driving activities are expected to produce sound levels that could adversely affect listed species. In Union Bay, a single-strike incident sound level of 199 dB_{PEAK}, and a BMP sound reduction level of 30 dB from BMP application are assumed (Appendix D).

EXHIBIT 6-19.
PILE-DRIVING ACTIVITIES AND DISTURBANCE DISTANCES FOR POTENTIAL EFFECTS ON LISTED SALMONIDS IN UNION BAY

Elevated Noise Source	Peak Values per Construction Year					
	2013	2014	2015	2016	2017	2018
Timing	July–April	N/A	July–April	N/A	N/A	N/A
Total piles	500	N/A	200	N/A	N/A	N/A
Maximum piles per day	16	N/A	16	N/A	N/A	N/A
Estimated driving days	31	N/A	13	N/A	N/A	N/A
Strikes per pile	500	N/A	500	N/A	N/A	N/A
Strikes per day	8,000	N/A	8,000	N/A	N/A	N/A
Strike duration per pile (minutes)	20	N/A	20	N/A	N/A	N/A
Strike duration per day (minutes)	320	N/A	320	N/A	N/A	N/A
Total ensonified area (acres) – 206 dB_{PEAK} [a]	N/A	N/A	N/A	N/A	N/A	N/A
Total ensonified area (acres) – 187 dB_{SEL} [a]	1.3	N/A	1.6	N/A	N/A	N/A
Total ensonified area (acres) – 183 dB_{SEL} [a]	1.3	N/A	1.6	N/A	N/A	N/A
Total ensonified area (acres) – 150 dB_{RMS} [a]	9.7	N/A	10.0	N/A	N/A	N/A

[a] Per work bridge constructed in calendar year; Assumptions:
187 dB_{SEL} and 183 dB_{SEL} distance = 2 meters from the pile (270 square feet per pile).
150 dB_{RMS} distance = 22 meters from the pile (0.7 acre per pile).
dB = decibels
N/A = not applicable
RMS = root mean square
SEL = sound exposure level

The potential effects of pile driving on listed salmonids in Union Bay are similar to those in Portage Bay (see Section 6.2.1.5). Exhibits 6-20a and 20b show the extent of pile-driving thresholds by construction year.



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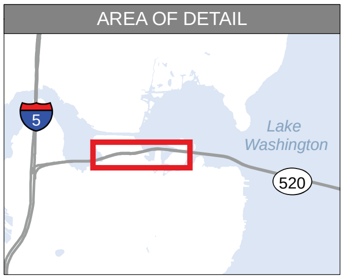

- Ordinary High Water Mark
- Ordinary High Water Mark (Not Surveyed)
- False Work
- Work Bridge
- Work Bridge and Falsework Construction in Progress

Potential Fish Behavior/Injury Thresholds

- 150 dB RMS
- 183/187 db SEL

N

0 250 500 1,000 Feet

Exhibit 6-20a. **Annual Pile-Driving Noise in Union Bay**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

Ordinary High Water Mark

Ordinary High Water Mark (Not Surveyed)

Work Bridge

Work Bridge Removal (Vibratory Removal)

Falsework Construction in Progress

Potential Fish Behavior/Injury Thresholds

150 db RMS

183/187 db SEL

Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

N

0 250 500 1,000 Feet

Exhibit 6-20b. **Annual Pile-Driving Noise in Union Bay**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

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6.2.3.3 Habitat Alteration

Potential habitat alterations resulting from the proposed project activities include riparian habitat disturbance and displacement, benthic habitat disturbance and displacement, shading, alteration of structural complexity, artificial lighting, and changes in localized limnology.

Riparian Disturbance and Displacement

Project activities in Union Bay will result in both the disturbance and the displacement of riparian habitat, which consists of wetlands and upland vegetated buffer areas. Construction activities will result in the clearing or filling of approximately 0.19 acre of wetlands and the clearing or filling of 2.11 acres of buffer (see Sections 4.5 and 4.6 for a description of riparian and wetland conditions in Union Bay).

Benthic Disturbance and Displacement

The substrate sediments in the Union Bay area are generally characterized by very dense silty, gravelly sand. Benthic habitat in the vicinity of proposed in-water disturbance (particularly pile driving) consists of varying thicknesses of organic muck with native and nonnative vegetation.

Construction of the north bridge will result in the disturbance of about 2,500 square feet of substrate area during construction years 1 and 2 and a peak of up to 5,500 square feet of substrate disturbance in construction year 3, when both the north and south work bridges are in place. The disturbance will remain at about 3,000 square feet for the remaining construction years until the south work bridge is removed.

Construction of the 104 drilled shafts to support the replacement of the Union Bay span will result in approximately 8,320 square feet of permanent benthic habitat displacement. Demolition of the existing bridge will remove 186 columns that currently occupy about 2,976 square feet of substrate, resulting in a net increase of up to about 5,300 square feet of substrate habitat and a corresponding increase in water column displacement. The greatest degree of benthic habitat disturbance (15,244 square feet) will occur when all the work bridge piles, proposed bridge shafts, and existing bridge columns are in place concurrently, which is expected in construction year 3.

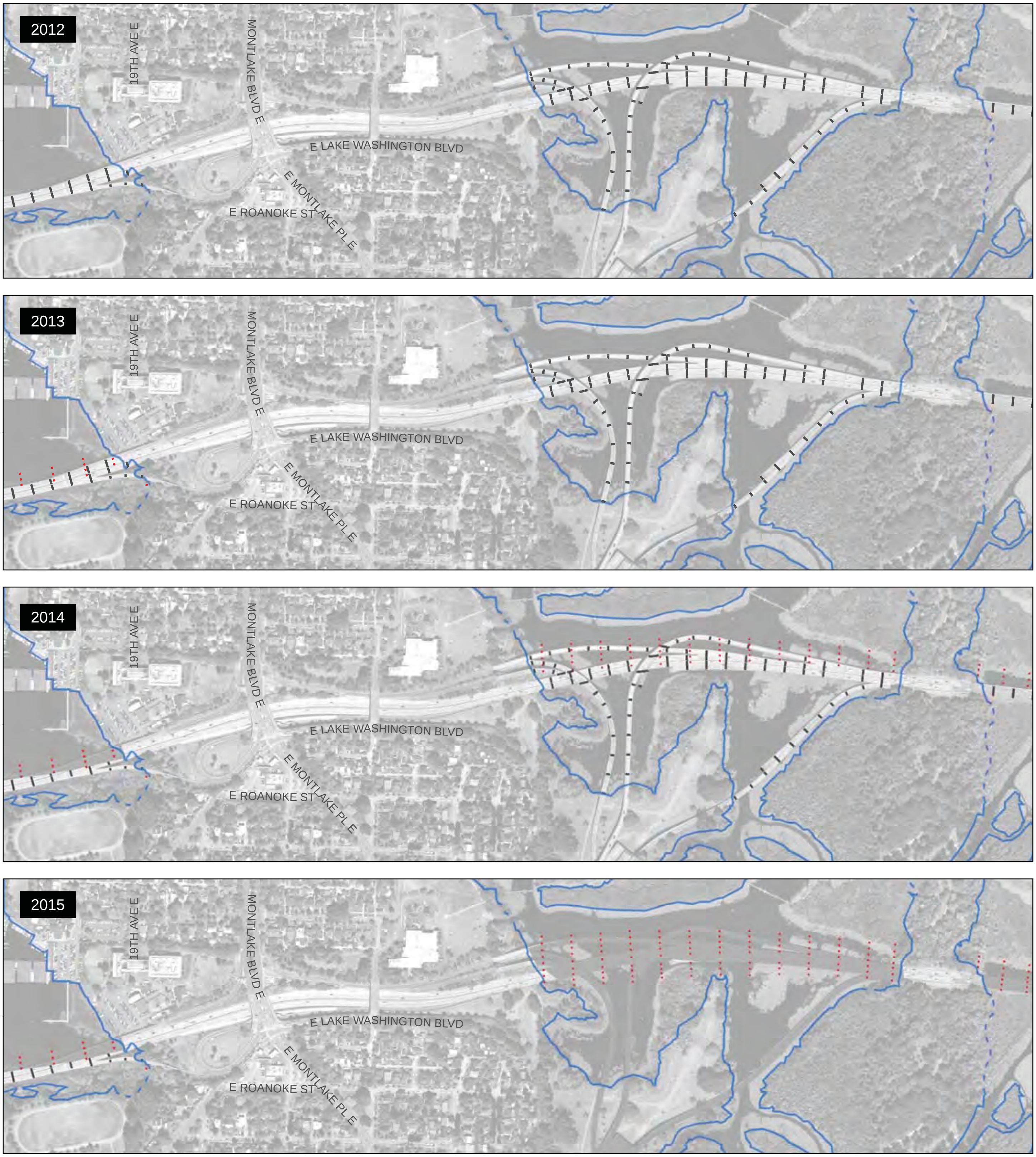
These activities will include the disturbance and displacement of native and nonnative aquatic vegetation. In addition to the shafts occupying the substrate area, the support columns will occupy portions of the water column, which currently supports aquatic vegetation and provides additional macroinvertebrate habitat. These habitat areas are expected to recover relatively quickly after the support piles and work bridges are removed. Although some piles or columns may need to be cut off below the mudline, they will be hollow, so the substrate will also recover quickly. Any depressions remaining from pile or column removal will be filled with appropriate material.

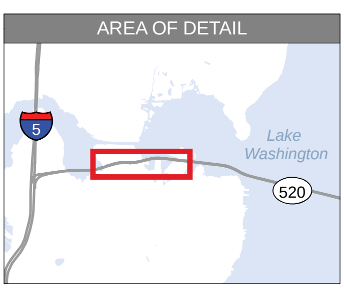
Exhibit 6-21 summarizes the expected extent of benthic habitat disturbance and displacement in the Union Bay area that will be caused by the installation of these structures. A year-by-year description of construction activities related to these structures is included in Section 2.6.4. Exhibits 6-22a and 6-22b show the extent of benthic habitat displacement by construction year.

EXHIBIT 6-21.
EFFECTS OF SUBSTRUCTURE ELEMENTS ON SUBSTRATE IN UNION BAY, BY CONSTRUCTION YEAR

Substrate Displacement Source	Peak Values per Construction Year (square feet)						
	2013	2014	2015	2016	2017	2018	Final
Existing bridge columns	2,976	1,424	1,424	N/A	N/A	N/A	N/A
Piles	2,500	2,500	5,500	3,000	3,000	3,000	N/A
Drilled shafts [a]	4,800	4,800	8,320	8,320	8,320	8,320	8,320
Total	**10,276**	**8,724**	**15,244**	**11,320**	**11,320**	**11,320**	**8,320**

[a] Conservatively assumes shafts (i.e., not columns) displace substrate in all cases.
N/A = not applicable





Existing Piers
Ordinary High Water Mark
Ordinary High Water Mark (Not Surveyed)
Bridge Substructure - Permanent Fill

Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

N
0 250 500 1,000 Feet

Exhibit 6-22a. **Annual Benthic Habitat Displacement in Union Bay**

SR520, I-5 to Medina: Bridge Replacement and HOV Project

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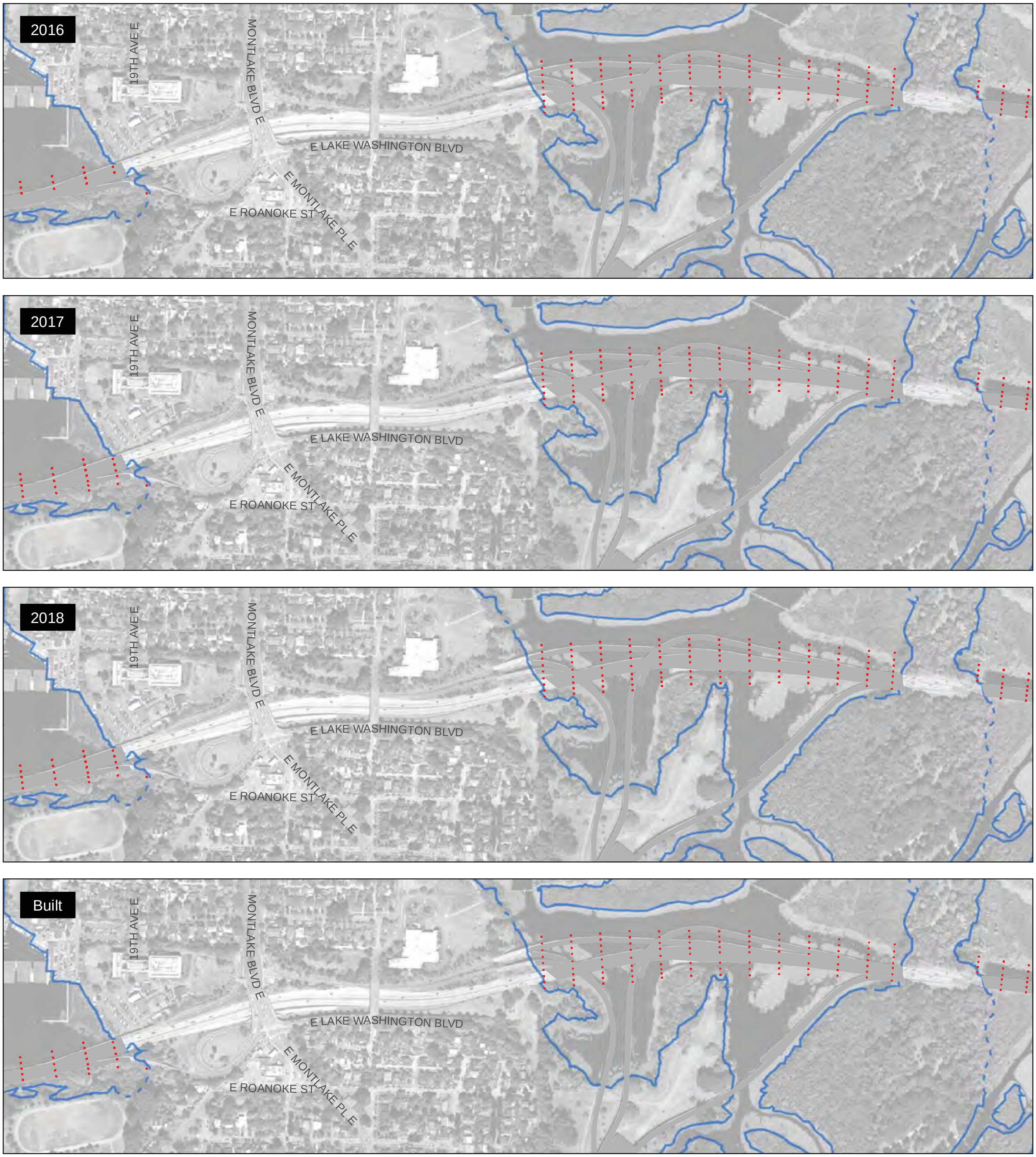

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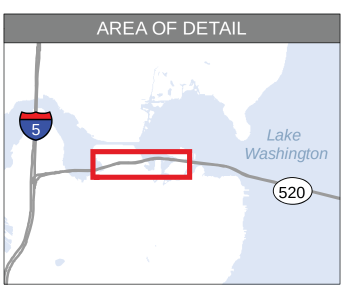

Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

N

0 250 500 1,000 Feet

Ordinary High Water Mark

Ordinary High Water Mark (Not Surveyed)

Bridge Substructure - Permanent Fill

Exhibit 6-22b. **Annual Benthic Habitat Displacement in Union Bay**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

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Shading

To evaluate the effect of shading, the total area of over-water cover was used to provide a year-by-year comparison of the variable shade conditions as project construction progresses to completion. Exhibit 6-23 provides a summary of these values.

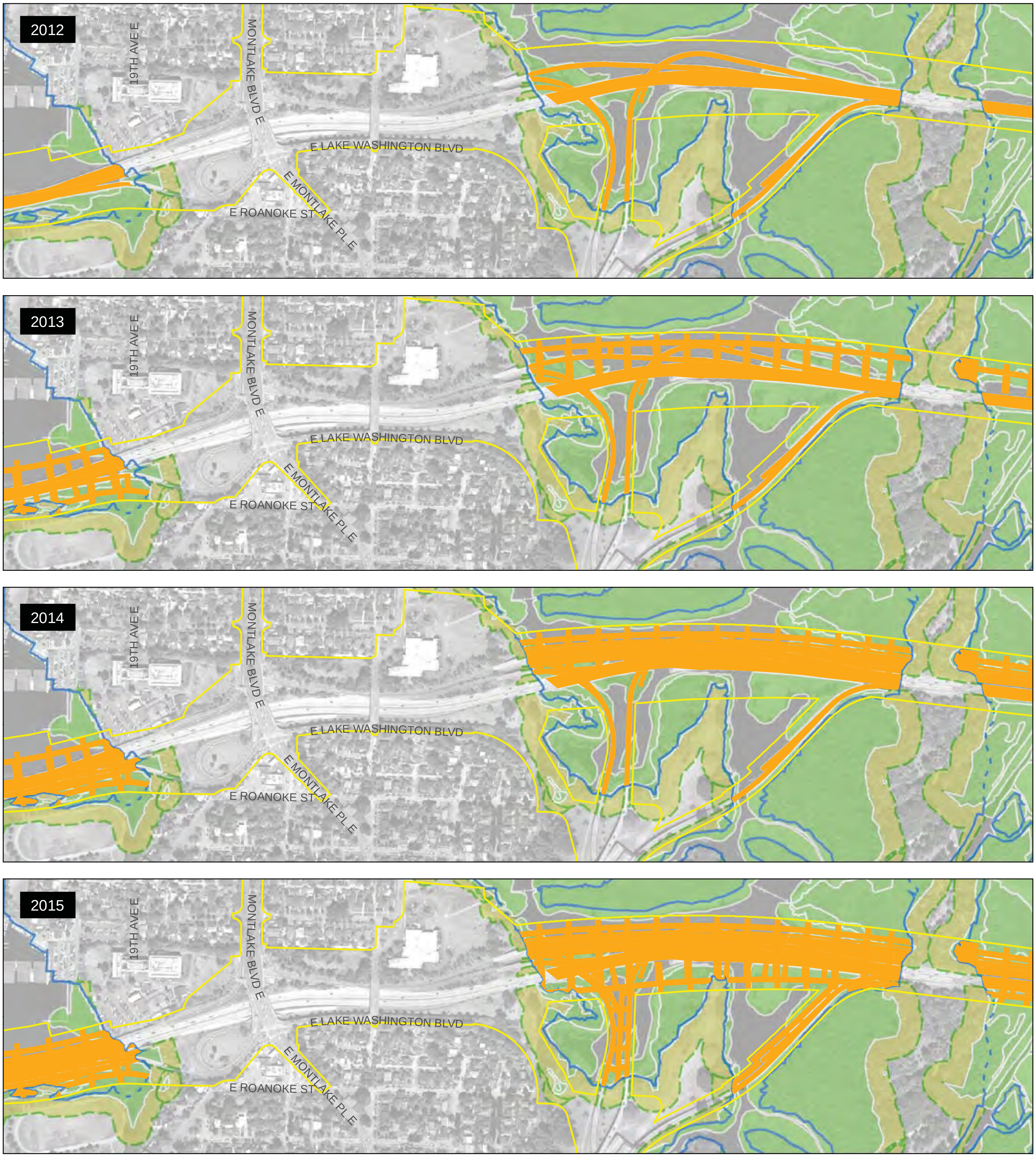
EXHIBIT 6-23.
OPEN-WATER AREA SHADED BY TEMPORARY AND PERMANENT BRIDGE STRUCTURES IN UNION BAY, BY CONSTRUCTION YEAR

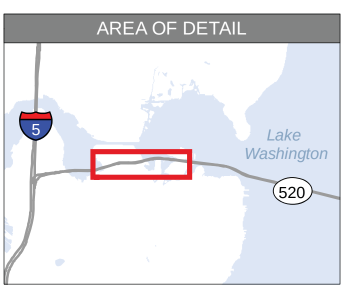
Shading Source	Peak Values per Construction Year (acres)						Final
	2013	2014	2015	2016	2017	2018	
Existing bridge deck area	5.9	3.9	3.9	N/A	N/A	N/A	N/A
Work bridge area	3.3	3.3	7.6	7.6	4.3	4.3	N/A
New bridge deck area	N/A	5.1	5.1	8.4	8.4	8.4	8.4
Total	**9.2**	**12.3**	**16.6**	**16.0**	**12.7**	**12.7**	**8.4**

N/A = not applicable

The increase in shade will begin with the construction of the work bridges in construction year 1. The overall amount of over-water shade will increase over the duration of project construction until the existing and temporary structures are removed (after year 3). Exhibits 6-24a and 6-24b show the extent of shade by construction year.

Within Union Bay, the project will result in 8.4 acres of permanent over-water cover, an increase of 1.8 acres over the baseline condition. The combined deck width through Union Bay will range from approximately 200 to 233 feet, compared to 57 to 104 feet for the existing bridge. The bottom of the bridge deck in Union Bay will range from 11 to 25 feet above the water surface (most of the existing structure is less than 10 feet above the normal high water surface elevation of the lake). The over-water height of the proposed bridge will increase from less than 3 feet to 11.6 feet near Montlake and from 4 to 18 feet at Foster Island. This increase in height for the proposed structure will allow more ambient light under the structure, although it will be wider than the existing bridge (see Exhibits 6-24a and 6-24b).





- Ordinary High Water Mark
- Ordinary High Water Mark (Not Surveyed)
- Limits of Construction
- Shading
- Wetland
- Wetland Buffer

Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

N

0 250 500 1,000 Feet

Exhibit 6-24a. **Annual Shade in Union Bay**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

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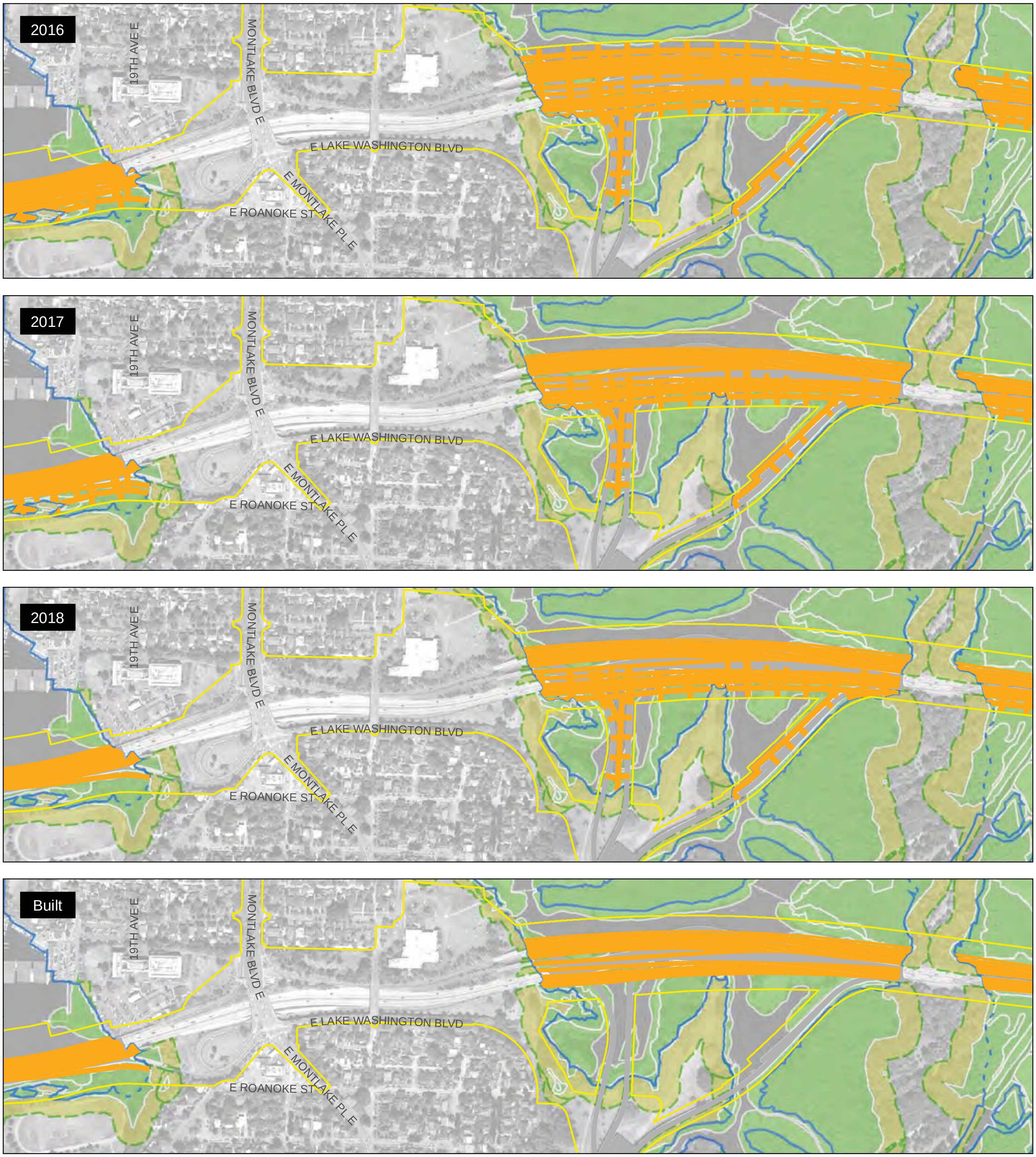
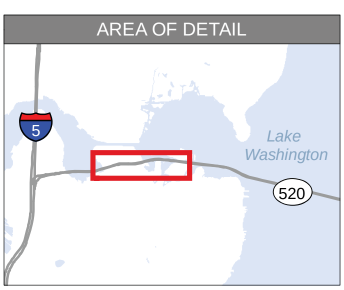




- Ordinary High Water Mark
- Ordinary High Water Mark (Not Surveyed)
- Limits of Construction
- Shading
- Wetland
- Wetland Buffer

Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

N

0 250 500 1,000 Feet

Exhibit 6-24b. **Annual Shade in Union Bay**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

Although the replacement bridge in the Union Bay area will be wider than the existing bridge, it will also be generally higher and have fewer in-water shafts or columns. Changes from the baseline condition include an increase in the width of the bridge deck to nearly double that of the existing condition, a decrease in the overall number and increase in the overall size of the columns, an increase in the spacing between columns, and an increase in the bridge deck height by about 8 to 14 feet above the water. Removal of the existing bridge and construction of the replacement bridge will result in a larger complex of in-water and over-water structure.

As sections of the new bridge are completed and become operational, the comparable existing bridge sections will be demolished, and the construction work bridges will be removed. Any effects on juvenile or adult salmonid migration due to the permanent structures in the Union Bay area will begin as soon as the structures are in place and will continue in perpetuity.

The potential effects of shading in Union Bay are expected to be similar to those in Portage Bay (see Section 6.2.1.3).

Alteration of Structural Complexity

The placement of temporary and permanent in-water structures will alter the structural complexity of the aquatic habitat. The effects of these structures on benthic habitat are discussed above; this section addresses water column habitat.

Habitat complexity influences both the behavior and the distribution of fish, both listed salmonids and predators on salmonids. Habitat complexity in the Union Bay area is believed to provide habitat for predator species that prey on migrating juvenile salmonids. However, the complexity provided by bridge structures in deeper water appears to provide juvenile salmonids increased access to these areas for foraging. Project-related factors that influence in-water structural complexity are primarily a function of the amount of in-water structure per unit area, as well as the spatial alignment of the structures in relation to one another: distance between shafts (or columns) and distance between piers (span length). To evaluate the effect of structural complexity, the total area of over-water cover and spacing metrics were used to provide a year-by-year comparison of the variable shade conditions as the project construction progresses to completion. Exhibit 6-25 provides a summary of these values.

EXHIBIT 6-25.
CHANGES IN STRUCTURAL COMPLEXITY (IN-WATER COLUMNS AND PILES) IN UNION BAY, BY CONSTRUCTION YEAR

Structural Complexity Source	Peak Values per Construction Year						Final
	2013	2014	2015	2016	2017	2018	
No. of existing bridge columns [a]	186	89	89	N/A	N/A	N/A	N/A
No. of work bridge piles [b]	500	500	1,100	600	600	600	N/A
No. of new bridge shafts/columns [c]	60	60	104	104	104	104	104
Total	**746**	**649**	**1,293**	**704**	**704**	**704**	**104**

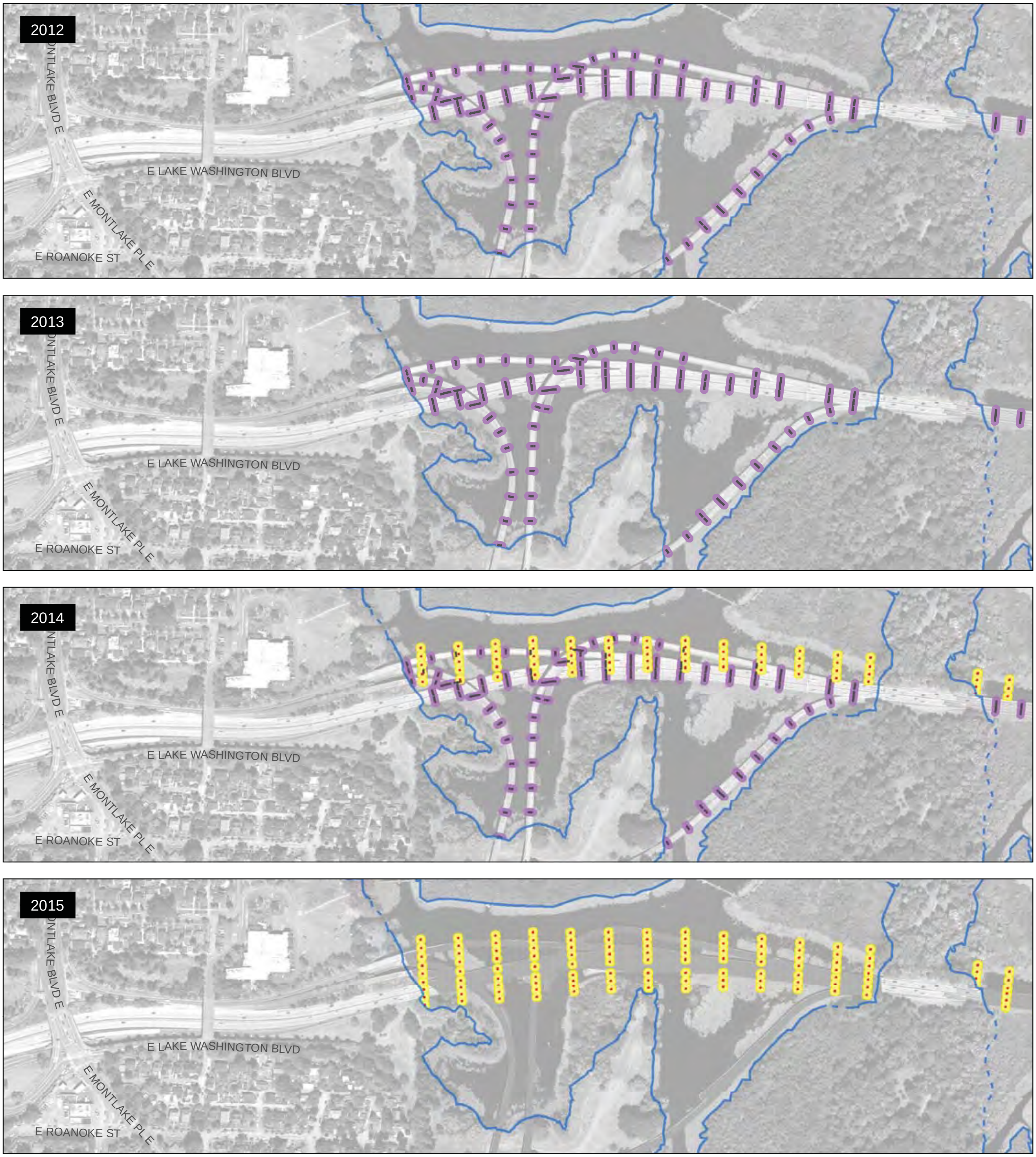
[a] Column spacing = 15 to 24 feet; span length = 100 feet; columns per acre = 31.5.
[b] Pile spacing = 18 feet; span length = 40 feet; piles per acre = 145.
[c] Column spacing = 24 to 33 feet; span length = 150 feet; columns per acre = 12.4.

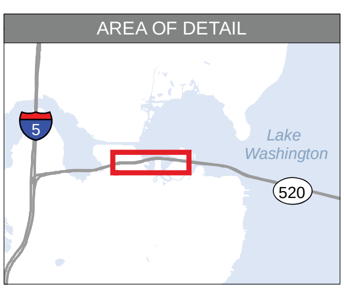
Construction of the work bridges will result in a substantial temporary increase in structural complexity in Union Bay due to the installation of up to 1,100 steel piles in the shallow-water, nearshore habitat. This increase in structural complexity will begin with the installation of the first work bridge during construction year 1 and continue until the existing structure and the north work bridge are removed in construction year 4. The highest degree of structural complexity will occur during construction year 3, when the north and south work bridges are in place and construction of the new northern half of the Union Bay span substructure has been completed. Exhibits 6-26a and 26b show the extent of the fixed-bridge vertical structure, shown as potential predator habitat, by construction year. Refer to Exhibits 6-20a and 6-20b for the spatial extent of work bridges, which also represents the extent of associated piles.

The new Union Bay structure will have fewer and more-widely-spaced shafts and columns than existing structure. Whereas the existing structure has approximately 100-foot span lengths (distance between bents) and roughly 15 feet between thecolumns within each bent, the proposed structure will have 150-foot span lengths and approximately 24 to 33 feet between columns. This will result in a lower overall structural complexity factor than that of the existing structure.

The completed project will result in a total of 13 in-water bents in the Union Bay area, consisting of 104 individual columns/shafts. All of these in-water structures will occur in areas commonly characterized by dense, nonnative aquatic macrophyte growth. The larger bridge will result in increased shading of the complex macrophyte communities, potentially reducing their densities and overall habitat complexity in these areas. The resultant effects of these changes in structural complexity in Union Bay will begin immediately after the completion of the new structure and will continue for the design life of the bridge.

The potential effects of structural complexity in the Union Bay area on listed salmonids are discussed in Section 6.2.3.6.





Existing Piers

Ordinary High Water Mark

Ordinary High Water Mark (Not Surveyed)

Potential Predator Habitat - Existing

Potential Predator Habitat - Proposed

Permanent Bridge Column

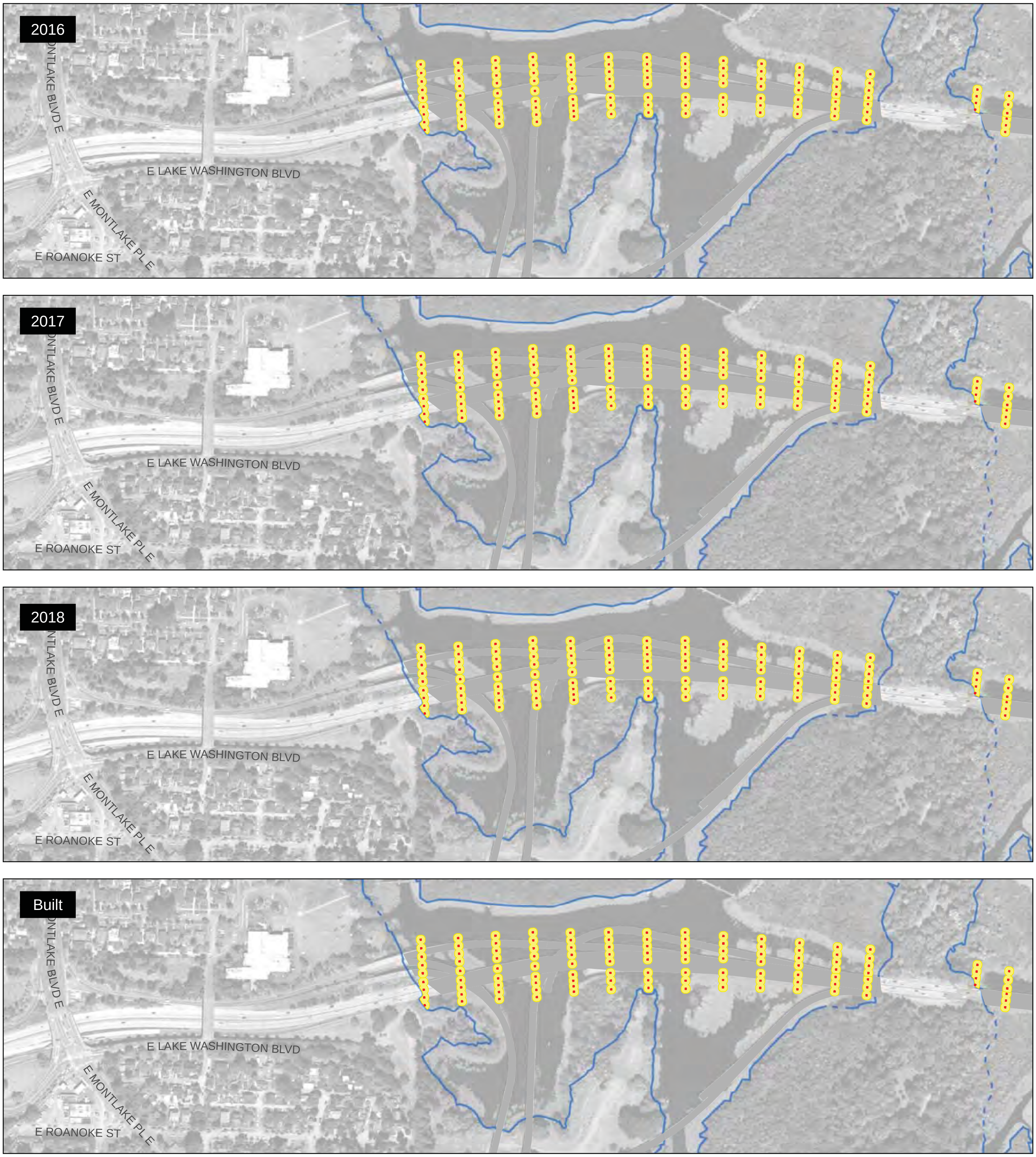
Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

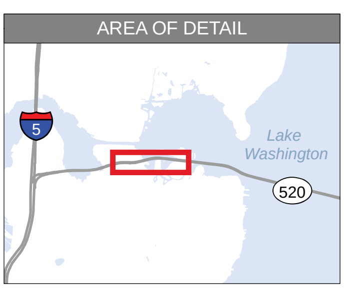
N

0 250 500 1,000 Feet

Exhibit 6-26a. **Potential Predator Habitat by Year in Union Bay**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project





Ordinary High Water Mark
Ordinary High Water Mark (Not Surveyed)
Potential Predator Habitat - Proposed
Permanent Bridge Column

Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

N
0 250 500 1,000 Feet

Exhibit 6-26b. **Potential Predator Habitat by Year in Union Bay**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

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Artificial Lighting

Artificial construction lighting has the potential to affect aquatic habitat conditions and listed species in Union Bay. The potential effects are expected to be similar to those discussed for Portage Bay (see Section 6.2.1.3).

Construction lighting is expected to result in effects on listed salmonids that are similar to those of operational lighting, which are discussed in detail in Section 6.3.1.

Effects on Localized Limnology

Limnological conditions in the Union Bay area are influenced by shade and aquatic vegetation growth. Union Bay is generally isolated from the lake by land masses that impede the movement of surface water by currents and winds, and the existing bridge has little effect on water circulation. The proposed bridge will have effects similar to those of the existing bridge.

The addition of over-water and in-water structures during construction, and the resulting net increase in the amount of over-water and in-water structure from the new Union Bay span, may result in localized effects on limnological processes, although these are expected to result largely from altered shading patterns. However, the change in photosynthetic activity resulting from the decreased solar radiation reaching the lake surface is likely to be undetectable. Therefore, the small increase in shading is unlikely to change primary production in Lake Washington. Although the limited water circulation in Union Bay could result in some localized effects, these will occur in areas that currently do not provide preferred habitat for listed species. Therefore, localized changes in limnological conditions are not expected to adversely affect listed salmonids.

6.2.3.4 Fish Handling

No handling of listed salmonid species during construction activities in Union Bay is proposed.

6.2.3.6 Species Response to Stressors

This section considers the spatial and temporal overlap of the presence of listed salmonids with the associated stressors in Union Bay (i.e., species exposure) and the expected responses by these species. The exposure of an organism is largely determined by its life history, behavior, and habitat uses. Exhibit 6-27 summarizes the expected use of Union Bay by listed salmonids.

EXHIBIT 6-27.
EXPECTED OCCURRENCE OF ANADROMOUS FISH SPECIES IN THE UNION BAY AREA, BY LIFE HISTORY STAGE

Species	Life History Stage	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Chinook salmon	Adult						Low	Low	Low	Low	Low		
	Residual	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal
	Juvenile			Low	Low	Low	Low	Low	Low				
Steelhead	Adult	Low	Low	Low	Low	Low	Nominal						Nominal
	Residual	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal
	Juvenile		Nominal	Nominal	Nominal	Low	Low	Low	Nominal				
Bull trout	Subadult	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal

Nominal presence
Low presence
High presence

The potential effects on ESA-listed species from construction and operation of the project in Union Bay are similar to those discussed for Portage Bay. These effects are discussed in detail in Section 6.2.1.5. Similar to the discussions in other sections, the effects are discussed with a focus on Chinook salmon as an umbrella species, with distinctions made for other listed species.

Puget Sound Chinook Salmon

Several potential stressors associated with project construction and operation in Union Bay have limited or no potential to affect the physical, chemical, or biological environment in that area. The potential stressors that will not adversely affect adult or juvenile Chinook salmon are summarized in Exhibit 6-28.

EXHIBIT 6-28.
NON-ADVERSE EFFECT STRESSORS IN THE UNION BAY AREA

Stressor	Rationale
Dissolved oxygen related to water quality	Dissolved oxygen is not expected to be affected by the proposed project activities; exposure risk is considered discountable.
Pollutants related to water quality	Pollutants are not known to be present; exposure risk is considered discountable.
Physical debris related to water quality	BMPs will prevent introduction of physical debris into the aquatic environment; exposure risk is considered discountable.
Terrestrial construction noise	Terrestrial noise transmission is not expected to exceed ambient underwater noise levels; exposure risk is considered discountable.

EXHIBIT 6-28.
NON-ADVERSE EFFECT STRESSORS IN THE UNION BAY AREA

Stressor	Rationale
Vessel operations related to underwater construction noise	Noise caused by vessel operations is not expected to exceed existing baseline underwater noise levels; exposure is considered insignificant.
Riparian habitat disturbance and displacement	Localized shading patterns and reduction in organic litter input will not result in significant disruption of behavior or injury of listed species. Nearshore communities of nonnative macrophytes provide marginal habitat for listed species. Effects on the species will be insignificant.
Benthic habitat disturbance and displacement	Primary productivity and forage base are not limiting. Reduction in benthos-derived productivity will not result in significant disruption of behavior or injury of listed species. Effects on the species will be insignificant.
Limnological process	Short-term alterations of temperature or phytoplankton production will not result in significant disruption of behavior of listed species. Effects on the species will be insignificant.

BMP = best management practice

Certain aspects of the proposed action are likely to adversely affect adult and juvenile Chinook salmon in Union Bay either through a modification of normal behavior or through direct injury or mortality. These stressors are the following:

- Water quality degradation from construction activities
- Underwater noise from impact pile driving
- Shading (note that shading and alteration of structural complexity are combined in the discussion below)
- Alteration of structural complexity (note that shading and alteration of structural complexity are combined in the discussion below)
- Artificial lighting

Water Quality Degradation from Construction Activities

As described in Section 6.2.1.5, turbidity may be increased during all aspects of in-water construction, although no activities are expected to produce long-term changes in turbidity. Turbidity may be at its highest during construction years 4 and 6, when most of the pile and column removal activities will occur. No pile driving will occur during construction years 4and 6; therefore, there will be no overlap between the disturbance due to pile-driving noise and the disturbance due to pile-removal turbidity.

Given the small area of the lake habitat affected at any one time (within 150-foot radius of turbidity-causing activity), the expected limited use of the existing habitat by listed salmonids, and the temporary duration of expected turbidity plumes during the in-water construction period, few, if any, Chinook salmon are likely to be exposed to and adversely affected by increased turbidity. Of those affected, few are likely to be juvenile fish.

Although the extent of expected harm and harassment of Chinook salmon due to increased turbidity is not insignificant or discountable, several factors will contribute to impact minimization and a reduced risk of exposure:

- Construction activities that may cause increased turbidity will occur during the approximately 7-month in-water construction period from September through April.
- Because of the timing of in-water work, adult Chinook salmon are more likely to be present during turbdity-causing activities than juvenile Chinook. However, the average time spent by adult Chinook salmon in the Lake Washington system in 1998 was 2.9 days (Fresh et al. 1999). Union Bay makes up a small portion of the migratory route through the Lake Washington system; therefore, the average time spent by adult Chinook salmon in Union Bay is anticipated to be less than 2.9 days. The likelihood that an adult fish would enter the shallow-water constructions zones is low.
- Adult Chinook salmon migration occurs primarily within deeper waters, more than 150 feet from turbidity-causing activities. Monitoring results from the SR 520 test pile project indicate that increased turbidity will be constrained to an area within approximately 150 feet of the construction activity (WSDOT 2010c).
- Juvenile Chinook salmon are not expected within the project area during the in-water construction period (September through April).
- The use of BMPs (Section 2.10) is expected to minimize the area affected by turbidity-causing activities to less than 150-foot radius from the construction activity.

Underwater Noise from Impact Pile Driving

In-water pile driving in Union Bay will occur over three approximately 9-month periods (September through April) during years 1, 2, and 3 (see Exhibit 6-19), when 500 piles or less will be installed.

Similar to Portage Bay, the risk of fish injury from single-strike peak noise levels (greater than 206 dB_{PEAK}) will be limited to an area of less than 1 meter immediately adjacent to the 24- or 30-inch-diameter hollow steel piles being driven, assuming a 30-dB reduction with a bubble curtain. The range at which the cumulative SEL will remain greater than the injury threshold for juvenile and subadult/adult fish (183 and 187 dB, respectively) is about 7 feet (area of 270 square feet per pile) for a 30-inch-diameter pile. In addition, the sound levels will exceed the disturbance threshold of 150 dB_{RMS} for a distance of about 72 feet (area of 0.7 acre per pile).

Although the extent of expected harm and harassment of Chinook salmon due to noise from impact pile driving is not insignificant or discountable, several factors will contribute to impact minimization and a reduced risk of exposure:

- Small numbers of Chinook fry begin migrating into Lake Washington from the Cedar River in January, whereas most Chinook fry enter the lake in mid-May, outside the in-water construction period. Adult Chinook salmon are expected to be present in low numbers during the in-water construction period, which is outside the adult migration period.

- Adult Chinook salmon are anticipated to migrate within deeper waters, away from behavioral and injury distances. The average time spent by adult Chinook salmon in Lake Washington in 1998 was 2.9 days. Union Bay makes up a small portion of the migratory route through Lake Washington, so the average time spent by adult Chinook salmon in Union Bay is anticipated to be less than 2.9 days. Therefore, pile-driving activities will have a limited effect on returning adults.
- The use of a bubble curtain is expected to substantially minimize the size of the area affected by sound levels in excess of the disturbance threshold.

Shading and Alteration of Structural Complexity

Chinook salmon responses to changes related to over-water shading and in-water structural complexity are discussed in detail in the description of habitat alterations in the west approach area (Section 6.2.4.3).

During the 6-year construction time frame, the amount of shade created by the project-related structures in the Union Bay area will range from approximately 9.2 acres in construction year 1 to approximately 16.6 acres in construction year 3. Total over-water cover resulting from the Union Bay structure will be approximately 8.4 acres, which is an increase of 1.8 acres compared to existing conditions (Section 2.6.4). However, the new Union Bay structure will be approximately 8 to 17 feet higher (the bottom of the bridge deck in Union Bay will range from 12 to 25 feet above the water) and will include 82 fewer columns than the existing structure. The higher structure will create more diffuse light-dark transitions than the existing structure, and the reduction in the number of columns used to support the new structure will decrease the shade cast in the under-structure environment.

Effects on Migratory Behavior

As many as 1,293 in-water piles, columns, and other structures placed during construction years 1 through 3 will increase the structural complexity of the Union Bay area (Section 2.6.4). Upon project completion, there will be 104 in-water columns in Union Bay. However, the proposed structure will have fewer and more-widely-spaced columns (approximately double the distance) than the existing structure.

The alteration of migratory behavior could cause Chinook salmon to occupy or migrate through areas that are more or less productive than habitats they would otherwise occupy, require different levels of energy expenditure, or subject the fish to conditions more or less conducive to survival, such as changes in predation potential or water quality. The available studies suggest that the primary potential behavioral response of juvenile salmonids (particularly Chinook salmon) to in-water and over-water structures is the alteration of migration rates and/or migration routes.

Overall, the migration behavior, particularly by adults, in response to the proposed bridge structures is expected to be similar to the behavior associated with the existing structure, which is narrower but lower relative to the water. The available information does not indicate that the existing bridge structure has an influence on the migratory behavior of adult salmonids in Lake Washington or the Ship Canal. Substantial fluctuations in adult returns have occurred in the basin despite relatively consistent conditions in the action area. The physical characteristics and locations of the new structures are sufficiently similar to those of the existing structures that they are not likely to have a different influence on the migratory behavior of adult salmonids.

Several factors suggest that the response of adult Chinook salmon in Union Bay is likely to be less significant than what is expected in the west approach area (see Section 6.2.4.3). The available data do not indicate that the existing Union Bay span has an influence on the migratory behavior of adult salmonids. The existing and proposed bridges are south of Foster Island and Marsh Island, whereas the most direct migratory route is north of these islands. Typically seeking deeper and colder water, adult fish are not expected to be present in Union Bay, although they will not be prevented from entering the area south of Foster Island and Marsh Island and encountering the temporary and long-term structures. WSDOT does not anticipate a significant disruption of normal migration behavior for Chinook salmon.

In conclusion, although the extent of expected harm and harassment of Chinook salmon due to increased shade and structural complexity is not insignificant or discountable, several factors will contribute to impact minimization and a reduced risk of exposure:

- The available data do not indicate that the existing Union Bay Bridge has an influence on the migration behavior of adult or juvenile salmonids within the Lake Washington system (including Union Bay).
- Although the new Union Bay structure will be wider, it will be higher and include fewer columns than the existing structure, producing narrower and more diffuse shadows than the existing structure.
- Adult and juvenile Chinook salmon migration occurs primarily near or within the Ship Canal, away from the proposed Union Bay span.

Effects on Predator-Prey Interactions

The available information does not indicate that the existing bridge structure has an influence on the predator-prey interactions for adult salmonids in Lake Washington or the Ship Canal (including Union Bay). The physical characteristics and location of the new structure are sufficiently similar to those of the existing bridge that the new structure is not likely to have a different influence on the predator-prey interactions for adult salmonids.

The available data discussed in Appendix G suggest that smallmouth bass may exhibit a habitat selection preference for those areas with greater structural complexity and vertical habitat elements such as columns and piles. Therefore, a similar selection preference for the proposed temporary and long-term structures may be observed in Union Bay. Assuming that the habitat selection in the west approach area occurs due to a concentration of outmigrating juveniles, a lower level of selection for the new Union Bay span can be expected.

Selection of this habitat by predators may increase during periods of greatest structural complexity, i.e., during construction, when multiple elements of the proposed structures will be in place concurrently. During construction, predator encounter rates may increase. One mitigating factor may be that the lower work bridges will create a more contrasting edge shadow effect. Individuals that exhibit an aversion to this edge may be less likely to make forays into the less favorable habitat.

The new Union Bay span will represent an improvement over the baseline condition because the bridge will be higher (although wider) and will have fewer and more-widely-spaced in-water structural elements, thereby reducing the overall complexity per unit area.

In conclusion, although the extent of expected harm and harassment of Chinook salmon due to increased shade and structural complexity is not insignificant or discountable, several factors suggest that the effects of associated predator-prey interactions will be minor:

- The new Union Bay spanwill represent an improvement over the baseline condition because the bridge will be higher (although wider) and will have fewer and more-widely-spaced in-water structural elements, thereby reducing the overall complexity per unit area.
- The available data do not indicate that the existing Union Bay span has an influence on predator-prey interaction associated with adult salmonids.
- Adult Chinook salmon migration occurs primarily away from the proposed Union Bay span, within deeper waters.
- Most juvenile Chinook salmon migration likely occurs away from the proposed bridge, north of Foster Island and Marsh Island.

Artificial Lighting

Artificial lighting during construction of the project has the potential to serve as an attractant to listed species as well as their predators. This could cause an alteration in normal behavioral patterns of listed species and increased predation on listed species. The construction effects are expected to be similar to those discussed for Portage Bay (see Section 6.2.1.5).

Construction lighting is expected to result in effects on listed salmonids that are similar to those of operational lighting, which are discussed in detail in Section 6.3.1.

Puget Sound Steelhead

For similar reasons as those described for Portage Bay (Section 6.2.1.5), the potential effects of the project activities in the Union Bay area on Puget Sound steelhead are expected to be similar to but substantially less probable and less severe than the effects on Chinook salmon. Generally, any adverse effects on Chinook salmon resulting from project activities could also apply to steelhead.

In conclusion, although the extent of expected harm and harassment of steelhead during project activities is not insignificant or discountable, several factors will contribute to impact minimization and a reduced risk of exposure:

- Steelhead, while not prevented from entering the Union Bay area, are expected to be present in low numbers during the in-water construction period (September through April), which is mostly outside the juvenile migration periods.
- Adult steelhead migration will mainly occur north of the Union Bay construction areas, away from the most intensive pile-driving impact areas. Adult steelhead are likely mobile enough to avoid areas of lesser effects.
- None of the available information identifies Union Bay as a location specifically used by juvenile steelhead for rearing. Steelhead rear for several years before migrating to Puget Sound; therefore, they are expected to be less dependent on the shallow nearshore habitat in the lake/and Union Bay.
- The use of BMPs (Section 2.10) is expected to minimize the size of the area affected by turbidity-causing activities.
- The use of a bubble curtain during pile driving is expected to minimize the size of the area affected by sound levels in excess of the disturbance threshold.

Coastal-Puget Sound Bull Trout

For similar reasons as those described for Portage Bay (Section 6.2.1.5), the potential mechanisms of effect from the project activities in Union Bay on bull trout are expected to be similar to the effects on Chinook salmon. However, the potential effects are less likely because of the low abundance of bull trout and the timing of their habitat use in Union Bay. The potential effects are also likey to be less intense because only adult and subadult life stages are expected to be exposed to them. Differences in potential responses of bull trout to the stressors are summarized below.

In addition to the stressors listed in Exhibit 6-28, the following stressors associated with Union Bay are not expected to result in adverse effects on bull trout:

- **Shading and structural complexity.** Bull trout are not dependent on the Union Bay area as a migratory corridor, nor are the subadult and adult forms of bull trout as susceptible to predation. The patterns of overwater shading and in-water structural complexity are not expected to result in a significant disruption of normal behavior or increased predation.

- **Construction lighting.** Foraging by subadult or adult bull trout may be improved somewhat during artificially illuminated conditions; however, a significant disruption in foraging behavior is not expected. Additionally, due to the timing of habitat use (late spring), the potential for exposure to artificially illuminated conditions during construction would be lower than that for the other listed salmonids.

- **Effects to prey base –** Although project-related stressors are expected to have some adverse effects on ESA-listed fish, and potentially other forage fish species, the abundance of prey resources is not expected diminish so as to significantly affect bull trout behavior or survival.

Potentially adverse effects on bull trout and responses to those stressors are summarized as follows:

- **Turbidity.**Individuals exposed to turbid conditions may experience gill abrasion, have reduced foraging potential, or exhibit avoidance behaviors.

- **Pile driving.** Individuals exposed to pile-driving noise are expected to experience some disruption of normal behavior (e.g. startle or avoidance response) within 22 meters; however, a cumulative SEL injury effect within 2 meters is considered discountable.

In conclusion, although the extent of expected harm and harassment of bull trout during project activities is not insignificant or discountable, several factors will contribute to impact minimization and a reduced risk of exposure:

- Bull trout, although not prevented from entering the Union Bay area, are expected to be present in low numbers, if at all, during the in-water construction period (September through April).
- If any bull trout are present, the individuals are expected to be adults or subadults, both of which are likely mobile enough to alter their route to avoid impact areas.
- The use of BMPs (Section 2.10) is expected to minimize the area affected by construction activities.

6.2.4 West Approach

This section addresses effects that will result from the following activities and conditions in the west approach area:

- Construction of the new fixed-span structure and associated temporary structures
- Removal of the existing west approach structure and the temporary structures
- Long-term presence of the proposed west approach structure

Project elements and construction activities for this area are described in Sections 2.2 and 2.3. Exhibit 6-29 summarizes the spatial and temporal extent of those project elements and the related construction activities.

EXHIBIT 6-29.
SPATIAL AND TEMPORAL EXTENT OF PROJECT ELEMENTS IN THE WEST APPROACH AREA

Project Element	Total Number	Frequency	Total Duration	In-Water/Over-Water Area
Work bridge pile installation	950	Up to 8 per day	Approx. 14 months	Up to 4,750 square feet
Temporary superstructure	2	Approx. 2,500 square feet per day	Approx. 14 months	Up to 6.8 acres
Drilled shaft	129 in water	2-4 days per shaft	Approx. 24 months	10,320 square feet
Bridge superstructure	25 spans	Varies	Approx. 40 months	10.6 acres
Materials transport	N/A	Daily	Ongoing	N/A
Column demolition	228	Approx. 8 to 10 per week	Approx. 6 months	Approx. 3,650 square feet
Pile removal	950	Approx. 4 to 6 per day	Approx. 9 months	Up to 4,750 square feet

N/A = not applicable

The project elements and associated construction activities described in Sections 2.2 and 2.3 are expected to result in the following mechanisms of effect or types of stressors on listed species and designated critical habitat:

- Water quality degradation
- Noise
- Habitat alteration
- Fish handling

The potential project-related effects in the west approach are discussed in detail below. Stressors are reported both cumulatively by construction year ("temporary" effects) and for the final proposed condition ("permanent" effects). The potential effects on listed salmonids related to this analysis are discussed in Section 6.2.4.5.

6.2.4.1 Water Quality Degradation

Potential water quality effects during the proposed activities include increased turbidity, decreased concentrations of dissolved oxygen, and introduction of pollutants and/or construction debris.

Turbidity

Project construction in and near aquatic habitat could result in increased turbidity. Upland construction and staging activities will disturb the substrate in shoreline areas, creating some potential for sediments to be introduced to the aquatic environment. However, implementation of appropriate BMPs will eliminate or minimize this potential (BMPs are described in Section 2.10). Any turbidity caused by upland activities will remain localized, and BMPs will be maintained, repaired, or augmented to eliminate turbid runoff.

Construction elements in Exhibit 6-30 include in-water work activities for the west approach area that are identified as sources of turbidity and may result in exposure of listed salmonids. Exhibit 6-30 represents the current estimated number of the construction elements, by construction year.

EXHIBIT 6-30.
PROJECT ACTIVITIES LIKELY TO INCREASE TURBIDITY IN THE WEST APPROACH AREA

Turbidity Source	Peak Values per Construction Year					
	2013	2014	2015	2016	2017	2018
No. of existing columns removed	N/A	N/A	80	168 [a]	N/A	N/A
No. of piles driven	450	N/A	500	N/A	N/A	N/A
No. of piles removed	N/A	N/A	N/A	450	N/A	500
No. of shaft casings installed	24	72	42	N/A	N/A	N/A
No. of shaft templates removed	24	72	42	N/A	N/A	N/A
Total	**498**	**144**	**664**	**618**	**0**	**500**

[a] Includes interim west approach columns.
N/A = not applicable

Short-term increases in turbidity may occur during all aspects of in-water construction (pile driving and removal, shaft installation and removal, and existing column removal) during each of the six in-water construction periods (Exhibit 6-30).

The greatest potential for suspended sediments is associated with the removal of in-water structures. These activities are expected to mobilize adjacent sediment particles upwardly into the water column as opposed to installation activities during which the forces would be directed into the substrate.

Turbidity may be at its highest during construction years 4 and 6; approximately 450 piles will be removed during year 4, and 500 piles will be removed during year 6. The removal of piles and columns may cause more turbidity than the installation of piles and columns because of the nature of the work required to extract piles as opposed to driving them. No pile driving will occur during construction years 4 and 6; therefore, the disturbance from pile-driving noise will not be concurrent with disturbance from pile-removal turbidity.

During the entire time frame of project construction, in-water construction activities are expected to cause a series of short-term, localized turbidity plumes (see Exhibit 6-30). Tugboat activity also has some potential to increase turbidity from propeller wash; however, tugboat activity will occur only in deeper water (more than 10 feet deep), minimizing the risk of substrate disturbance. The work in shallow-water areas will be conducted from the work bridges, including the construction and removal of the work bridge piles.

The substrate sediments in the west approach area are generally characterized by very dense silty, gravelly sand overlain by varying thicknesses of organic muck (WSDOT 2009g). Organic soil depths vary from a few feet to up to 60 feet. Approximately 50 percent of the proposed work in the west approach area will be confined to relatively shallow water (i.e., to the littoral zone, typically less than about 15 feet deep), where there is an abundance of aquatic macrophytes. The root mass associated with these macrophyte communities is expected to reduce the potential for sediment suspension in the water column. Evidence of aquatic macrophytes within west approach is clearly shown in the video taken during the test pile project.

Similar to Portage Bay, the spatial extent of inceased turbidity is expected to be limited by the nature of the proposed construction activities, the shallow water installation locations, the lack of water currents in this portion of Lake Washington, and the implementation of BMPs (Section 2.10). See Section 6.2.1.1 for details of the spatial extent of turbidity increases.

The total temporal extent of increased turbidity is expected to be the duration of construction and demolition activities in the west approach area, a total of about 35 months over the course of four approximately 7-month in-water construction periods. As indicated above, the higher intensity effects of turbidity are expected to occur during the extraction activities proposed in construction years 3 and 5.

As a result, in-water activities will result in only localized, intermittent, and short-term increases in turbidity. Additionally, the timing and duration of the proposed construction and demolition activities during the in-water construction period, along with the implementation of appropriate BMPs (Section 2.10), should limit the potential exposure of listed salmonids.

The potential effects of turbidity on listed salmonids are discussed in Section 6.2.4.5.

Dissolved Oxygen

Changes in dissolved oxygen concentrations due to increases in turbidity are discussed in Section 6.2.1.1.

Pollutants

There is no indication of contaminated sediments in the construction zones in the west approach area. The implementation of perimeter control (curbs and toe boards) and catchment measure (tarps and platforms) BMPs described in Section 2.10 is expected to minimize or eliminate the potential for introducing pollutants into the aquatic environment during construction activities. As in Portage Bay, localized increases in pH due to fugitive concrete dust are expected to be negligible and likely to be rapidly buffered by the water volume and chemical constituents of Union Bay.

Physical Debris

The implementation of perimeter control (curbs and toe boards) and catchment measure (tarps and platforms) BMPs described in Section 2.10 is expected to minimize or eliminate the potential for introducing physical debris from construction activities into the aquatic environment.

6.2.4.2 Noise

Potential noise generated by the proposed activities includes terrestrial construction noise and underwater construction noise (vessel operations and pile driving).

Terrestrial Construction Noise

Of all the project activities on land, impact pile driving will produce the loudest noise levels. This noise will not be transmitted into the water and, therefore, will not affect the aquatic environment or listed fish species.

Underwater Construction Noise

Several in-water activities proposed in the west approach area will have the potential to increase underwater noise levels, potentially affecting listed species. Three primary elements of the project have the potential to result in noise effects: vessel operations, vibratory pile driving, and impact pile driving.

Vessel Operations

The operation of tugboats or self-propelled work barges will produce in-water sounds, similar to those discussed for Portage Bay (see Section 6.2.1.2).

Pile Driving

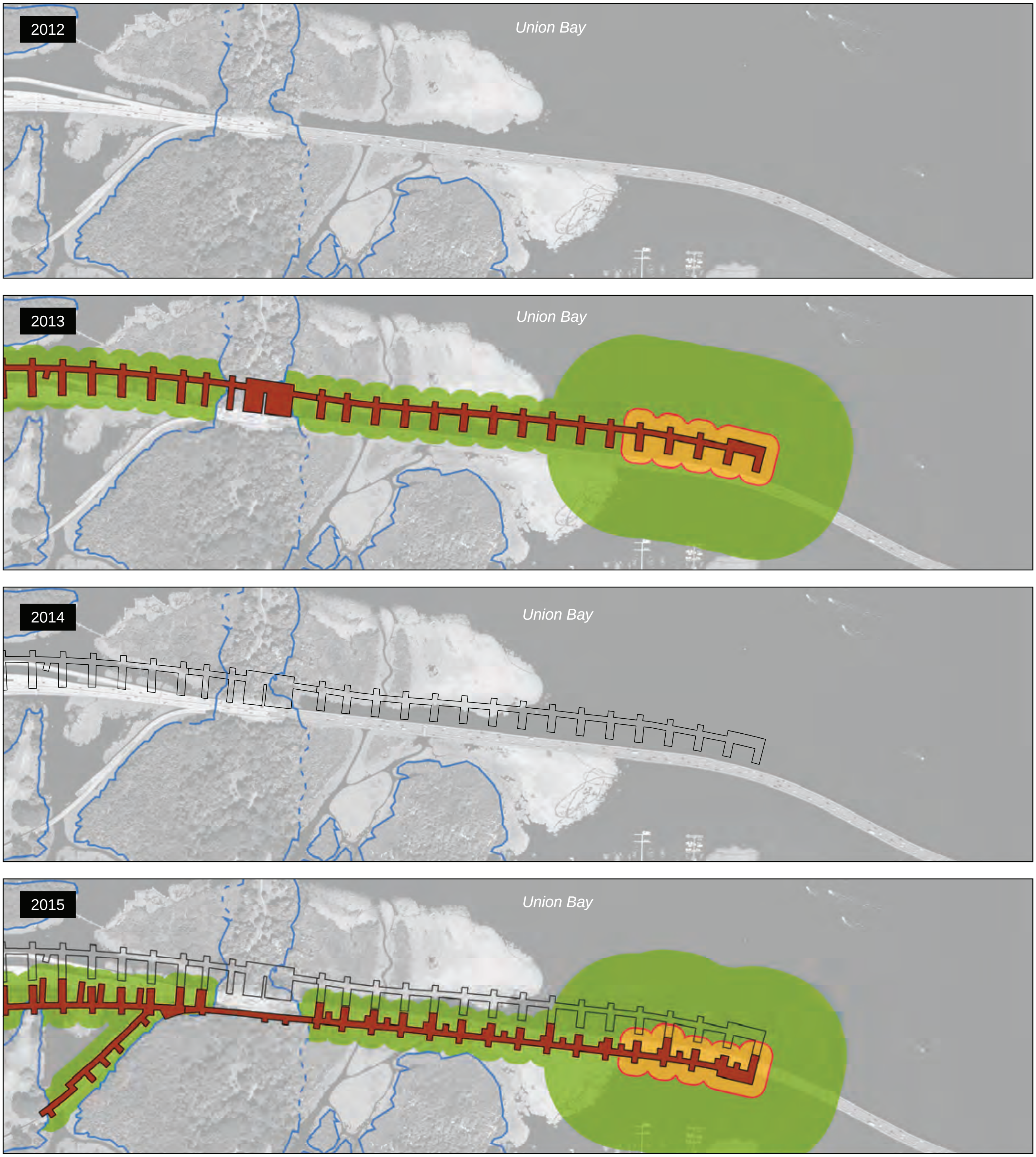
The proposed pile-driving activities for the west approach area and the distances for causing potential effects on listed salmonids in the west approach area are summarized in Exhibit 6-31. As noted in Appendix D, the test pile project indicated that efficacy of the bubble curtain in the west approach area varied due to substrate type. Therefore, different sound propagation distances are reported for the west approach. The western portion of the west approach uses the same assumptions for BMP efficacy (30-dB reduction) as those in Portage Bay and Union Bay, whereas the eastern portion of the west approach assumes both a lesser incident single-strike sound level (197 dB) and a lesser BMP efficacy (19-dB reduction), which results in greater noise propagation distances.

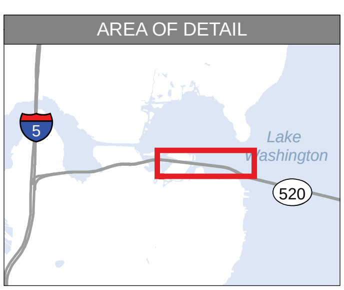
EXHIBIT 6-31.
PILE-DRIVING ACTIVITIES AND DISTURBANCE DISTANCES IN THE WEST APPROACH AREA FOR POTENTIAL EFFECTS ON LISTED SALMONIDS

Elevated Noise Source	Peak Values per Construction Year					
	2013	**2014**	**2015**	**2016**	**2017**	**2018**
Timing	Jul.–Mar.	N/A	Jul.–Mar.	N/A	N/A	N/A
Total piles	450	N/A	500	N/A	N/A	N/A
Maximum piles per day	8	N/A	8	N/A	N/A	N/A
Estimated driving days	28	N/A	28	N/A	N/A	N/A
Strikes per pile	500	N/A	500	N/A	N/A	N/A
Strikes per day	4,000	N/A	4,000	N/A	N/A	N/A
Strike duration per pile (minutes)	20	N/A	20	N/A	N/A	N/A
Strike duration per day (minutes)	160	N/A	160	N/A	N/A	N/A
Total ensonified area (acres) – 206 dB_{PEAK} [a]	N/A_	N/A	N/A	N/A	N/A	N/A
Total ensonified area (acres) – 187 dB_{SEL} [a]	4.0	N/A	3.8	N/A	N/A	N/A
Total ensonified area (acres) – 183 dB_{SEL} [a]	1.2	N/A	1.2	N/A	N/A	N/A
Total ensonified area (acres) – 150 dB_{RMS} [a]	42.8	N/A	41.7	N/A	N/A	N/A

[a] Per work bridge constructed in calendar year; Assumptions:
187 dB_{SEL} distance = 2 meters from the pile (270 square feet per pile) or 19 meters per pile (0.1 acre per pile) depending on the substrate.
183 dB_{SEL} distance = 2 meters from the pile (270 square feet per pile) or 22 meters per pile (0.3 acre per pile) depending on the substrate.
150 dB_{RMS} distance = 22 meters from the pile (0.7 acre per pile) or 136 meters per pile (15.1 acres per pile) depending on the substrate.
dB = decibels
N/A = not applicable
RMS = root mean square
SEL = sound exposure level

Pile driving will be most extensive in construction years 1 and 3, with the installation of up to 500 piles per year. Assuming an installation rate of 8 to 16 piles per day, 31 to 63 days of pile driving will be expected over a 7-month in-water construction period. A similar number of piles will also likely be installed in year 3, with up to about 38 days of pile driving, assuming a similar year.





Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

- Ordinary High Water Mark
- Ordinary High Water Mark (Not Surveyed)
- Work Bridge
- Work Bridge Construction in Progress

Potential Fish Behavior/Injury Thresholds

- 150 dB RMS
- 183 dB SEL
- 183/187 db SEL

N

0 250 500 1,000 Feet

Exhibit 6-32a. **Annual Pile-Driving Noise in the West Approach Area**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

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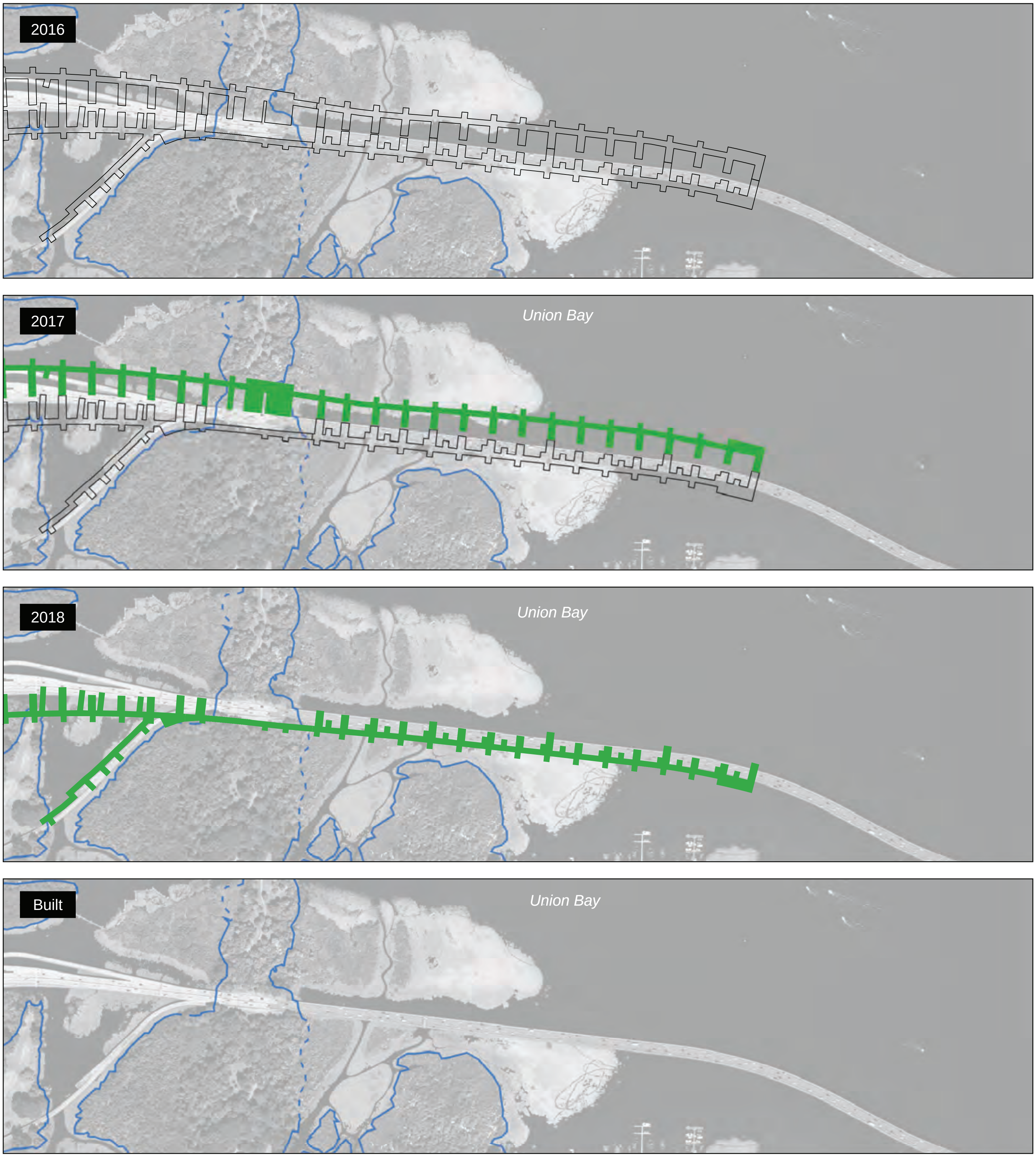
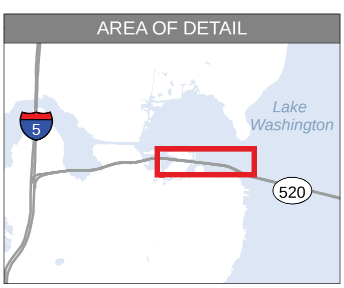




- Ordinary High Water Mark
- Ordinary High Water Mark (Not Surveyed)
- Work Bridge
- Work Bridge Removal (Vibratory Removal)

N

0 250 500 1,000 Feet

Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 6-32b. **Annual Pile-Driving Noise in the West Approach Area**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

Pile-driving activities will include both vibratory and impact pile driving, although only impact pile-driving activities are expected to produce sound levels that could affect listed species. Potential effects of pile driving on listed species are discussed in Section 6.2.4.5.

6.2.4.3 Habitat Alteration

Potential habitat alterations that might be caused by proposed project activities include riparian habitat disturbance and displacement, benthic habitat disturbance and displacement, shading, alteration of structural complexity, artificial lighting, and changes in localized limnology.

Riparian Disturbance and Displacement

Project activities in the west approach area will result in disturbance and displacement of riparian habitat, which consists of wetlands and upland vegetated buffer areas. Construction activities will result in clearing or fillling of approximately 1.19 acre of wetlands and clearing or filling of 0.09 acre of buffer (see Sections 4.5 and 4.6 for a description of riparian and wetland habitat conditions). Clearing or filling of riparian zones, as well as alteration of vegetation, reduces the capacity of the riparian zone to store stormwater, filter pollutants, protect lake shores, and provide fish habitat.

Benthic Disturbance and Displacement

The substrate sediments in the west approach area are generally characterized by very dense silty, gravelly sand. Benthic habitat in the vicinity of the proposed in-water disturbance (particularly pile driving) consists of substrate of varying thicknesses of organic muck overlain by native and nonnative vegetation.

The construction of the work bridges will result in the disturbance of about 2,250 to 2,500 square feet of substrate area in construction years 1, 2, and 6 due to the presence of either the north or south work bridge, and up to 4,750 square feet in construction years 3 through 5 when both work bridges will be in place at the same time.

The greatest degree of benthic habitat disturbance (19,438 square feet) will occur when all the work bridge piles, proposed bridge shafts, and existing bridge columns are in place concurrently, which is expected in construction year 3. The construction of the 129 proposed drilled shafts to support the west approach span will result in approximately 10,320 square feet of permanent benthic habitat displacement. Demolition of the existing bridge will remove 228 columns that currently occupy about 3,650 square feet of substrate, resulting in a net increase of about 6,670 square feet of substrate habitat and a corresponding increase in water column displacement.

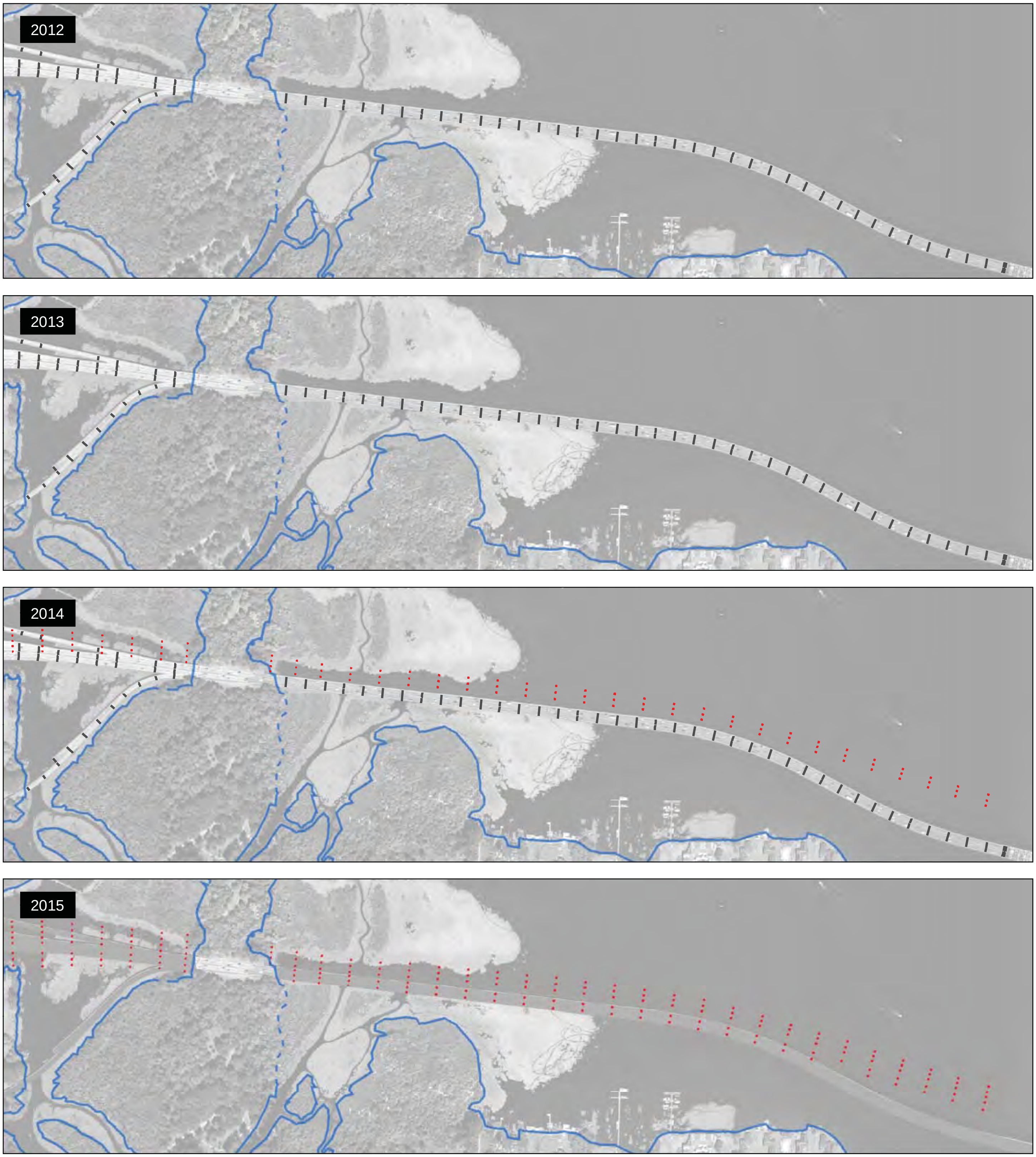
This effect will include the disturbance and displacement of native and nonnative aquatic vegetation. In addition to the shafts occupying the substrate area, the support columns will also occupy portions of the water column, which currently supports aquatic vegetation and provides additional macroinvertebrate habitat. These habitat areas are expected to recover relatively quickly after the support piles and work bridges are removed.

Exhibits 6-33 summarizes the expected extent of benthic habitat disturbance and displacement in the west approach area that will be caused by these structures. A year-by-year description of construction activities related to these structures is included in Section 2.6.4. Exhibits 6-34a and 6-34b show the extent of benthic habitat displacement by construction year.

EXHIBIT 6-33.
EFFECTS OF SUBSTRUCTURE ELEMENTS ON SUBSTRATE IN THE WEST APPROACH AREA, BY CONSTRUCTION YEAR

	Peak Values per Construction Year (square feet)						
Substrate Displacement Source	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Final**
Existing columns	3,648	3,648	3,648	2,368	N/A	N/A	N/A
Piles	2,250	2,250	4,750	4,750	2,500	2,500	N/A
Drilled shafts [a]	1,920	7,680	11,040	10,320	10,320	10,320	10,320
Total	**7,818**	**13,578**	**19,438**	**17,438**	**12,280**	**12,820**	**10,320**

[a] Conservatively assumes the shafts (i.e. not the columns) displace substrate in all cases.
N/A = not applicable



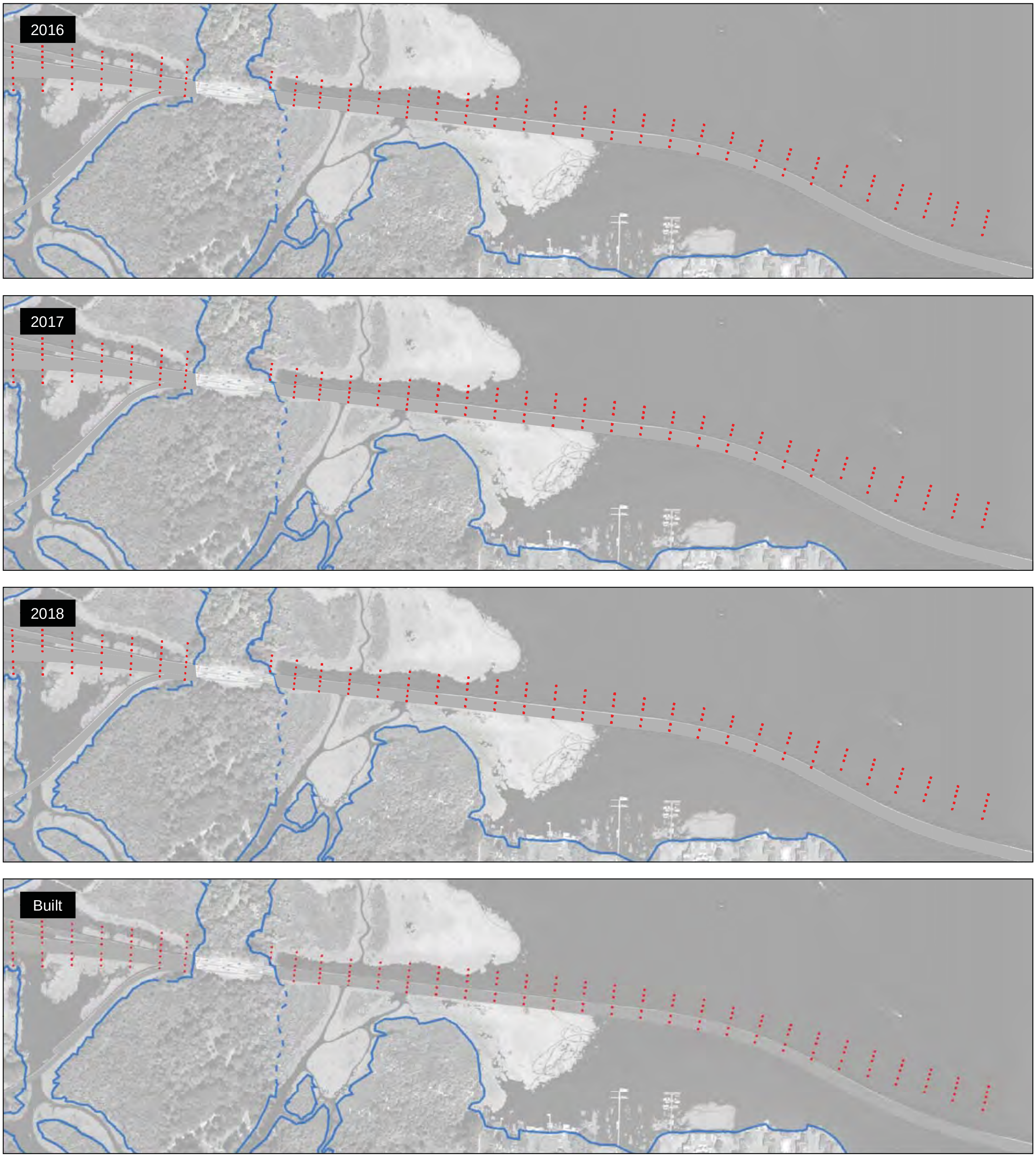
Existing Piers
Ordinary High Water Mark
Ordinary High Water Mark (Not Surveyed)
Bridge Substructure - Permanent Fill

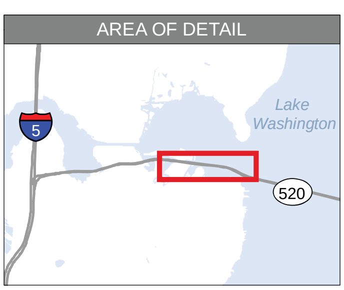
Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

N
0 250 500 1,000 Feet

Exhibit 6-34a. **Annual Benthic Habitat Displacement in the West Approach Area**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project





Ordinary High Water Mark

Ordinary High Water Mark (Not Surveyed)

Bridge Substructure - Permanent Fill

Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

N

0 250 500 1,000 Feet

Exhibit 6-34b. **Annual Benthic Habitat Displacement in the West Approach Area**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

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Shading

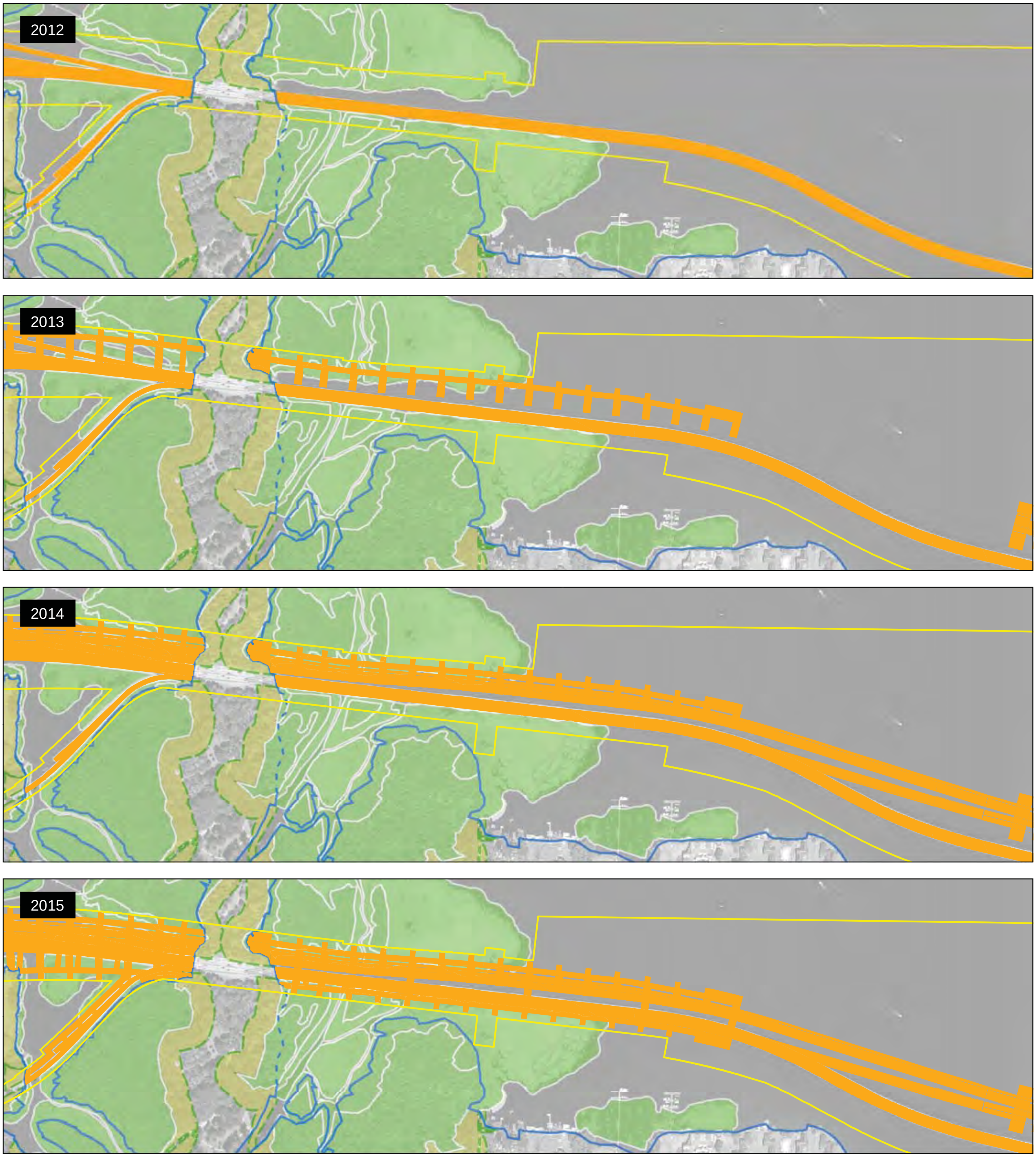
To evaluate the effect of shading, the total area of over-water cover was used to provide a year-by-year comparison of the variable shade conditions as the project construction progresses to completion. Exhibit 6-35 provides a summary of these values.

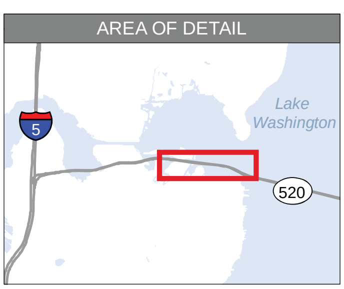
EXHIBIT 6-35.
OPEN-WATER AREA SHADED BY TEMPORARY AND PERMANENT BRIDGE STRUCTURES IN THE WEST APPROACH AREA, BY CONSTRUCTION YEAR

Shading Source	Peak Values per Construction Year (acres)						Final
	2013	2014	2015	2016	2017	2018	
Existing bridge deck area	4.8	4.8	4.8	N/A	N/A	N/A	N/A
Work bridge area	3.5	3.5	6.8	6.8	3.3	3.3	N/A
New bridge deck area	1.4 [a]	7.5	7.5	10.6	10.6	10.6	10.6
Total	**8.3**	**15.8**	**19.1**	**17.4**	**13.9**	**13.9**	**10.6**

[a] Interim west approach connection.
N/A = not applicable

The increase in shade will begin with the construction of the work bridges in construction year 1. As indicated above, the overall amount of over-water shade will increase over the duration of the project construction until the existing and temporary structures are removed. Exhibits 6-36a and 6-36b show the extent of shade by construction year.





- Ordinary High Water Mark
- Ordinary High Water Mark (Not Surveyed)
- Limits of Construction
- Shading
- Wetland
- Wetland Buffer

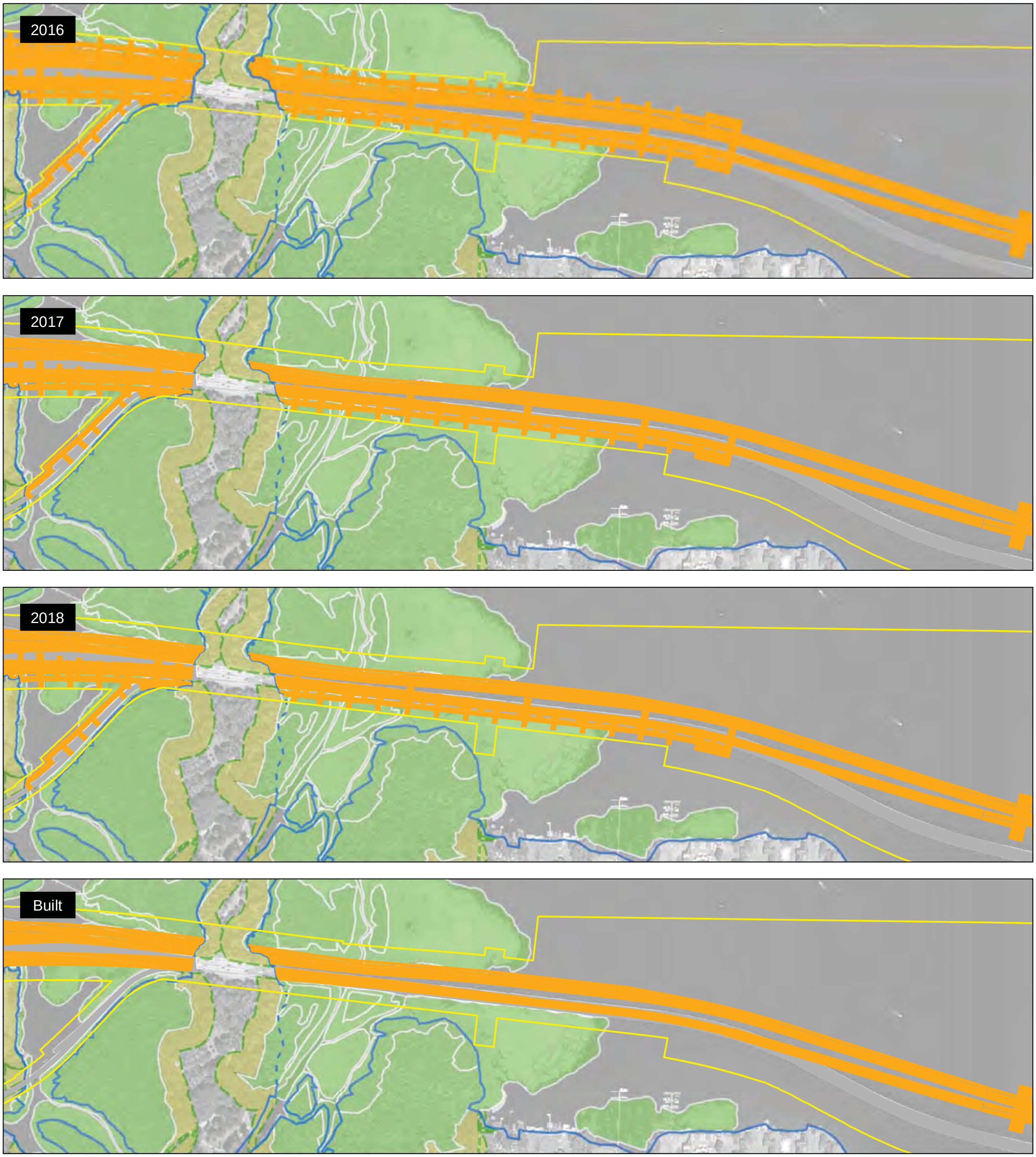
Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

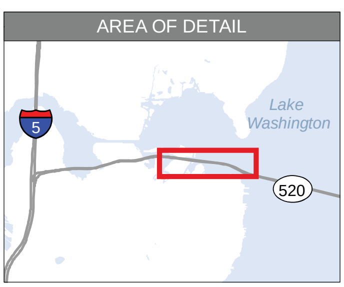
N

0 250 500 1,000 Feet

Exhibit 6-36a. **Annual Shade in the West Approach Area**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project





- Ordinary High Water Mark
- Ordinary High Water Mark (Not Surveyed)
- Limits of Construction
- Shading
- Wetland
- Wetland Buffer

Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

N

0 250 500 1,000 Feet

Exhibit 6-36b. **Annual Shade in the West Approach Area**

SR520, I-5 to Medina: Bridge Replacement and HOV Project

Within the west approach area, the project will result in 10.6 acres of permanent over-water cover, an increase of 5 acres over the baseline condition. The bridge configuration in the west approach area will range in width from approximately 112 feet at the west transition span to approximately 252 feet near Montlake, compared to the 57- to 104-foot-wide existing bridge. The new west approach structure will range in height above the water surface from approximately 18 feet just east of Foster Island to approximately 48 feet near the west transition span. Approximately 65 percent of the existing structure (western portion) is less than 10 feet above the surface water elevation at high water. This increase in height for the proposed structure will allow more ambient light under the structure, and although it will be wider, the intensity of the light-dark transition will be reduced overall.

The light-dark transitions will vary with the season, as conceptually illustrated in Exhibits 6-37a and 6-37b. As shown, a steeper solar angle will result in light-dark transitions that have greater contrast (i.e. creates a sharper transition boundary). Lower solar angles will result in more diffuse light-dark transistions, as will an increase in bridge height.

Although the replacement bridge in the west approach area will be wider than the existing bridge, it will also be generally higher and have fewer in-water shafts or columns. The changes from the baseline condition include an increase in the width of the bridge deck to nearly double that of the existing condition, a decrease in the overall number and an increase in the overall size of the columns, an increase in the spacing between columns, and an increase in the height of the bridge deck moving from the arboretum shoreline eastward. The removal of the existing bridge will result in a larger complex of in-water and over-water structure.

As sections of the new bridge are completed and become operational, the corresponding sections of the existing bridge will be demolished, and the construction work bridges will be removed. Any effects on juvenile or adult migration due to the permanent structures in the west approach area will begin as soon as the structures are in place and will continue in perpetuity.

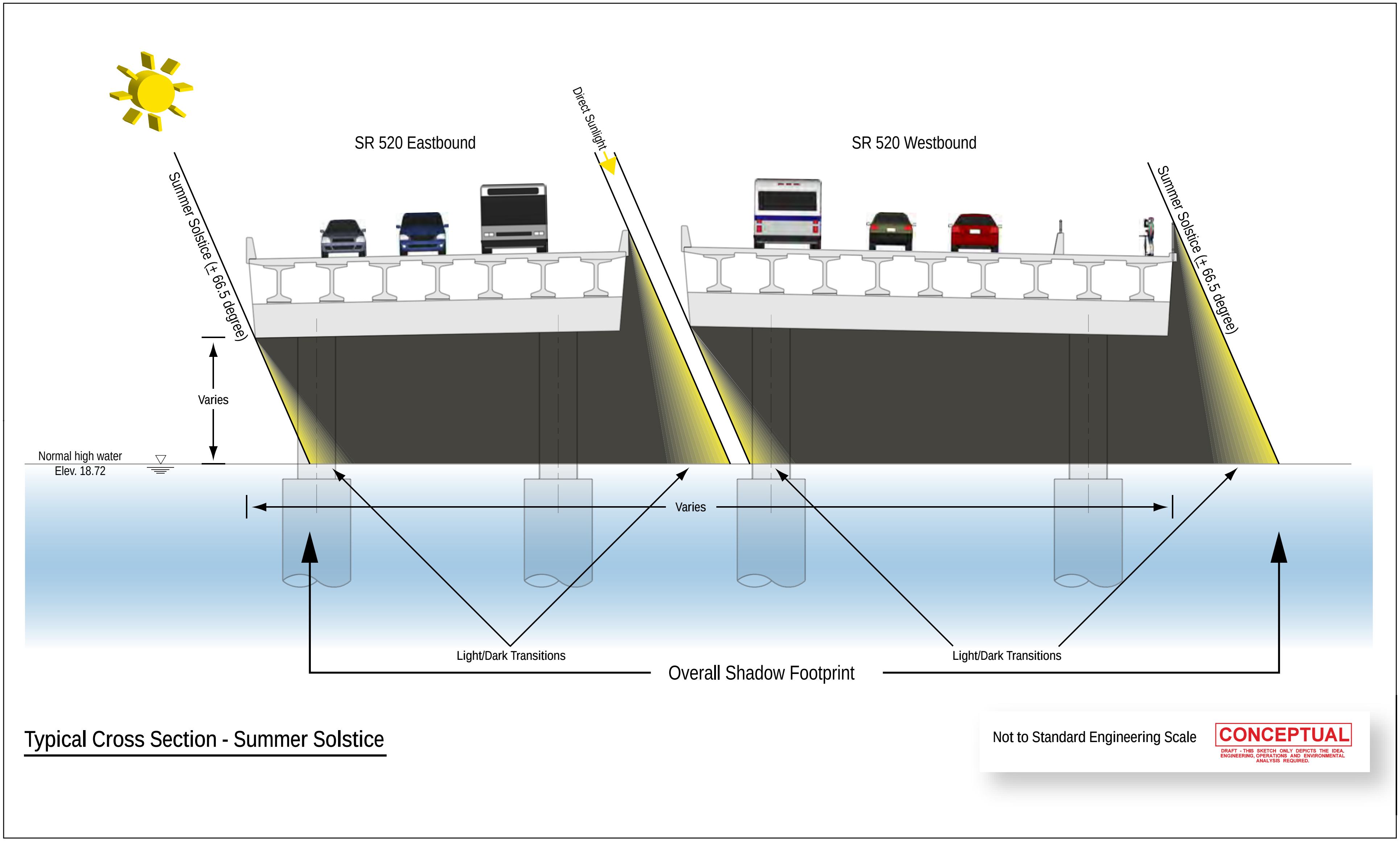
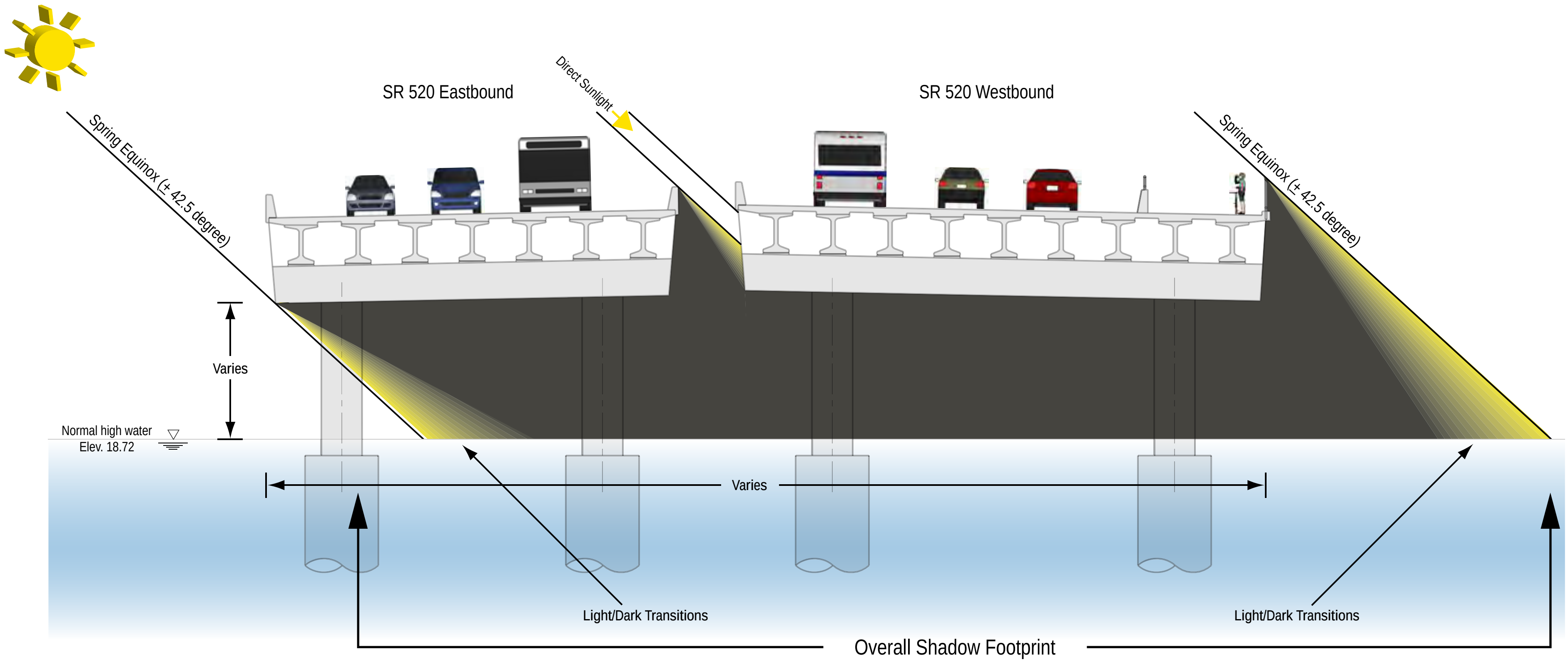


Exhibit 6-37a. **Shadow Diagram**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project



Typical Cross Section - Spring Equinox

Not to Standard Engineering Scale
October 2009

CONCEPTUAL
DRAFT - THIS SKETCH ONLY DEPICTS THE IDEA. ENGINEERING, OPERATIONS AND ENVIRONMENTAL ANALYSIS REQUIRED.

Exhibit 6-37b. **Shadow Diagram**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

Alteration of Structural Complexity

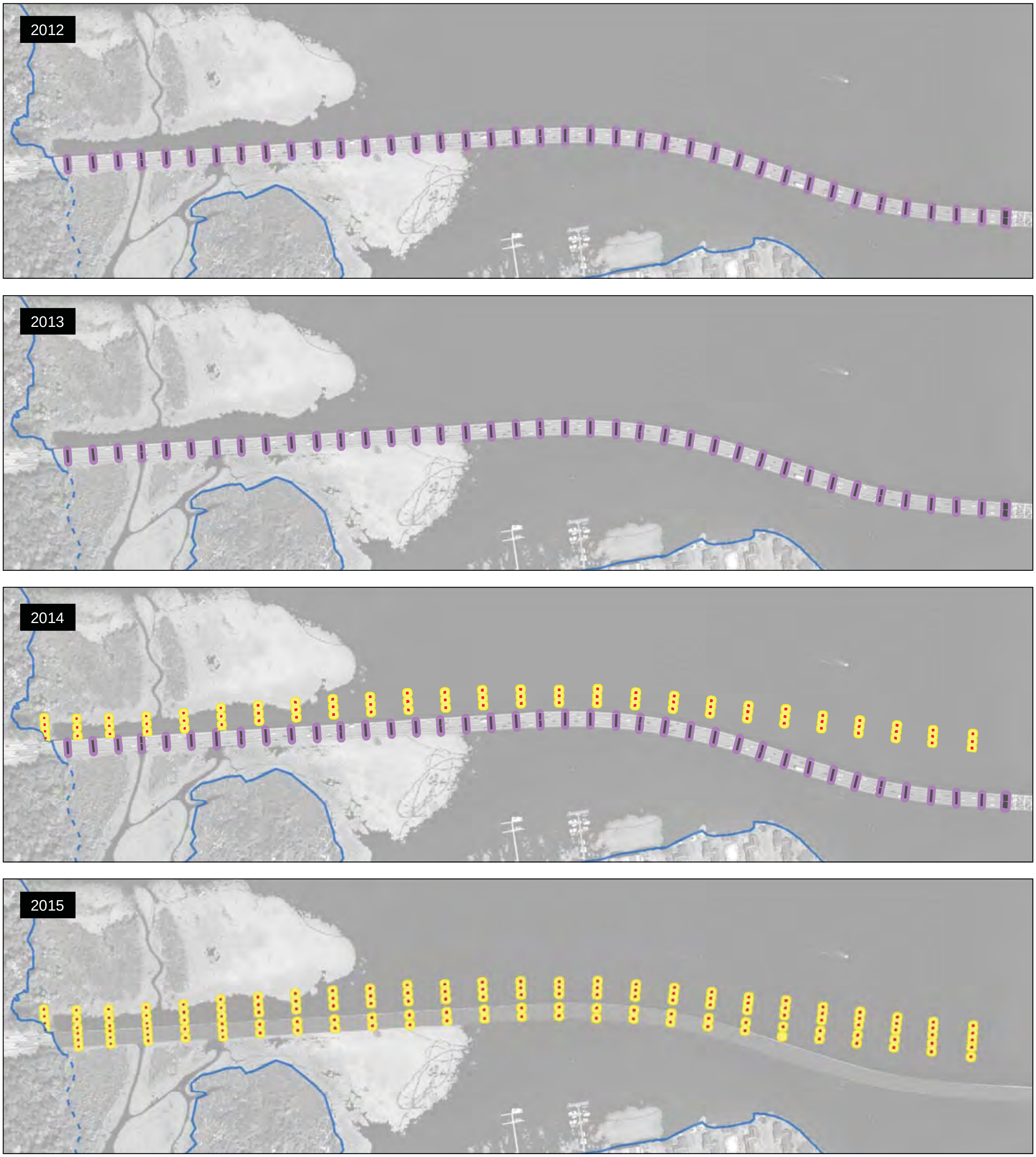
The placement of temporary and permanent in-water structures will alter the structural complexity of the aquatic habitat. Habitat complexity influences the behavior and distribution of fish, both listed salmonids and predators of salmonids. Each vertical structure is considered to represent potential predator habitat. To evaluate the effect of structural complexity, the total number of piles, shafts, columns, and spacing metrics was used to provide a year-by-year comparison of the variable shade conditions as the project construction progresses to completion. Exhibit 6-38 provides a summary of these values for each construction year.

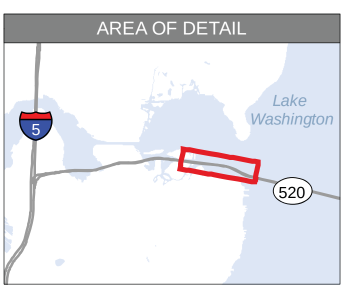
EXHIBIT 6-38.
CHANGES IN STRUCTURAL COMPLEXITY (IN-WATER COLUMNS AND PILES) IN THE WEST APPROACH AREA, BY CONSTRUCTION YEAR

Structural Complexity Source	Peak Values per Construction Year						Final
	2013	2014	2015	2016	2017	2018	
No. of existing bridge columns [a]	228	228	228	148	N/A	N/A	N/A
No. of work bridge piles [b]	450	450	950	950	500	500	N/A
No. of new bridge shafts/columns [c]	24	96	138	129	129	129	129
Total	**702**	**774**	**1,316**	**1,227**	**629**	**629**	**129**

[a] Column spacing = 15 to 24 feet; span length = 100 feet; columns per acre = 47.5.
[b] Pile spacing = 18 feet; span length = 40 feet; piles per acre = 140.
[c] Column spacing = 24 to 33 feet; span length = 150 feet; columns per acre = 12.2.
N/A = not applicable

The construction of the work bridges will result in a substantial increase in structural complexity in the west approach area due to the installation of up to 950 steel piles in the shallow-water nearshore habitat. This increase in structural complexity will begin with the installation of the first work bridge during construction year 1 and will progress until the existing structure and the north work bridge are removed in construction year 3. The highest degree of structural complexity will occur during construction years 3 and 4, when all the proposed work bridges are in place, and construction of the new west approach substructure has been completed.
Exhibits 6-39a and 6-39b show the extent of the fixed-bridge vertical structure, defined as potential predator habitat, by construction year. Refer to Exhibits 6-32a and 6-32b for the spatial extent of work bridges, which also represents the extent of associated piles.





- Existing Piers
- Ordinary High Water Mark
- Ordinary High Water Mark (Not Surveyed)
- Potential Predator Habitat - Existing
- Potential Predator Habitat - Proposed
- Permanent Bridge Column

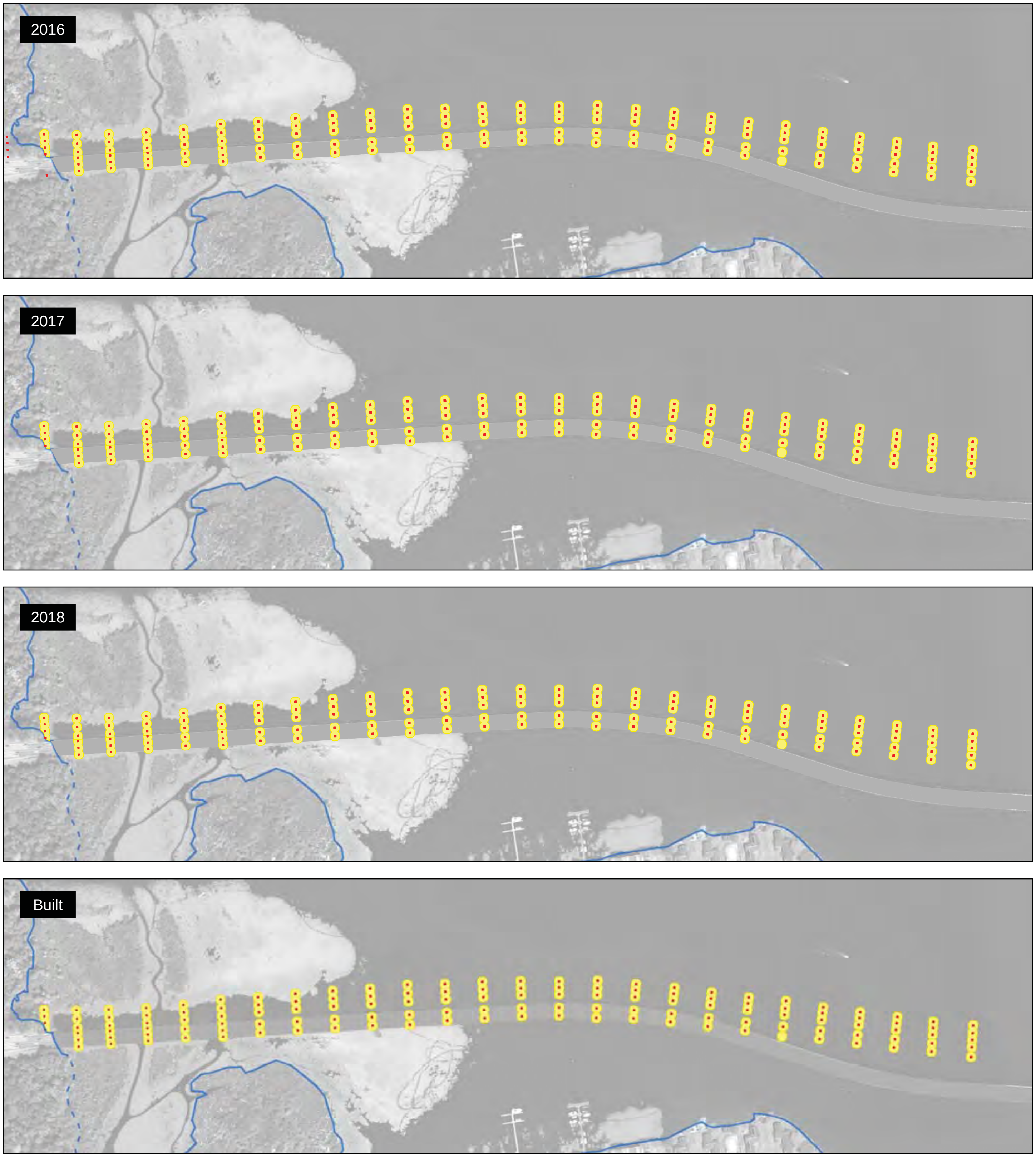
Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

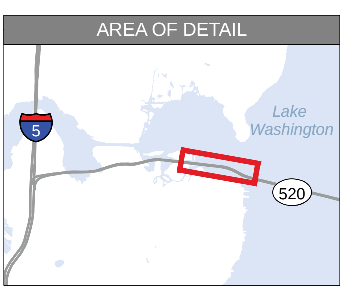
N

0 250 500 1,000 Feet

Exhibit 6-39a. **Potential Predator Habitat by Year in the West Approach Area**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project





Ordinary High Water Mark
Ordinary High Water Mark (Not Surveyed)
Potential Predator Habitat - Proposed
Permanent Fill

Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

N
0 250 500 1,000 Feet

Exhibit 6-39b. **Potential Predator Habitat by Year in the West Approach Area**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

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The proposed west approach structure will have fewer and more-widely-spaced shafts and piers compared to the existing conditions. Whereas the existing west approach structure has approximately 100-foot span lengths (distance between bents) and roughly 15 feet between columns within each bent, the proposed structure will have 150-foot span lengths and approximately 24 to 33 feet between columns. This configuration will result in less overall structural complexity factor compared to the baseline condition.

The completed project will result in a total of 26 pier bents throughout the west approach, consisting of 129 individual columns. Of these in-water structures, approximately one-half of them will occur in areas commonly colonized by dense nonnative aquatic macrophyte communities. The occurrence of the proposed structures within already complex macrophyte communities should reduce the overall habitat complexity in these areas, because the shading under the larger bridge structure is expected to reduce the density of aquatic macrophytes. The resultant effects of changes in structural complexity in the west approach area will begin immediately after the completion of the new structure elements and will continue for the design life of the bridge.

The potential effects of structural complexity on listed salmonids in the west approach area are discussed in Section 6.2.4.5.

Artificial Lighting

Artificial lighting during project construction has the potential to affect aquatic habitat conditions in the west approach area, potentially serving as an attractant to listed species as well as their predators. This could potentially cause an alteration in the normal behavior patterns of listed species and increased predation on listed species. The effects of construction lighting are expected to be similar to those discussed for Portage Bay (see Section 6.2.1.3).

Construction lighting is expected to result in effects on listed salmonids that are similar to those of operational lighting, which are discussed in detail in Section 6.3.1.

Effects on Localized Limnology

Limnological conditions under the west approach structure are influenced by wind-driven currents and, to some extent, outflow in the lake. Similar to the Union Bay area, the addition of over-water and in-water structures during construction, and the resulting net increase in the amount of over-water and in-water structure in the new west approach area, may result in localized effects on limnological processes (see Section 6.2.3.4). However, these changes are likely to be undetectable. The greater water circulation in a substantial portion of the west approach area, compared to the Portage Bay and Union Bay areas, further decreases the potential effects on localized limnological conditions. Therefore, it is not expected that this potential stressor will affect listed salmonids.

6.2.4.4 Fish Handling

No handling of listed salmonid species during construction activities in the west approach area is proposed.

6.2.4.5 Species Response to Stressors

Exhibit 6-40 summarizes the use of the west approach area by listed salmonids.

EXHIBIT 6-40.
EXPECTED OCCURRENCE OF ANADROMOUS FISH SPECIES IN THE WEST APPROACH AREA, BY LIFE HISTORY STAGE

Species	Life History Stage	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Chinook salmon	Adult						Low presence	High presence	High presence	High presence	Low presence		
	Residual	Nominal presence	Nominal presence	Nominal presence	Nominal presence	Nominal presence	Nominal presence	Nominal presence	Nominal presence	Nominal presence	Nominal presence	Nominal presence	Nominal presence
	Juvenile			Low presence	Low presence	High presence	High presence	High presence	Low presence				
Steelhead	Adult	Low presence	Low presence	Low presence	Low presence	Low presence	Nominal presence						Nominal presence
	Residual	Nominal presence	Nominal presence	Nominal presence	Nominal presence	Nominal presence	Nominal presence	Nominal presence	Nominal presence	Nominal presence	Nominal presence	Nominal presence	Nominal presence
	Juvenile		Nominal presence	Nominal presence	Nominal presence	Low presence	Low presence	Low presence	Nominal presence				
Bull trout	Subadult	Nominal presence	Nominal presence	Nominal presence	Low presence	Low presence	Low presence	Nominal presence	Nominal presence	Nominal presence	Nominal presence	Nominal presence	Nominal presence

Nominal presence
Low presence
High presence

Use of the west approach area by listed salmonids is expected to be substantially greater than their use of either the Portage Bay area or the Union Bay area (see Sections 6.2.1.5 and 6.2.3.6), because the eastern portion of the west approach is a migration path for listed salmonids.

Puget Sound Chinook Salmon

Several potential stressors associated with project construction have limited or no potential to affect the physical, chemical, or biological environment in the west approach area. The potential stressors that will not adversely affect adult or juvenile Chinook salmon are summarized in Exhibit 6-41.

EXHIBIT 6-41.
NON-ADVERSE EFFECTS STRESSORS IN THE WEST APPROACH AREA

Stressor	Rationale
Dissolved oxygen related to water quality	Dissolved oxygen is not expected to be affected by the proposed project activities; exposure risk is considered discountable**.**
Pollutants	Pollutants are not known to be present; exposure risk is considered discountable with BMP application.
Physical debris related to water quality	BMPs will prevent introduction of physical debris into the aquatic environment; exposure risk is considered discountable.
Terrestrial noise	Terrestrial noise is not expected to transmit to, or exceed, ambient underwater noise levels; exposure risk is considered discountable.
Vessel operations related to underwater construction noise	Noise caused by vessel operations is not expected to exceed existing underwater noise levels; exposure is considered insignificant.
Riparian disturbance and displacement	Localized shading patterns and reduction in organic litter input will not result in significant change in behavior or survival; effect on species is considered insignificant.
Benthic disturbance and displacement	Primary productivity and forage base are not limiting. Reduction in benthos-derived productivity will not result in significant changes in behavior or survival. Effect on species is considered insignificant.
Limnological process	Short-term alterations of temperature or phytoplankton production will not result in significant changes in behavior or survival. Effect on species is considered insignificant.

BMP = best management practice

Certain aspects of the proposed action are likely to adversely affect adult and juvenile Chinook salmon in the west approach area either through a significant modification of normal behavior or through direct injury or mortality. These stressors are the following:

- Water quality degradation from construction activities
- Underwater noise from impact pile driving
- Shading (note that shading and alteration of structural complexity are combined in the discussion below)
- Alteration of structural complexity (note that shading and alteration of structural complexity are combined in the discussion below)
- Artificial lighting

Adult salmonids may be migrating through the action area during in-water construction. Most Lake Washington Chinook salmon adults are likely to migrate through the action area from June through late September. However, individual adult salmonids are expected to migrate relatively quickly through the project area, and in relatively deep water (where water temperatures are cooler) away from the most intensive in-water construction areas. This behavior is likely to minimize potential effects on adult salmonids. The average time spent by adult Chinook salmon in the Lake Washington in 1998 was 2.9 days (Fresh et al. 1999). This tendency of adult salmonids to migrate quickly through Lake Washington, once they begin moving, and their lack of dependence on shoreline habitat limit their susceptibility to construction and operation of the Evergreen Point Bridge structures. The existing data indicate that adult salmon do not congregate within the west approach/Union Bay area during their migration to spawning areas in the Lake Washington basin.

Juvenile Chinook salmon typically migrate along the shoreline during the early morning and early evening, remaining in relatively shallow water throughout the day, but they are typically found farther offshore in deeper water near dawn and dusk. Shade produced by the bridge is believed to cause behavioral changes in juvenile Chinook, resulting in delayed passage through the action area (Celedonia et al. 2009). The bridge structures are also believed to provide cover habitat in deeper water areas, allowing access to potentially more productive foraging areas. Although the artificial lights on the bridge are also believed to alter behavior by attracting juvenile salmonids, potentially allowing extended feeding periods, the light could also attract predator species.

Most in-water construction activities are not expected to substantially affect juvenile Chinook salmon because they will occur during the in-water construction periods when juvenile salmonid presence is expected to be low. Construction activities outside the in-water construction periods, particularly during May and June, will have the highest potential to affect juvenile salmonids because of the large numbers migrating through the west approach area during this period. These activities will be limited to those that are either above water or fully contained with BMPs. Over-water construction will also be contained with BMPs intended to prevent the introduction of foreign materials into the water.

Despite the minimization of potential effects caused by construction activities, the additional over-water and in-water structures due to the presence of the work bridges and the replacement and existing bridge structures will affect juvenile Chinook salmon during their outmigration. These effects are due to increases in shading (migration delay), structure complexity (increased predation), and lighting (attraction/increased predation). These effects will be substantially greater than the baseline conditions during the construction and demolition phases of the project (years 3 and 5).

Because of the extended duration of the project construction, the project is expected to affect both the juvenile and adult life stages of multiple Chinook salmon age classes. The potential effects will be greater for age classes that migrate through the action area as juveniles and then again as adults during the construction phase. Chinook salmon typically spend 3 or 4 years in salt water before returning to their natal streams; therefore, 2- or 3-year age classes have the potential to be affected by construction activities as juveniles and adults. Other age classes will be affected by construction activities as either juveniles or adults.

Over the long term, the potential effects of a larger and higher bridge structure in the west approach area on adult Chinook are expected to be similar to existing conditions, because adults are expected to avoid this relatively warm shallow-water habitat as they migrate into the lake. In contrast, juvenile Chinook typically migrate through the west approach area and will be affected by the changed conditions associated with the replacement bridge. Based on recent tagging studies, Celedonia et al. (2009) suggest that conditions resulting from the replacement bridge structure will likely lessen the delay of actively migrating Chinook salmon smolts and have a minimal effect on holding smolts and their daytime attraction to the bridge compared to existing conditions. They also suggest that these effects may have positive (e.g., reduced predation rate, quicker entrance into the Ship Canal, less residualism), negative (e.g., reduced growth, less resting and energy replenishment along migration route), or negligible consequences for Chinook salmon fitness and survival. In addition, they suggest that the new bridge alignment could reduce the quality of habitat conditions for northern pikeminnow and smallmouth bass, potentially facilitating increased predation on Chinook salmon.

Potential adverse effects on Chinook salmon are discussed below. Adverse effects on PCEs are discussed in Section 6.4.

Water Quality Degradation from Construction Activities

As mentioned above, short-term increases in turbidity may occur during all aspects of in-water construction. Turbidity may be at its highest during construction years 5 and 6, when all of the pile removal activities will occur. No pile driving will occur during these years; therefore, the disturbance from pile-driving noise will not overlap the disturbance from pile-removal turbidity. A discussion of potential effects on salmonids due to changes in turbidity is provided in Section 6.2.1.5.

Although the extent of expected harm and harassment of Chinook salmon due to increased turbidity is not insignificant or discountable, several factors will contribute to impact minimization and a reduced risk of exposure:

- Construction activities that may cause increased turbidity will occur during the approximately 7-month in-water construction period from September through April.
- Because of the timing of in-water work, Chinook salmon adults are more likely than juveniles to be present during project activities that cause turbidity. However, the average time spent by adult Chinook salmon in the Lake Washington system in 1998 was 2.9 days (Fresh et al. 1999).
- Adult Chinook salmon migration occurs primarily within deeper waters, more than 150 feet from turbidity-causing activities. Monitoring results from the SR 520 test pile project demonstrated that increased turbidity will be constrained to an area within approximately 150 feet of the construction activity (WSDOT 2010c).
- Juvenile Chinook salmon are not anticipated to be within the action area during the in-water construction period (September through April).

- The use of BMPs (Section 2.10) is expected to minimize the size of the area affected by turbidity-causing activities to less than 150-foot radius from the construction activity.

Underwater Construction Noise from Impact Pile Driving

In-water pile driving in the west approach area will occur over an approximate 8-month period (September through April) during years 1 and 3 (see Exhibit 6-31). Each period of pile driving will consist of the installation of 500 piles or less. Detailed discussions of the types of effects expected to result from noise associated with project construction activities is provided in Section 6.2.1.5. Additional discussions of noise effects are provided in Appendix D.

As in the other areas, in the western portion of the west approach area, injury of fish from single-strike peak noise levels (greater than 206 dB_{PEAK}) will result within a distance of less than 1 meter immediately adjacent to the 24- or 30-inch-diameter hollow steel piles being driven, assuming a 30-dB reduction with a bubble curtain. The range at which the cumulative SEL will remain greater the injury threshold for juvenile and subadult/adult fish (183 and 187 dB, respectively) is about 7 feet for a 30-inch-diameter pile. In addition, the sound levels will exceed the threshold of 150 dB_{RMS} for a distance of about 72 feet.

In the eastern portion of the west approach area, where the organic soil layers are shallower and overlie a harder substrata (test pile location A [Illingworth and Rodkin 2010]), injury of fish from single-strike peak noise levels (greater than 206 dB_{PEAK}) will result within a distance of less than 1 meter immediately adjacent to the 24- or 30-inch-diameter hollow steel piles being driven, assuming a 19-dB reduction with a bubble curtain. The range at which the cumulative SEL will remain greater than the injury threshold for fish larger than 2 grams is about 62 feet, and for fish smallerthan 2 grams, the distance is about 72 feet for a 30-inch-diameter pile. In addition, the sound levels will exceed the threshold of 150 dB_{RMS} for a distance of about 446 feet.

Although the extent of expected harm and harassment of Chinook salmon due to impact pile-driving noise is not insignificant or discountable, several factors suggest that it will be low:

- Small numbers of Chinook fry begin migrating into Lake Washington from the Cedar River in January, and most Chinook fry enter the lake in mid-May, outside the in-water construction period.
- Adult Chinook salmon are anticipated to migrate within deeper waters, away from behavioral and injury disturbance areas. The average time spent by adult Chinook salmon in Lake Washington in 1998 was 2.9 days; therefore, the altered and/or modified habitat conditions within the pile-driving areas may have a limited effect on returning adults.
- The use of a confined or unconfined bubble curtain is expected to substantially minimize the size of the area affected by sound levels in excess of the disturbance threshold.

Although some disturbance and behavior modification are expected to occur, few juvenile or adult Chinook salmon are likely to occur in the action area during the construction period.

Shading and Alteration of Structural Complexity

Chinook salmon responses to changes in over-water shading and in-water structural complexity are discussed collectively below 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. It appears that juvenile Chinook may increase their residence time in the vicinity of the bridge shadow or in-water structure components. Although this increase may allow juvenile Chinook to access higher-value foraging habitat offshore, it also may contribute to an indirect reduction in overall fitness due to later entry into salt water and a direct potential for increased predator encounters in the vicinity of the bridge. The reviews of studies that form the basis of this analysis are provided in Appendices F and G. Potential effects on juvenile Chinook are summarized below.

Several features suspected of affecting the migration and rearing behavior of juvenile salmonids include the bridge shadow on the surface of the water during the day and the bridge support structures (columns) in the water that change the natural habitat for both the salmonids and their predators (see Appendix G). As indicated above, the extent of these features will change during the construction time frame as temporary structures (work bridges) are built, the new bridge is constructed, and the temporary structures and existing bridge are removed. Therefore, the overall extent and duration of over-water and in-water structures within the migration corridor will change over time, as will the potential effects of these features on migration behavior throughout the construction time frame and long-term operational phases associated with the new bridge.

Alteration of migratory behavior could cause the fish to occupy or migrate through areas that are more or less productive than habitats they would otherwise occupy, require different levels of energy expenditure, or subject the fish to more or less viable survival conditions such as changes in predation potential or water quality.

Past studies of Lake Washington indicate that the influence of in-water and over-water structures on fish behavior is complex and variable and likely varies by species, time of year, time of day, and other biological and physical factors. These studies also suggest that the existing bridge likely has a limited effect on the behavior of juvenile salmonids and resident predator species in the area. However, the project will result in a change from the baseline conditions likely to influence fish behavior.

Overall, the expressed migration behavior, particularly by adults, as a result of the existing bridge structures is expected to be similar to the behavior that will occur with the wider but higher replacement bridge. The available information does not indicate that the existing bridge structure has an influence on the migratory behavior of adult salmonids in Lake Washington or the Ship Canal. Substantial fluctuations in adult returns have occurred in the basin despite relatively consistent conditions in the action area. The physical characteristics and locations of the new structures are sufficiently similar to the existing structures that they are not likely to have a different influence on the migratory behavior of adult salmonids.

The available information indicates that the reaction of juvenile Chinook to the existing Evergreen Point Bridge is variable. In 1 year, Celedonia et al. (2008a) observed no apparent holding behavior of juvenile Chinook at the existing bridge, whereas in another year, minutes to hours of holding were observed for about half the fish (Celedonia et al. 2008a). Overall migration times through Lake Washington vary, depending n the entry timing into the lake from the natal streams, ranging from days to several weeks. Migration through the action area generally takes hours to days. Short delays in migration or slight alterations in migration routes are unlikely to result in detectable changes in the survival of Chinook salmon or other juvenile salmon at a cohort level as they migrate through Lake Washington and the Ship Canal. However, the potential effects on individuals or portions of the population will likely be greater.

DeVries et al. (2008) report consistent patterns between years—fish tagged and released later in the migration period are detected at much lower rates than those released earlier. Possible reasons include differential lake survival and reduced saltwater fitness of later migrating smolts, possibly in response to increased water temperature later in the season (Tabor et al. 2004b; DeVries et al. 2005, 2007). Predator rates also typically increase as water temperatures increase. Therefore, alteration of juvenile salmonid migrations out of Lake Washington could have a greater potential to reduce the survival or fitness of individuals that migrate later in the season. Increased holding behavior in suboptimal habitat could increase the susceptibility to predation or result in migration during warmer temperatures that might reduce survival. In reference to the existing Evergreen Point Bridge, Celedonia et al. (2008a) found that “the bridge did not appear to be a factor in delaying migration of holding fish.”

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 structures, 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. Other reviews have indicated that the progression of changes that a fish eye must undergo to adapt to changing light conditions is correlated to light intensity (Simenstad et al. 1999). 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.

The available studies suggest that the primary potential behavioral response of juvenile salmonids to in-water and over-water structures is the alteration of migration rates and/or migration routes, particularly for Chinook salmon. However, the most relevant information available indicates that the reaction of juvenile Chinook to the existing bridge is variable, with some juveniles passing directly under the bridge without delay and others holding in areas close to the bridge. It is also probable that the alteration of migration rates occurs only during specific periods and under specific environmental conditions. Migration times through the action area generally take hours to days, which is a small percentage of the typical overall outmigration durations. The studies suggest that short delays in migration or slight alterations in migration routes are unlikely to result in detectable changes in the survival of Chinook or other juvenile salmon compared to the overall migration rate through Lake Washington and the Ship Canal. However, alteration of the migration rate or migration route may expose juvenile salmonids to variable predation or water quality conditions.

There will be as many as 1,316 in-water piles, columns, and other in-water components during construction year 3. This will increase the structural complexity of the project area more than in any other year, with the project resulting in a final count of approximately 104 columns in Union Bay and 129 columns in the west approach area. However, the proposed structure will have fewer columns and more-widely-spaced columns (approximately double in distance) than the existing structure.

Given the understanding of how these mechanisms may affect fish behavior, WSDOT concludes that the residual effects on ESA-listed salmonids will consist of alterations in migration rate and/or route and predator-prey interactions. These effects will occur during both construction and long-term operation of the proposed replacement bridge, and primarily in the main Chinook migration corridor under the west approach span. Potential effects on Chinook salmon are summarized below.

Effects on Migratory Behavior

Numerous factors are believed to affect the migration of salmonids through Lake Washington; most of them are unlikely to be substantially affected by the presence of the existing bridge. Such factors include physiological development (smoltification) of migrating juvenile salmonids, overall water temperature of the lake and the Ship Canal, and the size and condition of the migrating fish. However, the bridge and in-water bridge structures do present unnatural conditions in the migration corridor, which have the potential to alter the behavior of migrating fish. Alteration of migratory behavior could cause the fish to occupy or migrate through areas that are more or less productive than habitats they would otherwise occupy, require different levels of energy expenditure, or subject the fish to more or less viable survival conditions.

Several features suspected of affecting the migration behavior and potential survival rates of juvenile salmonids include the bridge shadow on the surface of the water during the day, the artificial lights from the bridge and bridge traffic at night, and the bridge support structures (columns) in the water that change the natural habitat for both the salmonids and their predators.

These features are expected to change during construction time frame, as temporary structures are built to facilitate construction (work bridges), the new bridge is constructed, and the existing bridge is removed. Therefore, the overall extent and duration of over-water and in-water structures within the migration corridor will change over time, as will the potential effects of these changing features on migration behavior throughout the construction and long-term operational phases associated with the new bridge. However, past studies of Lake Washington have indicated that the influence of in-water shading on fish behavior is complex and variable, and it may vary by species, time of year, and other factors.

Adult Salmonid Response

The available information does not indicate that the existing west approach bridge structure has an influence on the migration behavior of adult salmonids as they return to the Lake Washington watershed to spawn. Adults are believed to migrate in the deeper water areas adjacent to the west approach. In addition, the physical characteristics and locations of the new structures are sufficiently similar that they are not likely to change potential unknown influences of the existing structures on the migrations of adult salmonids.

Juvenile Salmonid Response

Juvenile Chinook from the Cedar River tend to migrate along the western Lake Washington shoreline into Union Bay (Tabor et al. 2006; Celedonia et al. 2008a). Therefore, the proposed bridge crosses the migratory path of juvenile Chinook produced in the Cedar River. The bridge crosses the southeast edge of Union Bay, which serves as a migrational corridor and as a short-term (less than 24 hours) holding area (Celedonia et al. 2008a). The new west approach structure is prpopsed just north of existing structure in this area. The available information does not indicate that the existing bridge substantially alters the migration paths or timing of juvenile Chinook (Celedonia et al. 2008a, 2008b, 2009). In addition, some juvenile Chinook have been observed to move along the edge of the over-water approach structure before passing under the bridge; however, this behavior does not appear to adversely affect their survival. The proposed bridge structure will be wider and slightly higher above the lake surface than the existing bridge. The available information does not indicate that these differences are likely to substantially change the behavior of juvenile Chinook migrating under the bridge.

Some juveniles pass directly under the bridge without delay, while others spend up to 2 hours holding close to the bridge. These short delays are unlikely to result in detectable changes in the survival of Chinook or other juvenile salmon as they migrate through Lake Washington and the Ship Canal. Effects due to the in-water and over-water structures could result in changes to the rate and/or route of juvenile outmigration. However, the specific effect will differ by species and by the particular behavior patterns exhibited by individual fish. For some species and behavior patterns (e.g., Chinook juveniles exhibit active migration behavior), migration rates could be slowed slightly if fish tend to hold under a wider bridge deck for longer periods than under existing conditions. This change is not readily quantifiable but is expected to be unmeasurable relative to existing conditions. Based on past studies, overall migration routes are unlikely to change significantly, becaaue individuals will encounter a transition point (i.e., shadow boundary) similar to the baseline condition and will be expected to react in a similar manner. Therefore, the fish will pass through relatively quickly, move to deeper water to pass, or be inclined to hold and/or rear for some period of time. Because salmonids can see in dim conditions, the information suggests that contrast in the boundary of shade may be the primary factor in affecting behavior. Once the transition is made, fish either appear to move quickly through or hold in the shaded areas.

Actively migrating fish demonstrate three commonly observed behavior types: (1) minimal response, (2) paralleling, or (3) meandering or milling near the bridge after paralleling. The majority of fish exhibiting a holding behavior crossed multiple times or were observed milling under the bridge. None of these observations suggests that the width of the bridge shadow is influencing behavior. Diel spatial frequency data suggest that the majority of fish are not selecting for habitat under the bridge; therefore increased bridge width is not likely to result in a noticeable benefit in holding habitat. The available data suggest that the transition between light and shade and the sharpness of that contrast may be having the greatest influence on migration behavior.

A number of factors affect the migration rate and route of juvenile and adult salmonids through Lake Washington: depth preferences, temperature gradients, macrophyte density, and size of the migrating fish. Although the project could incrementally affect fish behavior, in terms of these innate biological factors, the available information on fish behavior in the project area suggests that the existing structures do not result in substantial alterations of migration behavior. The location of the replacement bridge will overlap the location of the existing bridge for a substantial portion of the primary juvenile migration route through the project area (near the west high-rise). Therefore, individuals will encounter a similar transition point (i.e., shade boundary) and similar depth conditions, although the extent and density of aquatic macrophytes could change slightly due to the wider bridge structure.

Studies indicate that active migration behavior is predominant in juvenile Chinook as opposed to holding behavior. Alteration of migration rate or migration route may result in increased energy expenditures by actively migrating fish that exhibit paralleling behavior. Relative to the overall energy expenditure (using time as a surrogate) of outmigration, actively migrating juvenile Chinook are adding only minutes to a migration typically lasting days to weeks. This change in the migration rate should not represent a significant disruption to migration behavior. Gauging any potential increase in energy expenditure in actively holding fish is speculative because they are likely taking advantage of foraging benefits during the holding period. The available information suggests that holding fish will likely behave in a manner similar to the current condition; moreover, the primary potential residual effect on the migration behavior of holding fish may be exposure to increased mean water temperatures from a later migration. The extent to which this effect may reduce survival is likely highly variable and speculative.

In conclusion, although the extent of expected harm and harassment of Chinook salmon due to increased shade and structural complexity is not insignificant or discountable, several factors will contribute to impact minimization and a reduced risk of exposure:

- The available data do not indicate that the existing bridge has a detrimental influence on the migration behavior of adult salmonids within the Lake Washington system.

- Although the new structure will be wider, it will be elevated higher and contain fewer columns than the existing structure. This will produce more diffuse shadows than the existing structure.
- Adult Chinook salmon migration occurs primarily away from the proposed bridge, within deeper waters.

Effects on Predator-Prey Interactions

Adult Salmonid Response

The available information does not indicate that the existing bridge structure has an influence on the predator-prey interactions of adult salmonids in Lake Washington. The physical characteristics and locations of the new structures are sufficiently similar to the existing structures that they are not likely to have a different influence on the predator-prey interactions for adult salmonids.

Juvenile Salmonid Response

Overall, any effects on associated predator-prey distributions 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 presence of the existing bridge, work bridges, and the replacement bridge during portions of the construction time frame will result in substantial increases in shading and habitat complexity in the area. These conditions are expected to provide additional predator habitat in the area during the construction time frame, although the long-term habitat conditions are expected to be similar to existing conditions (Exhibit 6-41). The available data from studies of movement and habitat use suggest that northern pikeminnows do not select areas near the bridge over other habitat types. Northern pikeminnows were primarily concentrated at 4- to 6-meter depths during all periods, and moderately dense vegetation was the most commonly used habitat type. Some attraction to nighttime lights was noted, although this was inconsistent from year to year (Celedonia et al. 2008a, 2008b, 2009).

Although smallmouth bass showed an affinity for the bridge columns, information suggests that their overall abundance is no greater at the bridge than in other suitable habitat types. In addition to selecting the bridge columns as part of their migration route, smallmouth bass were found to have an affinity for a depth of 4 to 8 meters and often sparse vegetation or edge habitat associated with macrophytes. Moderately dense to dense vegetation was used only occasionally. Neither pikeminnow nor smallmouth bass have been shown to have an affinity for the shading (i.e., overhead cover) provided by the overhead bridge structure (Celedonia et al. 2008a, 2008b, 2009).

The fewer and more-widely-spaced in-water columns of the proposed bridge structures are expected to reduce the habitat complexity in the immediate area of the bridge. This alteration is expected to diminish the quality of smallmouth habitat and reduce both predator and prey habitat provided by the permanent bridge structures. The increased habitat complexity associated with temporary structures will occur primarily in shallow-water areas, which already have substantial complexity due to aquatic macrophyte beds. An increase in bridge height could allow more ambient light under the bridge and an increase in macrophyte density, particularly along the southern exposure. An increase in height will also reduce the intensity of cover caused by shading. This increase could, in turn, positively affect northern pikeminnow habitat and negatively affect smallmouth bass habitat. Therefore, the project is not expected to increase the quality of the available predator habitat in the action area.

The amount of predation occurring in the action area is likely to be primarily a function of the overlap in available predator and prey habitat areas and selection preferences. As indicated above, the project is expected to reduce both of these habitat types, likely resulting in a small (unquantifiable) reduction in predation rates on juveniles. Assuming that smallmouth bass are selecting the bridge columns in their migration route and that Chinook show no preference for where they cross in the primary migration corridor, fewer columns may result in fewer incidences of prey exposure to predation by smallmouth associated with the bridge. This reduction in predation will apply particularly to juvenile Chinook exhibiting an active migration behavior. The extent to which the larger surface area of the proposed columns may attract more smallmouth bass per column is uncertain. When potential predator habitat is viewed as an area surrounding each vertical structure, a slight increase in the amount of potential predator habitat is expected in the eastern portion of the west approach where juvenile migration is highest.

Aside from potential changes in predator distribution, the information suggests that migrating juvenile salmonids that exhibit a holding behavior in association with the bridge are more likely to be susceptible to increased predation rates. The increased residence time around the structure may simply result in prolonged exposure to bridge-associated predators. The resulting higher, yet wider, bridge deck is likely to be equally as attractive or less attractive to holding salmonids.

In conclusion, some proportion of outmigrating juvenile Chinook salmon are likely to exhibit a holding behavior, resulting in increased residence time around the west approach structure. Of those fish exhibiting holding behavior, some proportion of them may experience direct mortality due to predation while holding near the structure, or a reduction in overall fitness as suggested by their later entry in to salt water.

Although the extent of expected harm and harassment of Chinook salmon due to increased shade and structural complexity is not insignificant or discountable, several factors will contribute to impact minimization and a reduced risk of exposure:

- The new bridge will represent an improvement over the baseline condition because it will be higher (although wider) and have fewer and more-widely-spaced in-water structural elements, reducing the overall complexity per unit area.

- The available data do not indicate that the existing bridge has an influence on predator-prey relations associated with adult salmonids.
- Adult Chinook salmon migration occurs primarily away from of the proposed bridge, within deeper waters.

Artificial Lighting

Adult ESA-listed salmonids are unlikely to be affected by the construction lighting because they are neither foraging in Lake Washington nor are there available data to suggest a potential attraction to artificial lighting.

Based on the available literature, including several studies conducted on Lake Washington, it is reasonable to predict that juvenile Chinook salmon will exhibit an attraction to illuminated areas. Much of the proposed over-water lighting will occur in shallower-water macrophyte communities where juvenile salmonid use is considered marginal. The construction lighting associated with building approximately the eastern half of the west approach has the greatest potential for affecting juvenile Chinook salmon.

Construction lighting is expected to result in effects on listed salmonids that are similar to those of operational lighting, which are discussed in detail in Section 6.3.1.

Puget Sound Steelhead

For reasons similar to those described for Portage Bay (Section 6.2.1.5), the potential effects of the project activities in the west approach area on Puget Sound steelhead are expected to be similar to but substantially less probable and less severe than the effects on Chinook salmon. Generally, any adverse effects on Chinook salmon resulting from project activities could also apply to steelhead.

In conclusion, although the extent of expected harm and harassment of steelhead during project activities is not insignificant or discountable, several factors will contribute to impact minimization and a reduced risk of exposure:

- Steelhead, although not prevented from using the west approach area, are expected to be present in low numbers during the in-water construction period (September through April), which is mostly outside the juvenile migration periods.
- Adult steelhead migration will occur primarily within deeper portion s of the west approach area, away from the most intensive pile-driving impact areas. Adult steelhead are likely mobile enough to avoid areas of lesser effects.
- None of the available information identifies the west approach area as a location specifically used by juvenile steelhead for rearing. Steelhead rear for several years before migrating to Puget Sound; therefore, they are expected to be less dependent on the shallow nearshore habitat in the lake/west approach.

- The use of BMPs (Section 2.10) is expected to minimize the size of the area affected by turbidity-causing activities.
- The use of a bubble curtain during pile driving is expected to minimize the size of the area affected by sound levels in excess of the disturbance threshold.

Coastal-Puget Sound Bull Trout

For reasons similar r to those described for Portage Bay (Section 6.2.1.5), the potential mechanisms of effect from the project activities in the west approach area on bull trout are expected to be similar to the effects on Chinook salmon; however, the potential effects are less likely due to the low abundance of bull trout and the timing of habitat use in the west approach area. and the potential effects are also likely to be less intense because only adult and subadult life stages are expected to be exposed to them. Differences in potential bull trout responses to stressors are summarized below.

In in addition to those listed in Exhibit 6-41, the following stressors associated with the west approach area are not expected to result in adverse effects on bull trout:

- **Shading and structural complexity.** Bull trout are not dependent on the west approach area as a migratory corridor, nor are the subadult and adult forms of bull trout as susceptible to predation. The patterns of overwater shading and in-water structural complexity are not expected to result in a significant disruption of normal behavior or increased predation.
- **Construction lighting.** Foraging by subadult or adult bull trout may be improved somewhat during artificially illuminated conditions; however, a significant disruption in foraging behavior is not expected. Additionally, due to the timing of habitat use (late spring), the potential for exposure to artificially illuminated conditions during construction would be lower than that for the other listed salmonids.
- **Effects to prey base –** Although project-related stressors are expected to have some adverse effects on ESA-listed fish, and potentially other forage fish species, the abundance of prey resources is not expected diminish so as to significantly affect bull trout behavior or survival.

Potentially adverse effects on bull trout and their responses to those stressors are summarized as follows:

- **Turbidity.** Individuals exposed to turbid conditions may experience gill abrasion, have reduced foraging potential, or exhibit avoidance behaviors.
- **Pile driving.** Individuals exposed to pile-driving noise are expected to experience some disruption of normal behavior (e.g. startle or avoidance response) within the 22- to 136-meter range or have potential for injury within the 22-meter cumulative SEL injury

zone; however, a cumulative SEL injury effect within 2 meters is considered discountable.

In conclusion, although the extent of expected harm and harassment of bull trout during project activities is not insignificant or discountable, several factors will contribute to impact minimization and a reduced risk of exposure:

- Bull trout, although not prevented from occupying the west approach area, are expected to be present in low numbers, if at all, during the in-water construction period (September through April).
- If any bull trout are present, the individuals are expected to be adults or subadults, both of which are likely mobile enough to alter their route to avoid impact areas.
- The use of BMPs (Section 2.10) is expected to minimize the area affected by construction activities.

6.2.5 Floating Bridge

This section addresses effects that will result from the following activities and conditions:

- Installation of pontoon mooring anchors
- Installation of the bridge pontoons and bridge superstructure
- Removal of the existing floating bridge span
- Long-term presence and operation of the floating bridge

Project elements and construction activities for this area are described in Sections 2.2 and 2.3. Exhibit 6-42 summarizes the spatial and temporal extent of those project elements and the related construction activities.

EXHIBIT 6-42.
SPATIAL AND TEMPORAL EXTENT OF PROJECT ELEMENTS IN THE FLOATING BRIDGE AREA

Project Element	Total Number	Frequency	Total Duration	In-Water/Over-Water Area
Anchor installation	58	7 to 8 per month	12 months	Up to 3.3 acres
Pontoon assembly	77	3 to 4 per month	21 months	21.9 acres
Bridge superstructure [a]	23	Approx. 1 per month	23 months	N/A [a]
Pontoon disassembly	24	2 per month	6 months	12.9 acres

[a] Over-water area is captured in the pontoon area.
N/A = not applicable

The project elements and associated construction activities described in Sections 2.2 and 2.3 are expected to result in the following mechanisms of effect or types of stressors on listed species:

- Water quality degradation
- Noise
- Habitat alteration

The potential project-related effects from the floating bridge are discussed in detail below. Stressors are reported both cumulatively by construction year (“temporary” effects) and for the final proposed condition (“permanent” effects). The potential effects on listed salmonids related to this analysis are discussed in Section 6.2.5.4.

6.2.5.1 Water Quality Degradation

Potential water quality effects during the proposed activities include increased turbidity,and introduction of construction debris. Potential long-term water quality effects associated with stormwater management for the project are discussed in Section 6.3.

Turbidity

Exhibit 6-43 lists the project elements that have been identified as sources of turbidity in the floating bridge portion of the action area.

EXHIBIT 6-43.
PROJECT ACTVITIES LIKELY TO INCREASE TURBIDITY NEAR THE FLOATING SPAN OF THE EVERGREEN POINT BRIDGE

Turbidity Source	Peak Values per Construction Year			
	2012	**2013**	**2014**	**2015**
No. of temporary pile anchors (less than 60 feet deep)	12	N/A	N/A	N/A
No. ofpile anchors removed	12	N/A	N/A	N/A
No. of anchors placed (less than 60 feet deep)	6	N/A	N/A	N/A
No. of anchors placed (greater than 60 feet deep)	52	N/A	N/A	N/A
Instances of pontoon disassembly	N/A	N/A	Approx. 12	Approx. 12
Total	**82**	**N/A**	**12**	**12**

N/A = not applicable

Localized and short-term increases in turbidity will occur during the installation of the pontoon anchors, particularly in areas where water-jetting is used to set the fluke anchors below the mudline in soft-bottom areas. In the harder and sloped substrate areas, excavation and fill placement will be used to establish a footing for the gravity anchors. A total of 58 anchors will be required to secure the floating bridge in place. The existing anchors will likely be left in place because they are expected to be too embedded to safely remove them, and leaving them in place will minimize potential turbidity effects.

Sediments may be suspended during pontoon anchor placement; however, in most instances, suspended sediments are expected to settle out of the water column within a short distance of the initial sediment plume. Limiting pontoon anchor installation in water less than 60 feet deep will minimize the potential for disturbing shallow-water substrate, which could be spread by surface wind-driven currents and wave action. Limited water currents likely occurring in the deepwater anchor locations will prevent any substantial dispersion of suspended sediments in those locations.

Potential water quality degradation (i.e., turbidity) from pontoon anchor placement will occur over a 6 to 7-month period during the construction year 1. Most of this work will likely occur during the summer months, when wind conditions will be more favorable for open-water construction activities, and the potential for winds to disperse sediments suspended in shallower waters will be reduced.

As a result, in-water activities associated with pontoon anchor placement will result in localized and short-term increases in turbidity. Additionally, disassembling the existing pontoons (up to 12 instances per year in construction years 3 and 4) will likely increase turbidity due to in-water concrete sawing. The location and duration of proposed construction activities, along with the implementation of appropriate BMPs, will limit the potential exposure of listed salmonids. The potential effects of turbidity on listed salmonids are discussed in Section 6.2.5.4.

Installation of the floating bridge will typically occur from barges, tugboats, or the pontoons. During installation of the floating bridge, BMPs outlined in Section 2.10 will be followed to minimize effects on water quality.

Pollutants

Two sediment-related studies addressed Portage Bay, but there have been no known studies within the Lake Washington portion of the action area (Cubbage 1992; Moshenberg 2004). The studies in Portage Bay indicated the presence of relatively low concentrations of pollutants such as metals, PCBs, PAHs, and phthalates in the sediment in the confined area of Portage Bay; however, they did not indicate contaminated sediments in the open-water areas of the lake. Consequently, there is no indication that contaminated sediments will be encountered during anchor placement and other construction activities.

Over-water work, such as pontoon installation, could introduce pollutants into the aquatic environment, particularly grouting of joints between pontoons. After assembling the pontoons with joint bolts, hydraulic rams will stress the bolts and compress the rubber seal between the pontoons, creating a 3-inch-wide watertight seal between the individual pontoons. Therefore, the spaces filled with cement grout between the watertight seals will be fully contained. To ensure that uncured grout does not come in contact with water, the forms will remain in place for at least 72 hours after the concrete is poured to ensure the concrete is adequately cured. In the event that uncured grout does enter the water, BMPs such as vacuums, diverters, absorption materials, holding tanks, and drainage systems will be used to contain the grout-exposed water.

Cutting concrete above or under water to separate the pontoons of the existing bridge is the primary project activity that could potentially affect the aquatic environment, in part because concrete dust could cause a localized increase in pH. Concrete dust is considered to be insoluble (0.1 percent maximum solubility) in water; therefore, localized increases in pH are expected to be negligible and are likely to be rapidly buffered by the water volume and chemical constituents of the lake.

Implementation of BMPs described in Section 2.10 will minimize or eliminate the potential to introduce pollutants into the aquatic environment during construction activities.

Physical Debris

Physical debris may be introduced into the aquatic environment during pontoon outfitting and removal of the existing floating bridge. Pontoon outfitting will occur during construction years 2 and 3 for a total of about 23 months, and demolition of the existing floating bridge will take a total of 6 months to complete. These activities will occur from the pontoons or construction barges. BMPs, as described in Section 2.10, will be implemented to minimize or prevent debris from entering the water during these activities. BMPs include but are not limited to nets, tarps, platforms, scaffolds, blankets, barges, and floats.

Debris—in particular fugitive concrete dust or slurry—may enter the lake during saw cutting at pontoon-to-pontoon joints during demolition or pontoon removal activities. The BMPs outlined in Section 2.10 will be implemented to minimize the potential for debris to enter the lake during demolition activities.

6.2.5.2 Noise

Potential noise effects during the proposed activities include underwater noise associated with vessel operations and vibratory pile driving.

Vessel Operations

While vessel operations are expected to be a primary means of accessing the floating bridge work areas, the potential noise generated by vessel operations in the open-water areas of the lake are unlikely to be much greater than the noise of existing vessel traffic or background noise levels (see Section 6.2.1.2). Therefore, noise levels generated by project-related vessels are expected to be within the range of baseline conditions for Lake Washington.

Pile Driving

The only potential pile-driving activities during the installation of the floating bridge will occur if pile anchors are used to temporarily secure the pontoons in place. However, temporary pile anchors will be driven only with a vibratory hammer, resulting in little or no effect on ESA-listed species. The limited potential for effects is a result of the low number (five or six) of pile anchors potentially needed (if any), the short duration of pile driving (hours), and the low intensity and frequency of the resulting underwater noise.

6.2.5.3 Habitat Alteration

Potential habitat alterations include benthic habitat disturbance and displacement, shading, alteration of structural complexity, and artificial lighting.

Benthic Habitat Disturbance and Displacement

As indicated above in the water quality discussion, the placement of 58 pontoon anchors will result in the disturbance and displacement of about 3.3 acres of substrate and benthic habitat. In addition to habitat under the anchors, approximately 2,500 square feet of benthic habitat around the pontoon anchors will be displaced during the installation process. This will occur from water-jetting the fluke anchors below the mudline, placing rock ballast on top of embedded fluke anchors, and from excavating and filling to level the gravity anchor locations, because these anchors will be the primary method of anchoring the pontoons in areas with sloping substrate. This habitat includes the area directly affected by the water-jetting and excavation and the area where suspended material settles to the lake bottom. Because of limited water currents in these locations, it is likely that the sediments will resettle rapidly.

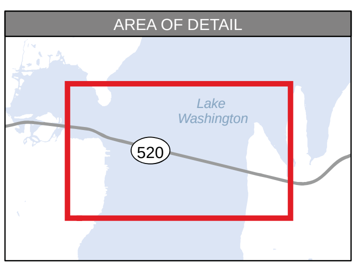
As shown in Exhibits 6-44 and 6-45, a total of approximately 3.3 acres of benthic substrate will be permanently occupied by the pontoon anchors, although some sedimentation and recolonization by benthic organisms could provide some recovery. In addition, up to about 12 temporary anchors will be installed at either end of the floating span in early 2013; this activity will temporarily displace about 60 square feet of benthic habitat.

EXHIBIT 6-44.
PROJECT ELEMENTS RESULTING IN DISPLACEMENT OF BENTHIC SUBSTRATE IN THE FLOATING BRIDGE AREA

Substrate Displacement Source	Peak Values per Construction Year (acres, unless otherwise noted)				Final
	2012	2013	2014	2015	
Temporary pile anchors (less than 60 feet deep)	60 square feet	N/A	N/A	N/A	N/A
Anchors (less than 60 feet deep)	0.3	0.3	0.3	0.3	0.3
Anchors (greater than 60 feet deep)	3.0	3.0	3.0	3.0	3.0
Total	**3.3**	**3.3**	**3.3**	**3.3**	**3.3**

Exhibit 6-45 shows the extent of benthic habitat displacement due to the floating bridge.

Potential effects from disturbance and displacement of benthic habitat on listed salmonids are discussed in Section 6.2.5.4.



Anchor and Cable

Pontoons

Limits of Construction

Permanent Fill

Proposed Edge of Pavement

Park

N

0 500 1,000 2,000 Feet

Source: King County (2006) Aerial Photo, CH2M HILL (2008) GIS Data (Park). Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 6-45. **Annual Benthic Habitat Displacement in the Floating Bridge Area**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

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Shading

To evaluate the effect of shading in the floating bridge area, the total area of over-water cover was used to provide a year-by-year comparison of the variable shade conditions as the project construction progresses to completion. Exhibit 6-46 provides a summary of these values.

EXHIBIT 6-46.
OPEN-WATER AREA SHADED BY EXISTING AND PROPOSED BRIDGE STRUCTURES IN THE FLOATING BRIDGE AREA, BY CONSTRUCTION YEAR

	Peak Values per Construction Year (acres)				
Shading Source	**2012**	**2013**	**2014**	**2015**	**Final**
Existing floating span	12.1	12.1	12.1	N/A	N/A
New floating span [a]	0.7	17.4	21.9	21.9	21.9
Total	**12.7**	**29.5**	**34.0**	**21.9**	**21.9**

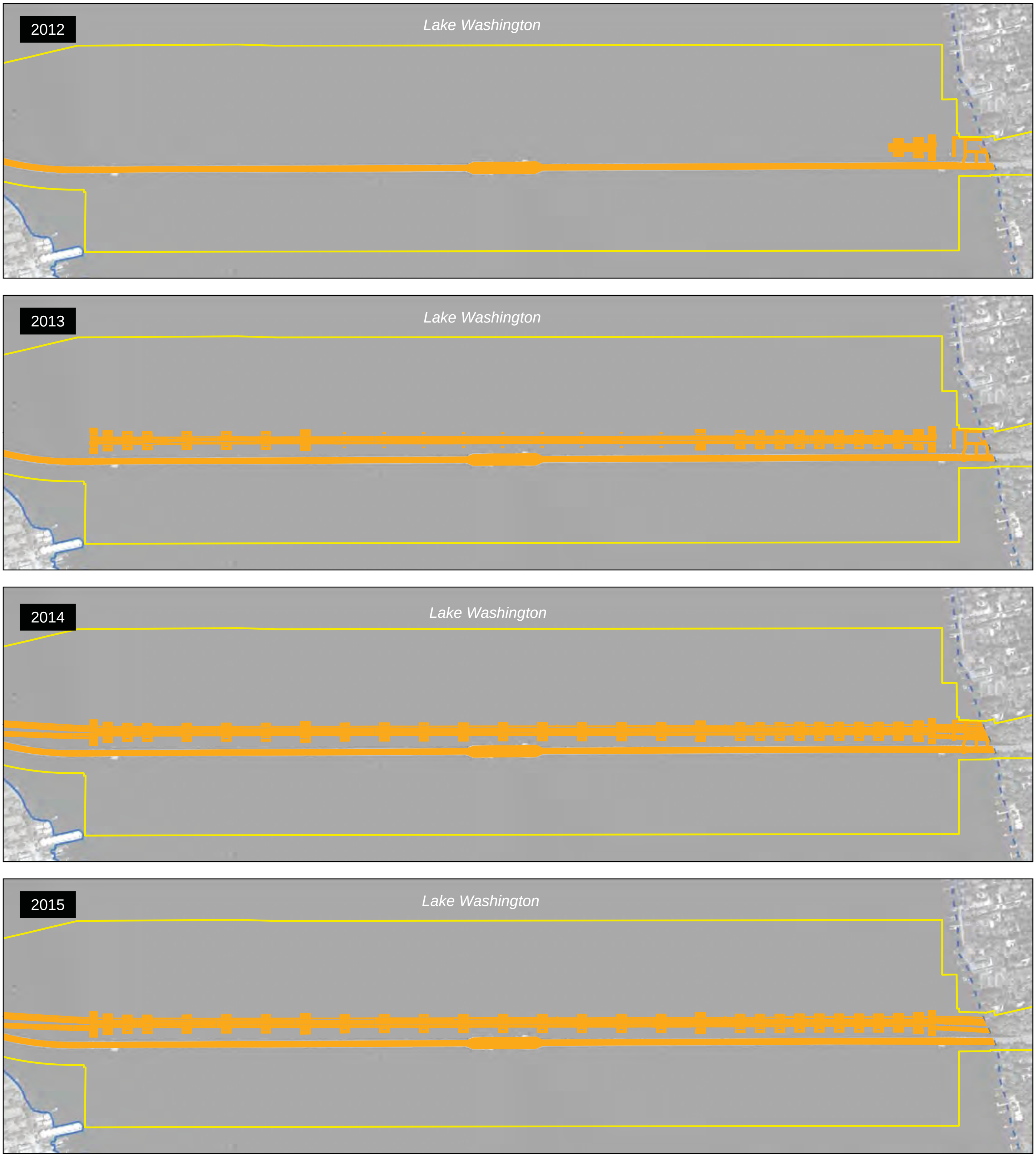
[a] Assumes the outermost footprint of either the pontoons or the bridge deck overhang.

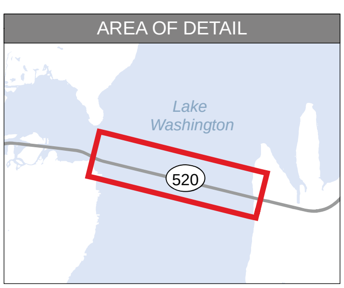
Exhibits 6-47a and 6-47b show the extent of shade from the floating bridge, by construction year.

The increased width and height of the new floating bridge will change the photosynthetic activity immediately adjacent to the bridge as aresult of the decreased solar radiation reaching the lake surface. Localized effects on primary productivity will occur; however, shading is not likely to have a measurable effect on primary productivity, as a whole, in the action area. The increase in shading is unlikely to result in a measurable effect on phytoplankton production in Lake Washington.

The effects of shading in the floating bridge area will be greatest during construction year 3, when both the existing and the replacement bridges are in place.

The potential effects of shading on listed salmonids are discussed in Section 6.2.5.4.





- Ordinary High Water Mark
- Ordinary High Water Mark (Not Surveyed)
- Limits of Construction
- Shading

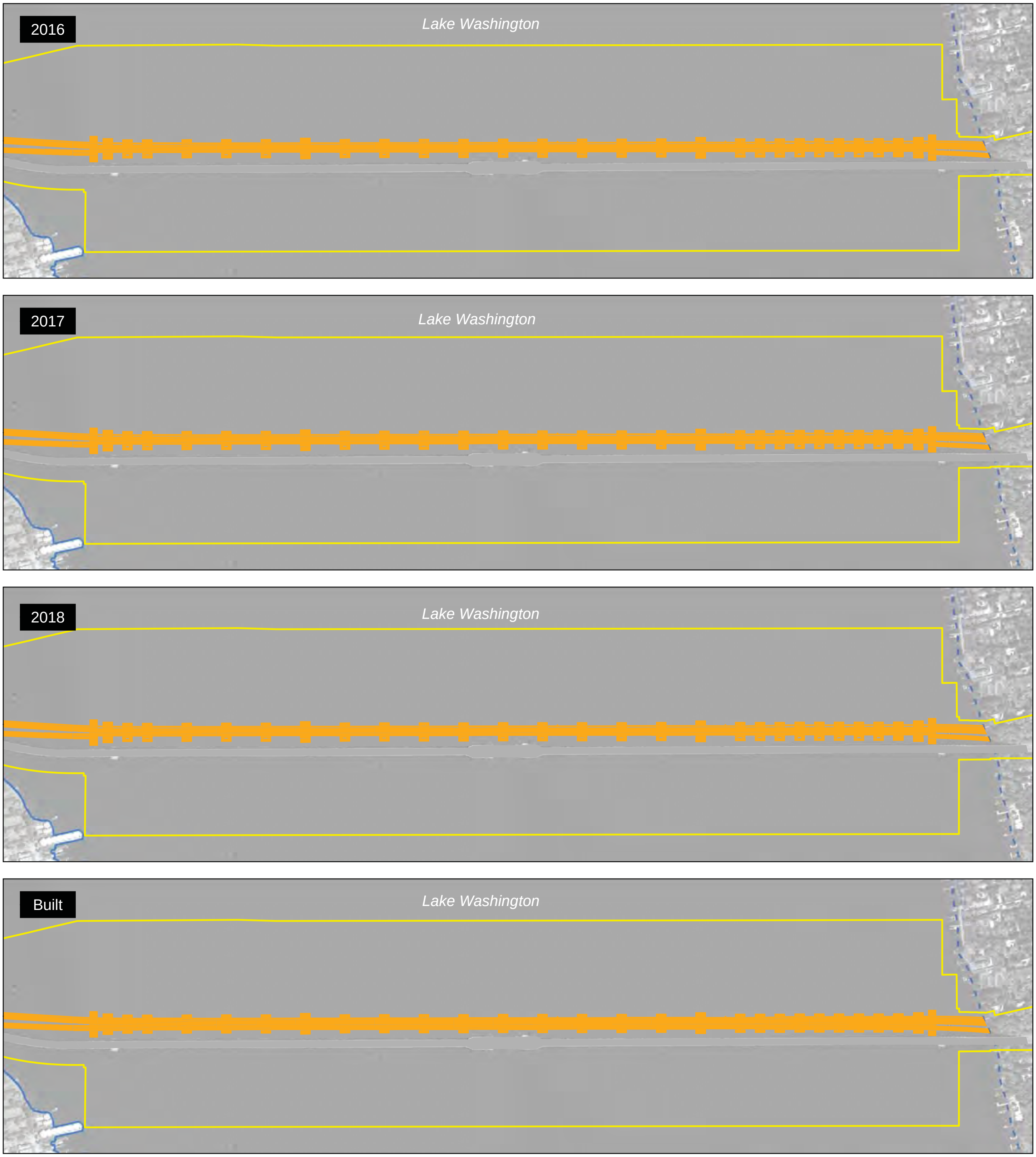
Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

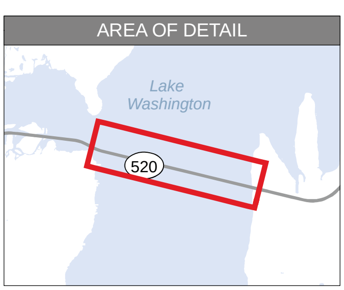
N

0 250 500 1,000 Feet

Exhibit 6-47a. **Annual Shade in the Floating Bridge Area**

SR520, I-5 to Medina: Bridge Replacement and HOV Project





Ordinary High Water Mark
Ordinary High Water Mark (Not Surveyed)
Limits of Construction
Shading

Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

N
0 250 500 1,000 Feet

Exhibit 6-47b. **Annual Shade in the Floating Bridge Area**
SR 520, I-5 to Medina: Bridge Replacement and HOV Project

Alteration of Structural Complexity

The placement of in-water structures will alter the structural complexity of the aquatic environment. Project-related factors that influence in-water structural complexity are primarily a function of the amount of in-water structure per unit area and the spatial alignment of the structures in relation to one another, such as spaces between the supplemental stability pontoons, the size and depth of the pontoons, and the distance along the face of the pontoons (i.e., perimeter) per the length (i.e., linear distance) of the floating span.

Section 2.2 provides details on the proposed floating bridge structure and supporting features, such as pontoon dimensions. The proposed floating bridge structure will be between 75 and 240 feet wide, almost three times wider than the existing structure. The new floating bridge structure will also be slightly longer (7,710 feet) than the existing floating bridge structure (7,578 feet). The new pontoons will be wider and extend deeper into the water column. Once the superstructure is installed, the proposed pontoons will have a typical draft of about 21.5 feet below the surface of the water, whereas the existing pontoons have a typical draft of about 8 feet below the water surface. In addition, the perimeter of the new pontoons will increase approximately 1,770 feet compared to the existing pontoons (Exhibit 6-48).

EXHIBIT 6-48.
CHANGES IN STRUCTURAL COMPLEXITY (ANCHORS AND PONTOONS) IN THE FLOATING BRIDGE AREA, BY CONSTRUCTION YEAR

Structural Complexity Source	Peak Values per Construction Year				Final
	2012	2013	2014	2015	
No. of temporary pile anchors (less than 60 feet deep)	12	N/A	N/A	N/A	N/A
No. of anchors (less than 60 feet deep)	6	6	6	6	6
Existing pontoon perimeter (linear feet)	7,580	7,580	7,580	N/A	N/A
New pontoon perimeter (linear feet)	1,200	4,675	9,350	9,350	9,350

N/A = not applicable

Changes in structural complexity will result in potential changes in salmonid and predator species interaction with the floating bridge, use of the structures by avian species, and lake circulation.

Bridge Features

Migrating juvenile salmonids may hold, migrate, or forage in the aquatic habitat adjacent to or under the floating bridge structure. Bridge features that attract juveniles include cover provided by the bridge edge, enhanced feeding opportunities due to possible zooplankton concentrations, and creation of a “migration corridor” that enables juveniles from the littoral zone to move effectively to deeper water for feeding (Celedonia et al. 2008a). The floating structure also likely provides habitat for predator species, which potentially increases the vulnerability of listed species to predators attracted to these same areas (Celedonia et al. 2008a, 2009).

The functions or opportunities provided by the existing bridge pontoons (for salmonids or predator species) are not expected to change with the new structure, despite its being about twice as wide as the existing structure. Juvenile salmonids are expected to interact with the floating bridge structure in the same manner as they currently interact with the existing structure.

Avian Species Use of Structures

The larger pontoons could provide additional perch habitat for avian species. However, there are few avian species known to forage from perches above the water surface at this location that also prey on juvenile salmonids. See Appendix G for more detailed discussion of predator-prey interactions in Lake Washington.

The effects of changes in structural complexity in the floating bridge areawill begin with the installation of the first pontoons during construction year 1 and will continue for the design life of the bridge. The highest degree of structural complexity will occur during construction year 2, when all of the pontoons, along with the existing bridge structure, are in place. The resultant effects of structural complexity in the floating bridge area on listed salmonids are discussed in Section 6.2.5.4.

Artificial Lighting

Artificial lighting during project construction has the potential to affect aquatic habitat conditions in the floating bridge area, potentially serving as an attractant to listed species as well as their predators. This could potentially cause an alteration of normal behavior patterns of listed species and increased predation on listed species.

The floating bridge will be constructed primarily from work vessels, barges, and the pontoons that will typically be located a substantial distance from shore. Therefore, the smaller juvenile salmonids that are typically shoreline-oriented are less likely to be attracted to these distant offshore areas, and larger juveniles are less likely to be adversely affected by congregating near the bridge.

Construction lighting is expected to result in effects on listed salmonids that are similar to those of operational lighting, which are discussed in detail in the Section 6.3.1.

Effects on Localized Limnology

Water circulation in the lake is strongly influenced by prevailing winds, causing surface water to move north and deeper water to move in the opposite direction. The Evergreen Point Bridge impedes the wind-driven movement of surface water. Both northerly and southerly winds force surface water through the openings at either end of the floating portion of the bridge, although southerly winds (winds from the south) provide the primary wind force that moves surface water in Lake Washington. Wind forces produce a slight increase in water surface elevation (head) on the windward side of the existing floating bridge. This increase in head causes water throughout the water column to move under the bridge to the leeward side, aided by the hydraulic pressure of increased water surface elevation on the upwind side of the floating bridge.

The deeper pontoon draft of the new floating bridge (typically 21.5 feet, compared to 8 feet) will increase the resistance to water movement under the floating bridge and require the wind to build up a higher head on the windward side of the bridge to push the same amount of water past the bridge. The overall effect is not expected to cause a substantial change in water movement past the bridge because of the large amount of remaining open area under and around the ends of the floating bridge. Therfore, the remaining open area with the new bridge is expected to be sufficient to allow generally free movement of water past the bridge.

The increased head on the windward side of the bridge during strong winds produces water movement throughout the water column, resulting in movement of water both above and below the thermocline. The depth of the summer epilimnion (above the thermocline) is about 60 feet (20 meters) (Arhonditsis et al. 2004). The persistent isotherm tilt described by Schock (2008) was modeled using data collected with the existing Interstate 90 (I-90) bridge in place. The depth (draft) of the I-90 bridge pontoon is about 20 feet; therefore, it is a reasonable surrogate for the proposed Evergreen Point Bridge, which will have a typical pontoon depth of 21.5 feet. Schock's (2008) analysis does not indicate an effect of the I-90 bridge on the isotherm layers in Lake Washington, implying that the floating bridge is not restricting circulation or producing mixing of surface and deeper layers.

The movement of water throughout the water column when strong winds occur during stratified periods is expected to move both epilimnion and hypolimnion water past the Evergreen Point Bridge with the typical proposed pontoon depths (21.5 feet). The average lake depth of about 170 feet provides a large cross-sectional open area under the floating bridge that will be decreased by only about 10 percent with the proposed deeper bridge. This small decrease in area under the floating bridge is not expected to substantially change the overall conditions in the lake or at the bridge location.

6.2.5.4 Species Response to Stressors

This section considers the spatial and temporal overlap of the presence of listed salmonids and the stressors associated with the floating bridge (i.e., species exposure), and the expected responses of those species. The exposure of an organism is largely determined by the life history, behavior, and habitat uses of the particular species. Exhibit 6-49 summarizes the expected use of Lake Washington by listed salmonids, Salmonid use of the floating bridge area is expected to be similar to their use of the west approach area, with limited numbers of steelhead and bull trout and peak usage by adult Chinook salmon from July through September, and by juveniles from May through July.

EXHIBIT 6-49.
EXPECTED OCCURRENCE OF ANADROMOUS FISH SPECIES IN THE FLOATING BRIDGE AREA, BY LIFE HISTORY STAGE

Species	Life History Stage	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Chinook salmon	Adult												
	Residual												
	Juvenile												
Steelhead	Adult												
	Residual												
	Juvenile												
Bull trout	Subadult												

Nominal presence

Low presence

High presence

Several potential stressors associated with project construction have limited or no potential to affect the physical, chemical, or biological environment in the floating bridge area. The potential stressors that will not adversely affect adult or juvenile Chinook salmon are summarized in Exhibit 6-50.

EXHIBIT 6-50.
NON-ADVERSE EFFECT STRESSORS IN THE FLOATING BRIDGE AREA

Stressor	Rationale
Dissolved oxygen related to water quality	Dissolved oxygen is not expected to be affected by the proposed project activities; exposure risk is considered discountable.
Pollutants	Pollutants are not known to be present; exposure risk is considered discountable.
Physical debris related to water quality	BMPs will prevent introduction of physical debris into the aquatic environment; exposure risk is considered discountable.
Terrestrial noise	Terrestrial noise is not expected to transmit to, or exceed, ambient underwater noise levels; exposure risk is considered discountable.
Vessel operations related to underwater construction noise	Noise caused by vessel operations is not expected to exceed existing underwater noise levels; exposure is considered insignificant.
Riparian disturbance and displacement	Localized shading patterns and reduction in organic litter input will not result in significant change in behavior or survival; effect on species is considered insignificant.

EXHIBIT 6-50.
NON-ADVERSE EFFECT STRESSORS IN THE FLOATING BRIDGE AREA

Stressor	Rationale
Benthic disturbance and displacement	Primary productivity and forage base are not limiting. Benthic habitat disturbance will be at depths not considered to be used by salmonids. Reduction in benthos-derived productivity will not result in significant changes in behavior or survival. Effect on species is considered insignificant.
Limnological process	Localized alterations of temperature or phytoplankton production will not result in significant changes in behavior or survival. Effect on species is considered insignificant.

BMP = best management practice

Certain aspects of the proposed action are likely to adversely affect adult and juvenile Chinook salmon in the west approach area either through a significant modification of normal behavior or through direct injury or mortality. These stressors are the following:

- Shading (note that shading and alteration of structural complexity are combined in the discussion below)
- Alteration of structural complexity (note that shading and alteration of structural complexity are combined in the discussion below)
- Artificial lighting

Habitat Alteration

Alteration of Structural Complexity

This section discusses salmonid responses to changes related to in-water structural complexity. The data suggest that migration behavior could be adversely affected by alterations to or disruption of physical structures (structural complexity) within the water column.

Bridge-edge aggregations around the new floating bridge will likely be similar to those around the existing bridge; therefore, salmonid migration through the lake and potential juvenile predation is not anticipated to change. Alterations to the floating bridge and pontoon dimensions are not likely to result in changes in the presence of Chinook salmon or steelhead near the floating bridge; however, the complexity and amount of the habitat near the floating bridge will change (see Section 6.2.5.3). Such changes in structural complexity could result in greater attraction of juveniles and predators to the floating bridge structure and pontoons, which could increase the overall predation rates and migration delays of Chinook salmon and steelhead, and result in an adverse effect on the species.

The spaces between the new pontoons could result in longer migration times if fish are specifically attracted to these areas for foraging and rearing, or if they are prone to lead along the edge of the bridge as they migrate across the lake. If this occurs, delays in the overall migration of juvenile salmonids through the lake could result and potentially decrease their overall survival rates due to increased predation or delayed entry into the salt water.

Because the pontoons will extend deeper into the water (typically 21.5 feet compared to 8 feet), they will likely produce a larger area of quiescent habitat on the lee side of the bridge. In addition, the variable widths of the floating bridge, resulting from the separation between the supplemental stability pontoons along the longitudinal pontoons, will further increase the amount of quiescent habitat in the immediate footprint of the bridge. The increase in quiescent habitat could potentially increase the use of this habitat by salmonids and predators or could result in changes in water quality conditions (water temperature).

Shading

The increased size and height of the new floating bridge span will increase the amount of shade from the bridge structure. Similar to changes in structural complexity, the increase in shade has the potential to attract both juvenile salmonids and predator species. Therefore, the increase in shade could result in a slight increase in the predation rates and/or migration passage time, which could result in a slight decrease in the survival of juvenile salmonids passing through the lake in the vicinity of the floating bridge. Juvenile Chinook salmon are more likely to be adversely affected by the effects from increased shading than steelhead or bull trout, because the larger fish are less likely to be attracted to in-water structures.

Artificial Lighting

Artificial lighting can serve as an attractant to listed species and their predators. Lighting used during project construction may increase the attraction of juvenile salmonids to the construction area, as well as predator species. This could result in decreased survival of juveniles, which is considered an adverse effect on listed salmonids. Similar to the effects from shading, juvenile Chinook salmon will be more likely to be adversely affected than steelhead and bull trout.

Puget Sound Steelhead

For reasons similar those described above, the potential effects of the project activities in the floating bridge area on Puget Sound steelhead are expected to be similar to the effects on Chinook salmon. Generally, any adverse effects on Chinook salmon resulting from project activities could also apply to steelhead.

In conclusion, although the extent of expected harm and harassment of steelhead during project activities is not insignificant or discountable, the use of BMPs (Section 2.10) is expected to minimize the area affected by construction-related activities.

Coastal-Puget Sound Bull Trout

The potential mechanisms of effect from the project activities in the floating bridge area on bull trout are expected to be similar to the effects on Chinook salmon. However, adult and subadult bull trout are expected to exhibit some different life history traits in the deepwater portions of

Lake Washington than either Chinook salmon or steelhead; therefore, some differences in potential bull trout responses to stressors are expected. These are summarized below.

In in addition to those listed in Exhibit 6-50, the following stressors associated with the floating bridge are not expected to result in adverse effects to bull trout:

- **Shading and structural complexity.** Bull trout are not dependent on the floating bridge area as a migratory corridor, nor are the subadult and adult forms of bull trout as susceptible to predation. The patterns of overwater shading and in-water structural complexity are not expected to result in a significant disruption of normal behavior or increased predation.

- **Construction lighting.** Foraging by subadult or adult bull trout may be improved somewhat during artificially illuminated conditions; however, a significant disruption in foraging behavior is not expected. Additionally, due to the timing of habitat use (late spring), the potential for exposure to artificially illuminated conditions during construction would be lower than that for the other listed salmonids.

- **Effects to prey base –** Although project-related stressors are expected to have some adverse effects on ESA-listed fish, and potentially other forage fish species, the abundance of prey resources is not expected diminish so as to significantly affect bull trout behavior or survival.

In conclusion, the potential effects on bull trout from the floating bridge portion of the project are considered insignificant or discountable.

6.2.6 East Approach

This section addresses effects related to the east approach area and the proposed maintenance facility that will result from the following activities and conditions:

- Construction of the new fixed-span structure and associated temporary structures
- Construction of a new upland maintenance facility
- Construction of a new dock for the maintenance facility
- Removal of the existing east approach structure and the temporary structures
- Long-term presence of the proposed east approach structure

Project elements and construction activities for this area are described in Sections 2.2 and 2.3; Exhibit 6-51 summarizes the spatial and temporal extent of these project elements and the related construction activities.

EXHIBIT 6-51.
SPATIAL AND TEMPORAL EXTENT OF PROJECT ELEMENTS IN THE EAST APPROACH AREA

Project Element	Total Number	Frequency	Total Duration	In-Water/Over-Water Area
Work bridge/falsework pile installation	165	Up to 8 per day	Up to 7 months	Up to 825 square feet
Work bridge deck	1	Approx. 2,500 square feet per day	Up to 3 months	Up to 0.8 acres
Cofferdams	1	1 per construction year (2013)	Up to 4 months	Approx.8,950 square feet total
Mudline footings	2	2 per construction year (2013)	Up to 4 months	Up to 8,300 square feet total
Bridge superstructure	2 spans	Varies	Approx. 12 months	1.3 acres
Materials transport	N/A	Daily	Ongoing	N/A
Column demolition	14	Approx. 2 to 3 weeks	Approx. 2 months	Approx. 350 square feet
Pile removal	165	Approx. 4 to 6 per day	Approx. 3 months	Up to 825 square feet
Cofferdam removal	1	3 per construction year for 2 years	Approx. 1 month	Approx. 650 square feet

N/A = not applicable

These project elements and activities are expected to result in the following mechanisms of effect or stressors on listed species and designated critical habitat, which are discussed in detail below:

- Water quality degradation
- Noise
- Habitat alteration
- Fish handling

The potential project-related effects from the east approach are discussed in detail below. Stressors are reported both cumulatively by construction year ("temporary" effects) and for the final proposed condition ("permanent" effects). The potential effects on listed salmonids related to this analysis are discussed in Section 6.2.6.4.

6.2.6.1 Water Quality Degradation

Potential water quality effects include the increased turbidity, resuspension of contaminated sediments, and the introduction of pollutnats and/or construction debris during the proposed activities. Each is discussed in more detail below.

Turbidity

Project construction will result in increased turbidity in and near aquatic habitat. Upland construction and staging activities will disturb the soils in shoreline areas, creating some potential for sediments to be introduced to the aquatic environment. However, implementation of appropriate BMPs is expected to eliminate or minimize this potential risk. Any turbidity caused by upland activities will remain localized, and BMPs will be maintained, repaired, or augmented to minimiz or eliminate turbid runoff.

Pile driving (both vibratory and impact) to construct the work bridges and falsework structures, deconstruction activities such as pile removal, and other construction activities necessary to construct the permanent bridge have the potential to increase turbidity in the immediate construction area. Falsework and work bridge piles that are not accessible for removal by vibratory methods will be cut off at the mudline. This activity will increase turbidity in the immediate work area, with the potential disturbance and suspension of lake sediments, as well as the release of concrete or metal particles during cutting.

The construction elements in Exhibit 6-52 include in-water work activities for the east approach area that have been identified as sources of turbidity and may result in the exposure of listed salmonids. However, increased turbidity is expected to be minimal and localized in the east approach area. The work bridges will be confined to relatively shallow-water areas (typically less than about 20 feet of depth), where the sediments are relatively consolidated, with nearshore substrate consisting of small cobble and gravel material and offshore sediments consisting primarily of sandy material. These substrate types are not expected to contain sufficient fine-grained material to result in resuspension during construction activities in the east approach area. However, the falsework piles will extend to the transition span/navigation channel, where sediments could contain some fine-grained material.

EXHIBIT 6-52.
PROJECT ACTIVITIES LIKELY TO INCREASE TURBIDITY IN THE EAST APPROACH AREA

Turbidity Source	Peak Values per Construction Year			
	2012	**2013**	**2014**	**2015**
No. of existing columns removed	N/A	N/A	N/A	14
No. of piles driven	125	40	N/A	N/A
No. of piles removed	N/A	N/A	N/A	165
No. of shaft casings installed	9	N/A	N/A	N/A
No. of shaft templates removed	9	N/A	N/A	N/A
No. of cofferdams installed	1	N/A	N/A	N/A
No. of cofferdams removed	1	N/A	N/A	N/A
Total	**137**	**40**	**0**	**179**

N/A = not applicable

The removal of the work bridge and falsework support piles and existing bridge columns has the greatest potential to result in turbidity. However, this work will be accomplished inside a silt curtain, and the larger-grained sediments are expected to be readily expelled from inside the piles as they are vibrated out of the substrate, resulting in limited potential for turbidity. The drilled shaft construction activities will occur within the cofferdam and will not result in additional potential for turbidity. As a result, the in-water activities will likely increase turbidity only in a localized area and for a relatively short duration. In all cases, however, turbidity will meet the state water quality standard (5 NTUs over background) within 150 feet of the project activity.

The temporal extent of potential increased turbidity is expected to be periodic during the construction and demolition process in the east approach area, which will occur during a total of 24 months, extending through three 8-month in-water construction periods. However, the higher intensity effects of turbidity are expected to occur during cofferdam removal in construction year 2, and during pile and existing column removal in construction year 4.

The spatial extent of increased turbidity (sufficiently greater than baseline to cause concern) is expected to be limited by the nature of the proposed construction activities, the shallow-water installation locations, the lack of current in Lake Washington, and the implementation of BMPs (see Section 2.10) such as floating booms or turbidity curtains as necessary to minimize the dispersion of turbidity. Additionally, the timing and duration of proposed construction and demolition activities during the in-water construction periods should limit the potential exposure of listed salmonids.

Upland construction and staging activities also have the potential to result in turbidity in the nearshore habitat in the east approach area. However, implementation of appropriate sediment and erosion control BMPs, such as silt fences (see Section 2.10), is expected to minimize this potential. Although the water currents in the area are weak, substantial wave action occurs along the shoreline as a result of the predominant northerly wind patterns in the lake. Therefore, any turbidity caused by upland activities will remain localized along the shoreline during relatively calm weather conditions, except for the greater dispersion effects occurring during windy periods.

Dissolved Oxygen

Changes in dissolved oxygen concentrations due to increases in turbidity are discussed in Section 6.2.1.1.

Pollutants

There is no indication of contaminated sediments along the east approach area. The Ecology 303(d) list (2009) does not include any impaired sediments within the area of east approach construction. The limited fine-grained sediments in the area, along with the effects of periodic wave action, suggest that the accumulation of pollutants in this portion of the action area is unlikely. The introduction of concrete dust from cutting in the water column has the potential to raise localized pH. Concrete dust is considered to be insoluble (0.1 percent maximum solubility) in water. However, localized increases in pH are expected to be negligible and likely to be rapidly buffered by the massive water volume and chemical constituents of Lake Washington.

The implementation of perimeter control (curbs and toe boards) and catchment measure (tarps and platforms) BMPs described in Section 2.10 is expected to minimize or eliminate the potential for pollutants to be introduced by construction and demolition activities.

Physical Debris

The implementation of perimeter control (curbs and toe boards) and catchment measure (tarps and platforms) BMPs described in Section 2.10 is expected to minimize or eliminate the potential for physical debris to be introduced by construction activities.

6.2.6.2 Noise

Terrestrial Construction Noise

Terrestrial construction noise in the east approach area is expected to be similar to noise levels in other portions of the action area. Impact pile driving will produce the loudest airborne noise levels. As discussed for other areas of project construction, generation of terrestrial noise is not expected to affect the aquatic environment or listed fish species.

Underwater Construction Noise

As in other portions of the action area, vessel operations, vibratory pile driving, and impact pile-driving activities have the potential to increase underwater noise levels in the east approach area. Therefore, these activities have the potential for disrupting the behavior of listed species.

Vessel Operations

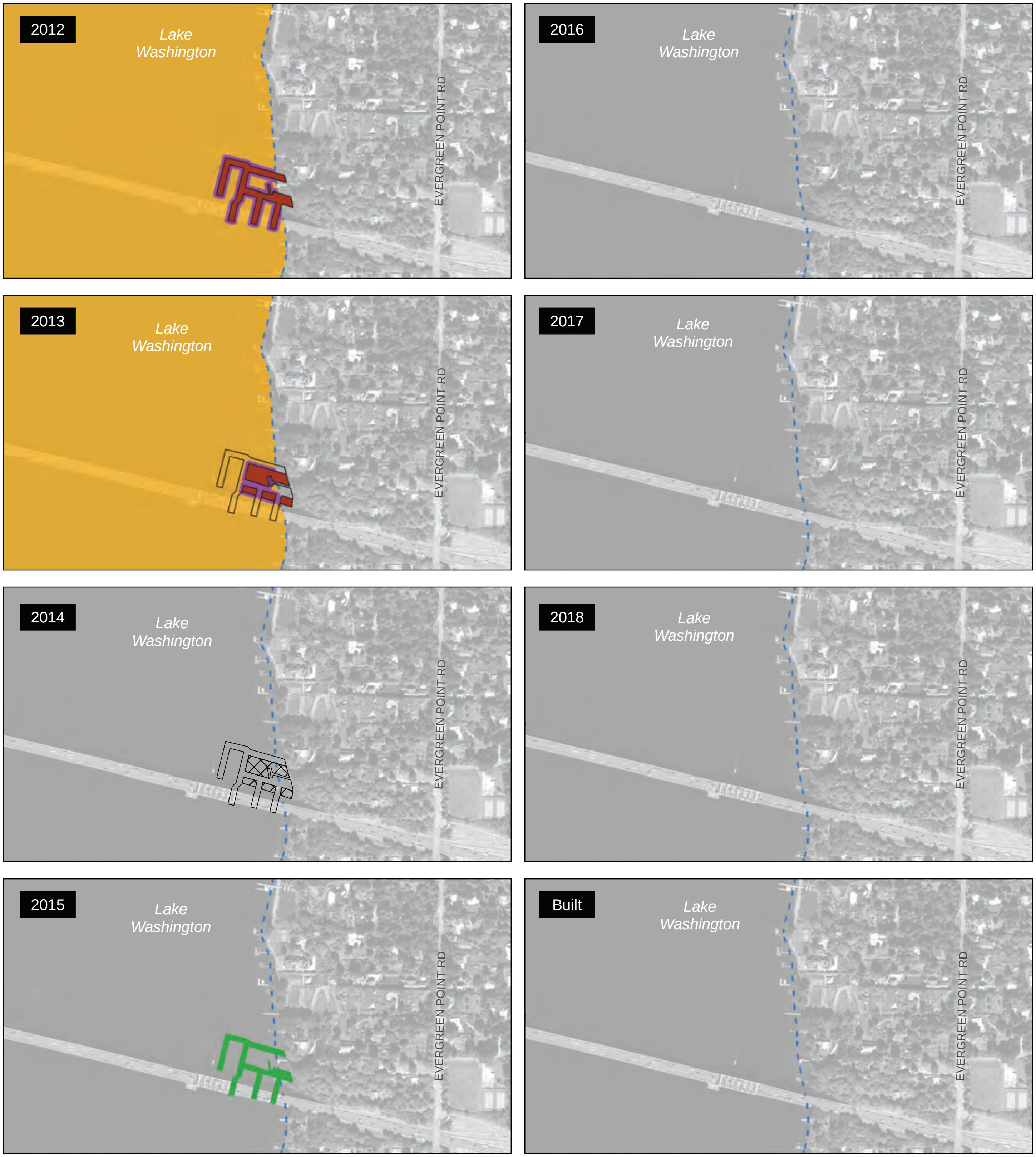
The operation of the tugboats or self-propelled work barges will likely produce in-water sound levels that exceed ambient levels. These potential noise levels will be very similar to those generated in other portions of the action area (see Section 6.2.1.2). However, the relatively small construction area and the relatively short overall in-water construction period are expected to result in a limited extent and frequency of vessel operation activity in this portion of the action area. Much of the east approach bridge structure and maintenance facility dock will be staged from the work bridges, minimizing vessel operations.

Pile Driving

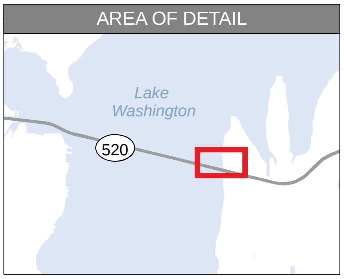
Only impact pile-driving activities are expected to produce sound levels that could measurably affect listed species. Unlike other portions of the action area, no test pile evaluations were conducted in the east approach area. In addition, the substrate composition (primarily cobble, gravel, and sand) in the east approach area is substantially different from that in the areas of the test pile evaluation (primarily mud, silt, and sand). As a result, the project-specific data might not accurately represent the noise levels that will be generated by pile driving in the east approach. Therefore, WSDOT used the results from other pile-driving studies, as summarized in the WSDOT Advanced BA Training Manual (WSDOT 2010b), to predict initial sound levels.

Based on the previous studies, it is assumed that the impact driving of 30-inch-diameter piles in the east approach area will result in single-strike peak sound levels of approximately 212 dB, a typical single-strike SEL of about 195 dB, and a root mean square sound level of 186 dB_{RMS} (all measured at a 33-foot distance from the source). However, these sound levels do not assume any reductions achieved with an attenuation device (Exhibits 6-53a and 6-53b).

In addition to conservative estimates of unattenuated sound levelsfor pile driving in the east approach area, conservative estimates of the attenuation that can be achieved by the use of a bubble curtain and the number of pile strikes per day were assumed. Based on results from past WSDOT projects, it is assumed that a bubble curtain applied to driven piles in the east approach area will result in a 10-dB reduction in noise levels, compared to at least a 19- to 31-dB reduction observed during the SR 520 test pile project (Illingworth and Rodkin 2010). It is also assumed that an average of 1,000 pile-driving strikes will be required for each pile, with a total of eight piles driven per day in the east approach area. Based on these conservative assumptions, peak sound levels will remain in excess of the injury threshold (206 dB) within about 16 feet of the pile, whereas the cumulative SEL will remain in excess of the injury threshold for about 1,770 feet (see Appendix D).



AREA OF DETAIL



- - - Ordinary High Water Mark (Not Surveyed)
WorkBridge
False Work
WorkBridge Removal
Work Bridge Construction in Progress

Potential Fish Behavior/Injury Thresholds

183/187 db SEL
206 db PEAK

Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

N
0 250 500 1,000 Feet

Exhibit 6-53a. **Annual Pile-Driving Noise in the East Approach Area**
SR 520, I-5 to Medina: Bridge Replacement and HOV Project

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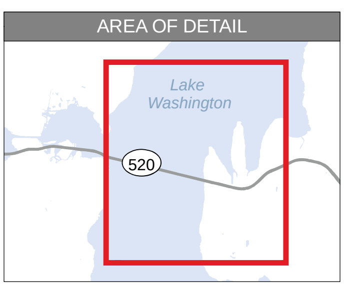

- - - Ordinary High Water Mark (Not Surveyed)

Work Bridge Construction in Progress

Potential Fish Behavior/Injury Thresholds

206 db PEAK

183/187 db SEL

Potential Behavioral Effects Zone

Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

N 0 500 1,000 2,000 Feet

Exhibit 6-53b. **Year 2012 Pile-Driving Noise in the East Approach Area**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

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Based on these results, the practical spreading loss model for assessing underwater sound suggests that pile-driving sound levels will attenuate to less than the 150 dB_{RMS} sound level threshold for fish disturbance at a distance of 7,070 feet for 30-inch-diameter piles (see Appendix D). The proposed pile-driving activities and resultant effects for the east approach area are summarized in Exhibit 6-54, from the pile-driving analysis provided in Section 2.3.

EXHIBIT 6-54.
PILE-DRIVING ACTIVITIES AND DISTURBANCE DISTANCES IN THE EAST APPROACH AREA FOR POTENTIAL EFFECTS ON LISTED SALMONIDS

Elevated Noise Source	Peak Values per Construction Year	
	2012	2013
Timing	Jul.–Mar.	Jul.–Mar.
Total no. of piles	125	40
Maximum piles per day	8	8
Estimated driving days	28	5
Strikes per pile	500	500
Strikes per day	4,000	4,000
Strike duration per pile (minutes)	20	20
Strike duration per day (minutes) [a]	160	160
Total ensonified area (acres) – 206 dB_{PEAK} [a]	0.9	0.4
Total ensonified area (acres) – 187 dB_{SEL} [a]	150.2	134.1
Total ensonified area (acres) – 183 dB_{SEL} [a]	150.2	134.1
Total ensonified area (acres) – 150 dB_{RMS} [a]	1,809.5	1763.6

[a] Per work bridge constructed in calendar year; Assumptions:
206 dB_{PEAK} distance = 5 meters from the pile (845 square feet per pile).
187 dB_{SEL} and 183 dB_{SEL} distance = 541 meters from the pile (125.4 acres per pile).
150 dB_{RMS} distance = 2,154 meters from the pile (1,741 acres per pile).
dB = decibels
RMS = root mean square
SEL = sound exposure level

Pile driving will also occur during the in-water construction periods to minimize the potential effects on ESA-listed species. The east approach area is not expected to be a primary migration route for juvenile or adult fish as they leave or enter the lake through the Ship Canal, which limits the potential to affect these species.

As in other portions of the action area, the potential for detrimental construction effects will be greatest for impact pile driving necessary to support work bridge and falsework structures. Pile driving will be most extensive in constructionyear 1, with the installation of about 125 work bridge support piles. Assuming an installation rate of about eight piles per day, about 16 to 28 days of pile driving will be expected over a 7-month in-water construction period. In construction year 2, about 40 falsework piles will be installed, during as few as 5 days, within the construction year.

6.2.6.3 Habitat Alteration

Potential habitat alterations that will result from proposed project activities include riparian habitat disturbance and displacement, benthic habitat disturbance and displacement, shading, alteration of structural complexity, artificial lighting, and changes in localized limnology.

Riparian Disturbance and Displacement

The new bridge alignment will be shifted to the north relative to existing conditions, and some temporary clearing may be required for construction of the east approach. However, the existing riparian conditions in the east approach area are already substantially disturbed; the area consists primarily of maintained residential properties, with some shoreline armoring, residential docks, and limited natural vegetation. These conditions are similar to those currently found under the existing bridge. Although the proposed east approach bridge will be about twice as wide as the existing structure, it will also be slightly higher. In addition, there will be a gap between the eastbound and westbound lanes. Therefore, the light levels under the proposed bridge are expected to be similar to or greater than the existing light conditions, which will provide sufficient light for riparian vegetation to survive and grow.

Although the temporary removal of riparian vegetation may be required, all temporarily disturbed areas will be replanted. The long-term status of riparian areas in the east approach area will likely be improved relative to existing conditions because of the implementation of a planting plan designed to enhance the riparian buffer zone by replacing the existing maintained residential shoreline features. The area under the existing bridge currently has a natural sloping shoreline, which will also be enhanced by planting additional riparian vegetation. However, this (relatively) small and localized area on a lake the size of Lake Washington is not expected to result in measurable effects on aquatic habitat in the area. BMPs for erosion and sedimentation control are expected minimize the effects of riparian disturbances on water quality conditions in the east approach portion of the lake (see Section 2.10).

Benthic Disturbance and Displacement

The installation of piling for the construction of the work bridges will result in the disturbance of about 625 square feet of substrate in construction year 1, increasing to about 825 square feet in construction year 2, with the construction of falsework. Overall, these habitat areas will recover relatively quickly after the support piles are removed.

In addition to the disturbances resulting from the construction and presence of the work bridges and falsework, the construction of the mudline footings to support the five proposed bridge columns will permanently displace about 8,300 square feet of substrate. The installation of the cofferdam needed to construct the footings will result in a larger temporary disturbance footprint of about 14,000 square feet of substrate. However, the cofferdam and the footings will be constructed in relatively deep water (more than 20 feet), where the biological productivity of the substrate is limited. The demolition of the existing bridge will remove 14 columns that currently occupy about 350 square feet of substrate, resulting in a net increase of about 7,950 square feet of substrate habitat displacement and corresponding water column displacement for the permanent structures.

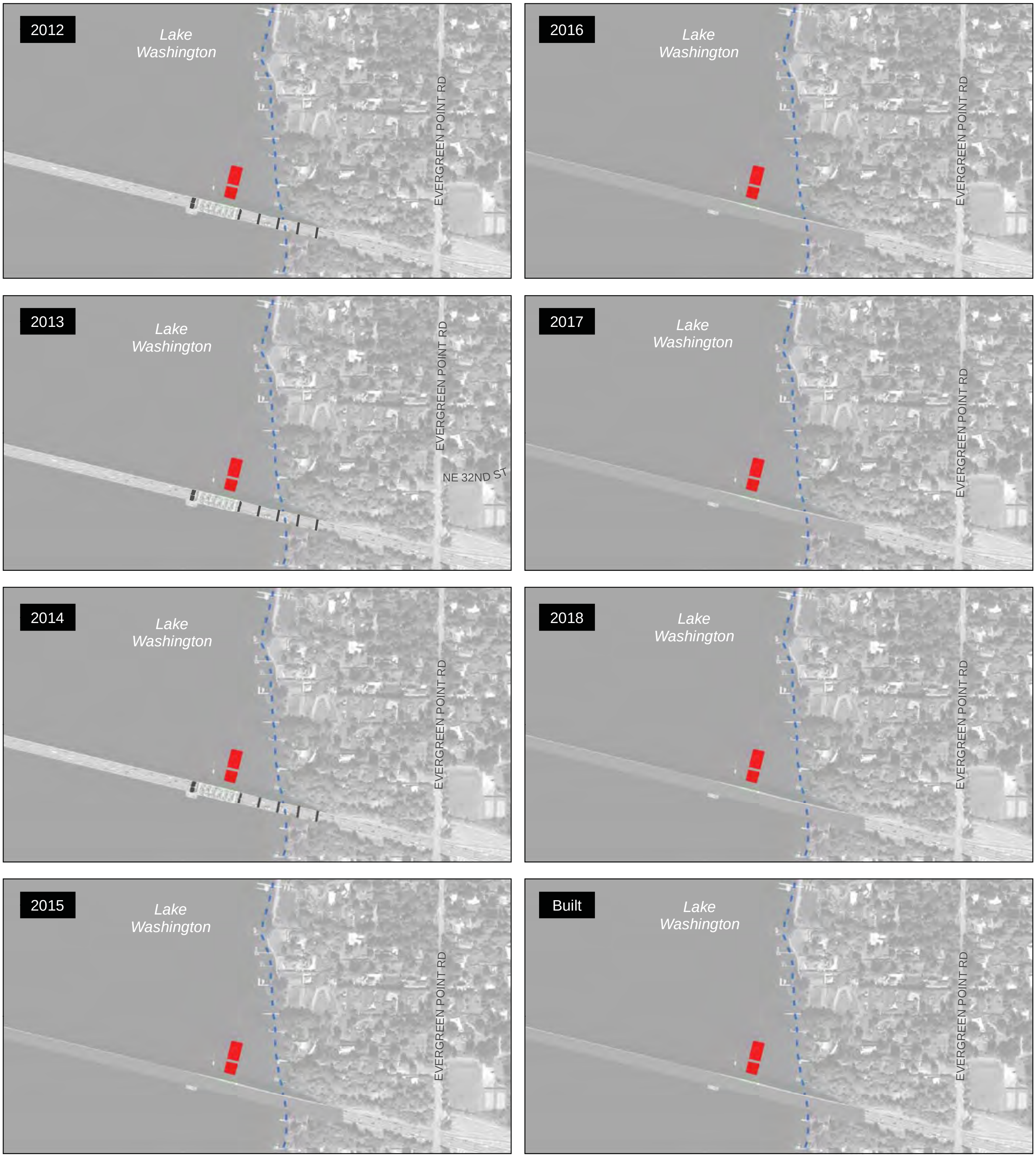
Exhibit 6-55 summarizes the expected extent of benthic habitat disturbance and displacement in the east approach area that will be caused by these structures.

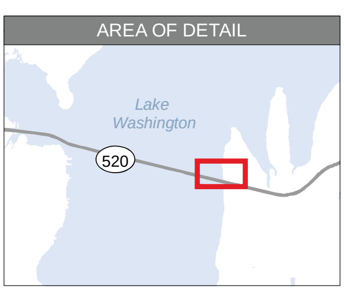
EXHIBIT 6-55.
EFFECTS OF SUBSTRUCTURE ELEMENTS ON SUBSTRATE IN THE EAST APPROACH SUBSTRATE AREA, BY CONSTRUCTION YEAR

	Peak Values per Construction Year (square feet)				
Substrate Displacement Source	**2012**	**2013**	**2014**	**2015**	**Final**
Existing columns	354	354	354	354	N/A
Piles	625	825	825	825	N/A
Cofferdams	8,950	N/A	N/A	N/A	N/A
Mudline footings [a]	N/A	8,300	8,300	8,300	8,300
Maintenance dock columns	120	120	120	120	120
Total	**9,929**	**9,599**	**9,599**	**9,599**	**8,420**

[a] Does not include drilled shafts beneath mudline footings.

Exhibit 6-56 shows the extent of benthic habitat displacement by construction year.





- Existing Piers
- Ordinary High Water Mark
- Ordinary High Water Mark (Not Surveyed)
- Bridge Substructure - Permanent Fill

Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

N

0 250 500 1,000 Feet

Exhibit 6-56. **Annual Benthic Habitat Displacement in the East Approach Area**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

Shading

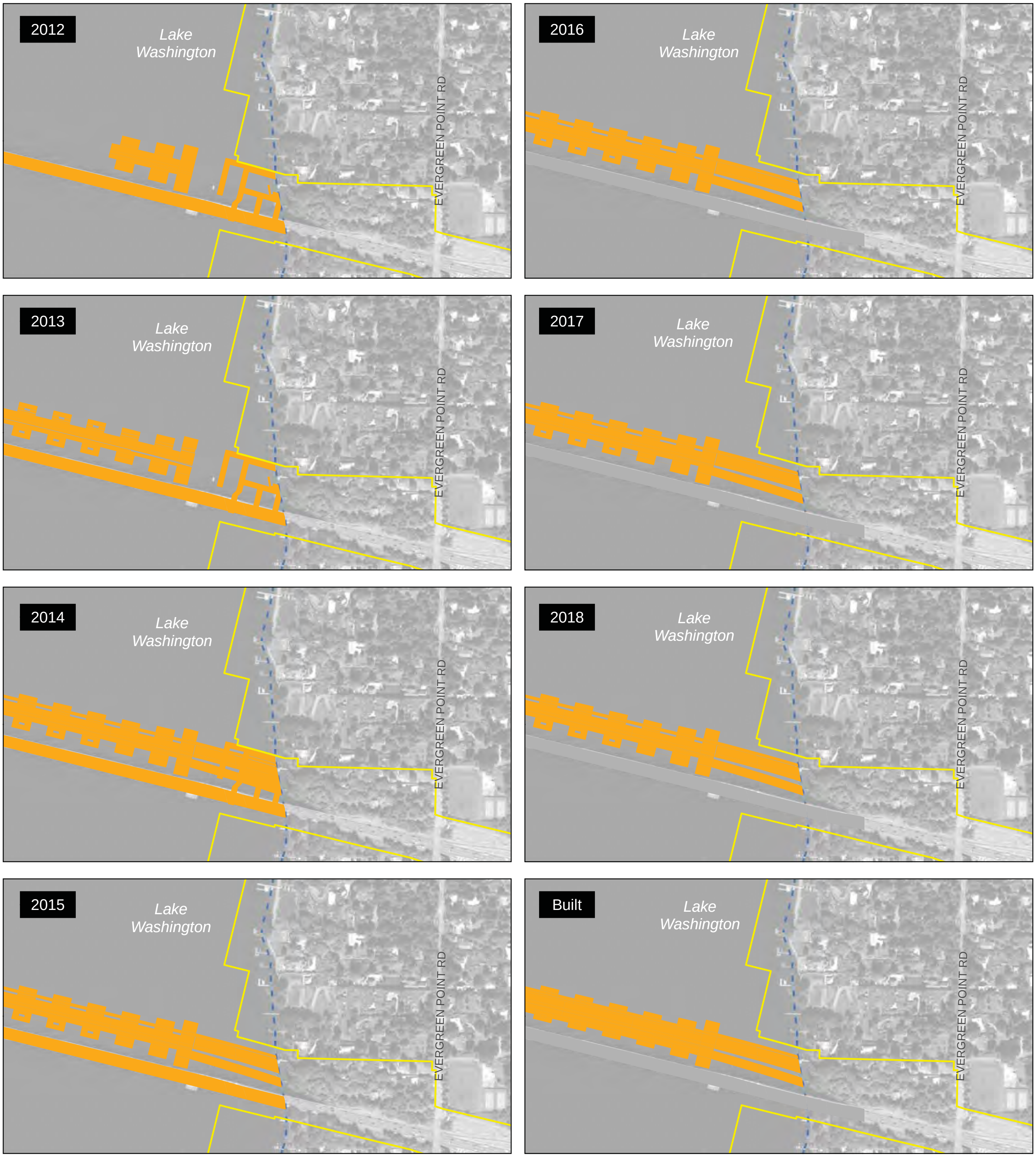
The placement of additional permanent over-water structures will alter in-water shading intensities and patterns. To evaluate the effect of shading, the total area of over-water cover was used to provide a year-by-year comparison of the variable shade conditions as the project construction progresses to completion (Exhibits 6-57). Exhibit 6-58 shows the extent of shade in the east approach area by construction year.

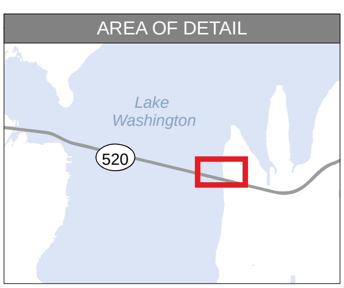
EXHIBIT 6-57.
OPEN-WATER AREA SHADED BY TEMPORARY AND PERMANENT STRUCTURES IN THE EAST APPROACH AREA, BY CONSTRUCTION YEAR

	Peak Values per Construction Year (acres)				
Shading Source	**2012**	**2013**	**2014**	**2015**	**Final**
Existing bridge deck area	0.3	0.3	0.3	0.3	N/A
Work bridge area	0.8	0.8	0.8	0.8	N/A
New bridge deck area	1.3	1.3	1.3	1.3	1.3
Maintenance dock	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Total	**2.4**	**2.4**	**2.4**	**2.4**	**1.3**

N/A = not applicable

As indicated above, the increased overall height of the new east approach structure is expected to generally offset the increased width of the proposed bridge. The separation of the eastbound and westbound bridge structures, by up to about 30 feet, will also allow additional light to penetrate under the structures. The project will also result in 1.3 acres of permanent over-water cover, which is an increase of 0.6 acre (or 85 percent) over the baseline condition (see Exhibit 6-57). The bridge will be approximately 13 feet higher than the existing structure along the majority of the approach. This increase in height for the proposed structure will allow more ambient light under the structure, and although the structure will be wider, the intensity of light-dark transisitons will be reduced overall. Therefore, the proposed structure is likely to have similar or lower shade intensities than the existing structure. The existing bridge is already high enough to allow upland and riparian vegetation to grow both directly underneath and within the shadow zone, indicating the relatively low intensity of the shade.





Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAD88.

N
0 250 500 1,000 Feet

- - - Ordinary High Water Mark (Not Surveyed)
Shading
Limits of Construction

Exhibit 6-58. **Annual Shade in the East Approach Area**
SR 520, I-5 to Medina: Bridge Replacement and HOV Project

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The work bridges used during construction will be substantially lower than the proposed east approach and could affect the species for the 3 years that they are in place. The work bridges will produce about 0.8 acre of additional shading in the east approach area (see Exhibit 6-57). As in the other areas along the alignment, the work bridges will be relatively narrow structures (about 30 feet wide), but they will be located only about 5 to 10 feet above the water surface elevation. These low-elevation structures will produce relatively distinct shade boundaries on the water surface, which have been shown to affect fish migration behavior and result in changes in use of the available habitat by fish. These work bridges will be in place for about 3 years, affecting three age classes of juvenile salmonids.

The maintenance dock will also be a low-elevation structure, with a minimum clearance of only about 1.8 feet at high lake level and 4 feet at low lake level. The T-shaped maintenance dock will consist of a 10-foot-wide main stem, extending no more than about 100 feet from the shoreline and a 50-foot-long T-portion aligned parallel to the shoreline. The dock will shade a total area of about 1,400 square feet (less than 0.1 acre).

After the new bridge is completed and operational, the existing bridge will be demolished, and the construction work bridges will be removed. Any effects on juvenile or adult migration from permanent structures in the east approach area will begin as soon as the structures are in place and will continue in perpetuity.

Alterations of Structural Complexity

The placement of temporary and permanent in-water structures will alter the complexity of the aquatic habitat in the east approach area. The effects of habitat complexity related to the project structures are discussed in detail in Section 6.2.1.3. The changes in structural complexity will differ on a year-by-year basis during construction (Exhibit 6-59).

EXHIBIT 6-59.
CHANGES IN STRUCTURAL COMPLEXITY (IN-WATER COLUMNS AND PILES) IN THE EAST APPROACH AREA, BY CONSTRUCTION YEAR

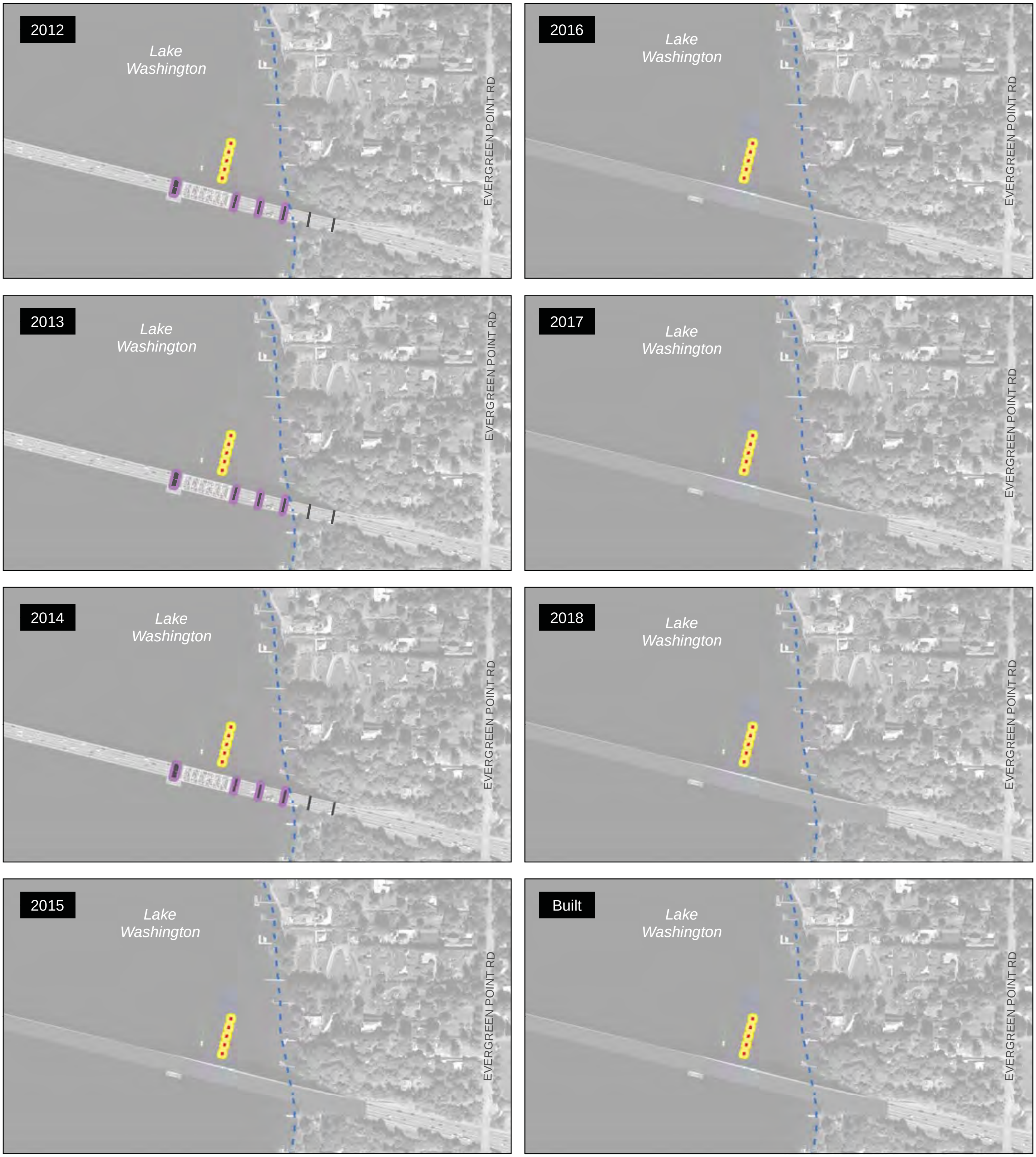
	Peak Values per Construction Year				
Structural Complexity Source	**2012**	**2013**	**2014**	**2015**	**Final**
No. of existing bridge columns [a]	14	14	14	14	N/A
No. of work bridge piles [b]	125	165	165	165	N/A
No. of new bridge shafts/columns [c]	5	5	5	5	5
No. of maintenance dock columns	4	4	4	4	4
Total	**148**	**188**	**188**	**188**	**9**

[a] Column spacing = 11 feet; span length = 100 feet; columns per acre = 18.9.
[b] Pile spacing = 18 feet; span length = 30 feet; pile per acre = 110.
[c] Column spacing = 36 feet; span length = 192 feet to 350 feet; columns per acre = 3.8.

The construction of the work bridges and falsework will result in a moderate increase in structural complexity in the east approach area due to the installation of about 165 steel piles in the shallow-water nearshore habitat. This increase in structural complexity will begin with the installation of the first work bridge during construction year 1. The greatest degree of structural complexity will be reached during construction years 2, 3, and 4 because all the existing, temporary, and proposed structures will be in place. When the existing and temporary structures are removed, only five in-water structures for the new east approach will remain. Exhibit 6-60 shows the extent of the fixed-bridge vertical structure, defined as potential predator habitat, by construction year. Refer to Exhibits 53a and 53b for the spatial extent of work bridges, which also represents the extent of associated piles.

The proposed east approach structure will have fewer and more-widely-spaced shafts and columns compared to the existing condition. Whereas the existing east approach structure has approximately 100-foot span lengths (distance between bents) and roughly 7 feet between columns within each bent, the proposed structure will have 250- to 350-foot span lengths and approximately 26 feet between columns. This configuration will result in a lower overall structural complexity factor than the baseline. However, the habitat complexity under existing conditions is limited, with no patches of dense aquatic macrophytes; therefore, the decrease in long-term habitat complexity will be relatively small in magnitude.

The completed project will have two bents in the east approach area, each consisting of five individual columns, although one of these bents will be located in an upland area. An additional four in-water columns will support the maintenance facility dock, along with two mooring dolphins. The effects of structural complexity changes in the east approach area will begin immediately after the completion of the new structure elements and will continue for the design life of the structure. However, the effects of structural complexity in the east approach area on listed salmonids are likely to be similar to existing conditions, as discussed in Section 6.2.5.4.



Existing Piers
Ordinary High Water Mark
Ordinary High Water Mark (Not Surveyed)
Potential Predator Habitat - Existing
Potential Predator Habitat - Proposed
Permanent Bridge Column

Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

N
0 250 500 1,000 Feet

Exhibit 6-60. **Potential Predator Habitat by Year in the East Approach Area**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

Artifical Lighting

Construction lighting in the east approach area will be similar to the lighting in other portions of the action area, where construction staging will occur from both work bridges and barges. The potential effects of this lighting on fish behavior and potential predation rates on juvenile salmonids will also be similar. However, appropriate BMPs will minimize such effects.

Construction lighting is expected to result in effects similar to those of operational lighting. The potential effects of operational lighting are discussed in Section 6.3.1.

Effects on Localized Limnology

Limnological conditions under the east approach are apparently influenced by wind-driven currents and, to some extent, outflow in the lake. The existing bridge impedes the movement of surface water driven by winds, forcing surface water under the pontoons and through the openings at either end of the floating portion of the bridge. The effects of the wind-driven waves are evident by the relatively large substrate material (typically cobble and gravel) along the east approach shoreline. The proposed bridge will decrease the open area under and around the floating bridge by about 10 percent, although there is no available information that indicates the increased depth and length of the proposed bridge pontoons will substantially alter the movement of surface water or mixing forces in the lake.

The addition of over-water and in-water structures during construction and the resulting net increase in the amount of over-water and in-water structure from the new east approach span may cause localized effects on limnological processes. Any such effects are expected to result largely from altered shading patterns. However, the change in photosynthetic activity resulting from the decreased solar radiation reaching the lake surface is likely to be undetectable. Measurable changes in phosphorus concentrations in the lake, and therefore algal production, are not anticipated with the implementation of treatment of stormwater discharge from the bridge. Therefore, the small increase in shading is unlikely to result in a detectable change in primary production in Lake Washington. However, some localized effects could potentially occur but likely in areas that currently do not provide preferred habitat for listed species. In addition, the most likely change will be a slight decrease in temperature due to the increased shading.

6.2.6.4 Fish Handling

Cofferdams will be necessary to install the mudline footings for the east approach structure. WSDOT fish handling and exclusion protocols will be implemented to minimize potential effects (WSDOT 2009a). No cofferdams are needed for constructing the maintenance facility dock, and the drilled shaft casings are not expected to trap any fish because they will be slowly lowered to the bottom. Construction will occur during in-water construction periods to minimize the presence of juvenile salmonids in the action area. The potential effects of cofferdam installation and associated fish handling are discussed in Section 6.2.1.4.

6.2.6.5 Species Response to Stressors

This section considers the spatial and temporal overlap of the presence of listed salmonids with the associated stressors in the east approach area (i.e., species exposure) and the expected responses of these species. The exposure of an organism is largely determined by the life history, behavior, and habitat uses of the particular species. Exhibit 6-61 summarizes the expected use of the east approach habitat by listed salmonids.

EXHIBIT 6-61.
EXPECTED OCCURRENCE OF ANADROMOUS FISH SPECIES IN THE EAST APPROACH AREA, BY LIFE HISTORY STAGE

Species	Life History Stage	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Chinook salmon	Adult						Low	High	High	High	Low		
	Residual	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal
	Juvenile			Low	Low	High	High	High	Low				
Steelhead	Adult	Low	Low	Low	Low	Low	Nominal						Nominal
	Residual	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal
	Juvenile		Nominal	Nominal	Nominal	Low	Low	Low	Nominal				
Bull trout	Subadult	Nominal	Nominal	Nominal	Low	Low	Low	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal

Nominal presence
Low presence
High presence

Because of the generally similar life history and habitat requirements of all ESA-listed salmonids, effects are discussed with a focus on Chinook salmon as an umbrella species, and distinctions are made for steelhead and bull trout as appropriate in their respective subsections.

Puget Sound Chinook Salmon

Several aspects of the project are expected to affect the physical, chemical, or biological environment in the east approach area, but these effects will not increase to the level of significant disruption of normal behavior for adult or juvenile Chinook salmon, nor will they result in direct injury or mortality. These potential effects are summarized in Exhibit 6-62.

EXHIBIT 6-62.
NON-ADVERSE EFFECT STRESSORS IN THE EAST APPROACH AREA

Stressor	Rationale
Pollutants	Pollutants are not known to be present; exposure risk is considered discountable.
Terrestrial noise	Terrestrial noise transmission is not expected to exceed ambient underwater noise levels; exposure risk is considered discountable.
Riparian disturbance	Localized shading patterns and reduction in organic litter input will not result in significant disruption of behavior. Effect on species is considered insignificant.
Benthic disturbance	Primary productivity and forage base are not limiting. Reduction in benthos-derived productivity will not result in significant disruption of behavior. Effect on species is considered insignificant.
Limnological process	Short-term and minor alterations of temperature or phytoplankton production will not result in significant disruption of behavior. Effect on species is considered insignificant.

Certain aspects of the proposed action are likely to adversely affect adult and juvenile Chinook salmon in the west approach area either through a significant modification of normal behavior or through direct injury or mortality. These stressors are the following:

- Water quality degradation from construction activities
- Underwater noise from impact pile driving
- Shading (note that shading and alteration of structural complexity are combined in the discussion below)
- Alteration of structural complexity (note that shading and alteration of structural complexity are combined in the discussion below)
- Artificial lighting

Although adult salmonids will migrate through the action area during the in-water construction period, the east approach area is not expected to be a primary migration corridor; the migration route into the lake is through the Ship Canal. In addition, adult salmonids are expected to migrate in relatively deep (cooler) water, away from most intensive in-water construction activities. This behavior is likely to minimize potential effects on adult salmonids. There are also no data indicating that adult salmon congregate within the east approach area during their migration to spawning areas in the Lake Washington basin.

Most in-water construction activities are not expected to substantially affect juvenile Chinook salmon because they will be conducted during the in-water construction periods when juvenile

Chinook presence is expected to be low. In addition, even during the juvenile Chinook migration period (late-April through June), the east approach area is not expected to be heavily used because it is across the lake from the primary migration corridor of Union Bay and the Ship Canal.

Construction activities in May and June will have the highest potential to affect juvenile salmonids because of the potential for their migration through the east approach area during this period. However, these activities will be limited to those that are either above water or fully contained within a cofferdam or other BMPs. Over-water construction will also be contained with BMPs intended to prevent the introduction of foreign materials into the water.

As described in previous sections, the additional over-water and in-water structures during and after construction could potentially affect juvenile Chinook salmon during their outmigration. These effects are due to increases in shading (migration delay), structural complexity (increased predation), and lighting (attraction/increased predation). These effects will be substantially greater than the existing conditions during the construction and demolition phases of the project (years 2 to 4), although the long-term effects of the presence of the new structures are expected to be less than or similar to the existing conditions. The potential effects will be greater for age classes that migrate through the action area as juveniles and then again as adults during the construction phase. These will include 2- or 3-year age classes of juveniles and adults. Over the long term, both life stages could be affected by the presence of a larger bridge structure compared to the existing conditions. The potential adverse effects on Chinook salmon and their critical habitat are discussed below.

Water Quality Degradation

Turbidity may be increased during all aspects of in-water construction, although no activities are expected to produce long-term changes in turbidity. Timing restrictions and construction BMPs, as discussed for other portions of the action area, will minimize the potential for species exposure (see Section 2.10). The limited distribution of fine-grained substrate material in the east approach area will also result in less potential for turbidity, compared to other portions of the action area.

Exposure to increased turbidity beyond a 150-foot radius from the source of suspended sediments is not expected because of adherence to state water quality standard for the mixing zone and the results of preliminary pile-driving investigations in other areas, demonstrating that water quality standard can be achieved. Given the small area of the lake habitat that will be affected at any one time (typically within less than about a 150-foot radius), the expected limited use of the existing habitat by listed salmonids, and the short-term duration of any expected turbidity plumes, few Chinook salmon are likely to be adversely affected by increased turbidity. Overall recovery rates after the expected exposure levels are expected to be fast (i.e., minutes to hours). In addition, WSDOT expects that any increases in turbidity will elicit an avoidance response. See Section 6.2.1.5 for additional discussion of potential water quality effects.

Lastly, the potential for turbidity generated by propeller wash is considered negligible. The maintenance vessel will be operated only in the vicinity of the facility and the berth at low speeds, with minimal propeller thrust. Operation of the boat at low speeds is unlikely to produce propeller wash that will disturb bottom sediment.

Noise

The primary stressor associated with pile-driving activities that could affect Chinook salmon within the action area is underwater noise. The mechanisms of effect for this stressor and the estimated extent of noise effects are discussed in Section 6.2.6.2. Based on the scope, scale, and timing of the proposed construction and demolition activities, the response of juvenile and adult Chinook salmon to underwater noise associated with these activities will vary.

Pile driving in the east approach area will occur during about an 7-month period during construction years 1 and 2, with the majority of pile driving conducted in construction year 1. The actual duration of impact pile driving during that time frame is expected to last more like 30 to 40 days. During construction year 1, a minimum of 125 piles will be installed with an impact hammer to construct the work bridges. During construction year 2, an additional 40 piles will be installed with a vibratory hammer, to support the falsework, and about 40 additional piles will be installed to support the cofferdam walls and the drilled-shaft templates. The use of a bubble curtain is expected to substantially minimize the area affected by impact pile-driving sound levels in excess of the disturbance threshold. No substantial effects are expected from the vibratory pile-driving activities (see Appendix D). Although some disturbance and behavior modification are expected, relatively few Chinook salmon are likely to be in the action area during in-water construction.

In some cases, direct mortality, or more likely, physiological damage or behavioral effects due to increased noise and vibration may occur. Although the areas in which these effects could occur are limited in size and will generally be within approximately 16 feet of the impact-driven pile, some physiological effects from accumulated pile strike energy could also occur in a wider area, extending out about 1,800 feet from the impact-driven pile (see Appendix D). However, these effects will occur only if an individual fish is exposed to hundreds or thousands of repeated pile blows, and the effects will likely be nonlethal, particularly at the outer edge of this zone. The potential behavioral changes will be short term, including potentially slight alterations in migratory or feeding behavior. In most cases, these behavioral changes are expected to be relatively minor and will not extend beyond approximately 7,000 feet from the driven pile). Vibratory pile driving is not expected to result in any mortality or physiological damage (see Appendix D).

Although pile driving will affect individual adult and juvenile Chinook salmon to varying degrees, it likely will not result in substantial direct injury or mortality of the species and will not result in a measurable change at the overall population or ESU level.

Habitat Alteration

Effects related to habitat alteration in the east approach area are expected to be primarily a function of the changes to in-water and over-water structures. To a lesser degree, artificial construction lighting is also expected to affect Chinook salmon during nighttime construction.

Artificial Lighting

It is unlikely that adult Chinook salmon will be affected by the construction lighting because they are not foraging in Lake Washington and there are no available data to suggest a potential attraction to artificial lighting.

Construction lighting is expected to result in effects similar to those of operational lighting. The potential effects of artificial lighting on listed salmonids are discussed in detail in Section 6.3.1.

Shading and Alteration of Structural Complexity

As discussed in Section 6.2.1.5, data suggest that migration behavior could be affected by two primary mechanisms related to changed habitat conditions: alterations or disruption of physical structures (structural complexity) within the water column and increased or altered shading patterns created by new over-water structures. As indicated above, the overall extent and duration of over-water and in-water structures within the nearshore zone will change over time, as will the potential effects of these features on migration behavior throughout the construction time frame and the long-term operation of the project. However, the east approach span is not considered a primary migration corridor; therefore, the magnitude of any effects will be limited. Furthermore, the height of the new east approach structure will be significantly greater than that of the west approach structure, thereby reducing the shade intensities and potential adverse effects on Chinook salmon behavior for both juveniles and adults.

The four in-water columns and two mooring dolphins for the maintenance facility dock are expected to slightly increase the habitat complexity in the immediate east approach area, potentially providing some amount of habitat for smallmouth bass. The relatively low height of the maintenance facility dock over the water will allow less ambient light under the structure, potentially resulting in an increased incidence of predation on juvenile Chinook salmon. The removal of at least one residential dock in the area will offset some of the potential increase in predation.

In conclusion, some proportion of outmigrating juvenile Chinook salmon could exhibit holding behavior, resulting in increased residence time around the east approach and the maintenance facility dock. Of those fish exhibiting holding behavior, some proportion of them may experience direct mortality due to predation while holding near the structure, or a reduction in overall fitness due to delayed saltwater entry.

Effects on Predator-Prey Interactions

Adult Salmonid Response

The available information does not indicate that the existing bridge structure has an influence on the predator-prey interactions associated with adult salmonids in Lake Washington. The physical characteristics and locations of the new structures are sufficiently similar in that they are not likely to have a different influence on the predator-prey interactions for adult salmonids.

Juvenile Salmonid Response

The presence of the existing bridge and the proposed work bridges in the east approach area during portions of the construction time frame will result in measurable increases in shading and habitat complexity in the area. These conditions are expected to provide additional predator habitat in the area. However, the construction-related structures will be temporary and will be present for only 1 to 3 construction years.

The available data suggest that pikeminnows are strongly associated with over-water structures (Celedonia et al. 2008a) and are most active at night, although they are often present where moderate amounts of macrophytes exist. No such vegetation is present within the east approach area. Some attraction to nighttime lights is also expected, although this may not be consistent from year to year (Celedonia et al. 2008, 2009).

The available data discussed in Appendix G and in Section 6.2.1.5 suggest that smallmouth bass may exhibit a habitat selection preference for areas with higher structural complexity and vertical habitat elements such as columns and piles (Celedonia et al. 2009). Therefore, a similar selection preference could occur in the east approach area as a result of the proposed temporary and long-term in-water structures. Assuming that the apparent habitat selection in the west approach area by predators is due to a concentration of outmigrating juveniles, a lower level of selection for the east approach area can be expected.

As indicated above, the project is expected to have only minor long-term effects on habitat in the east approach area, likely resulting in a small (unquantifiable) change in predation rates on juveniles. In addition, the east approach is not considered part of the primary migration path of juvenile Chinook salmon; therefore, few Chinook are expected to occur in the area, likely resulting in insignificant effects on the Chinook population in Lake Washington.

Puget Sound Steelhead

For reasons similar those described for Portage Bay (Section 6.2.1.5), the potential effects of the project activities in the east approach area on Puget Sound steelhead are expected to be similar to but substantially less probable and less severe than the effects on Chinook salmon. Generally, any adverse effects on Chinook salmon resulting from project activities could also apply to steelhead.

In conclusion, although the extent of expected harm and harassment of steelhead during project activities is not insignificant or discountable, several factors will contribute to impact minimization and a reduced risk of exposure:

- Steelhead, although not prevented from using the east approach area, are expected to be present in low numbers during the in-water construction period (July to May), which is mostly outside the juvenile migration periods.
- Adult steelhead migration will occur primarily within deeper portion s of the east approach area, away from the most intensive pile-driving impact areas. Adult steelhead are likely mobile enough to avoid areas of lesser effects.
- None of the available information identifies the east approach area as a location specifically used by juvenile steelhead for rearing. Steelhead rear for several years before migrating to Puget Sound; therefore, they are expected to be less dependent on the shallow nearshore habitat in the lake/east approach.
- The use of BMPs (Section 2.10) is expected to minimize the size of the area affected by turbidity-causing activities.
- The use of a bubble curtain during pile driving is expected to minimize the size of the area affected by sound levels in excess of the disturbance threshold.

Coastal-Puget Sound Bull Trout

For reasons similar to those described for Portage Bay (Section 6.2.1.5), the potential mechanisms of effect from the project activities in the east approach area on bull trout are expected to be similar to the effects on Chinook salmon. However, the potential effects are less likely because of the low abundance of bull trout and the timing of their use of habitat in the west approach area.The potential effects will also be less intense because only adult and subadult life stages are expected to be exposed to them. Differences in potential bull trout responses to stressors are summarized below.

In addition to those listed in Exhibit 6-62, the following stressors associated with the west approach area are not expected to result in adverse effects on bull trout:

- **Shading and structural complexity.** Bull trout are not dependent on the east approach area as a migratory corridor, nor are the subadult and adult forms of bull trout as susceptible to predation. The patterns of overwater shading and in-water structural complexity are not expected to result in a significant disruption of normal behavior or increased predation.
- **Construction lighting.** Foraging by subadult or adult bull trout may be improved somewhat during artificially illuminated conditions; however, a significant disruption in foraging behavior is not expected. Additionally, due to the timing of habitat use (late

spring), the potential for exposure to artificially illuminated conditions during construction would be lower than that for the other listed salmonids.

- **Effects to prey base –** Although project-related stressors are expected to have some adverse effects on ESA-listed fish, and potentially other forage fish species, the abundance of prey resources is not expected diminish so as to significantly affect bull trout behavior or survival.

Potentially adverse effects on bull trout and their responses to those stressors are summarized as follows:

- **Turbidity.** Individuals exposed to turbidity may experience gill abrasion, have reduced foraging potential, or exhibit avoidance behaviors.
- **Pile driving.** Individuals exposed to pile-driving noise are expected to experience some disruption of normal behavior (e.g. startle or avoidance response) within the 2,154-meter range or a potential for injury within the 541-meter cumulative SEL injury zone; however, injury related to peak sound levels within 5 meters is considered discountable.

In conclusion, although the extent of expected harm and harassment of bull trout during project activities is not insignificant or discountable, several factors will contribute to impact minimization and a reduced risk of exposure:

- Bull trout, although not prevented from occupying the east approach area, are expected to be present in low numbers, if at all, during the in-water construction period (July to May).
- If any bull trout are present, the individuals are expected to be adults or subadults, both of which are likely mobile enough to alter their route to avoid impact areas.
- The use of BMPs (Section 2.10) is expected to minimize the area affected by construction activities.

6.3 Project Operations

This section describes the potential effects of project operation on listed species. It includes discussions of the following:

- Artificial lighting
- Maintenance facility operations
- Spill control
- Stormwater
- Mitigation actions (per local, state, and federal regulations)

Each subsection initially focuses on the effect of each potential stressor on the physical, chemical, and biological conditions of the environmental baseline. It then describes the analysis of species exposure (intensity, frequency, duration, etc.) and resulting species response in the context of each of the stressors and provides conclusions about the resulting effect on each species.

6.3.1 Artificial Lighting

Artificial lighting associated with the proposed roadway and bridge has the potential to affect the distribution and behavior of fish, depending on its intensity and proximity to the water. Adaptations and responses to light are not universal for all species of fish—some predatory fish are adapted for hunting in low light intensities, while others are attracted to higher light intensities; some species school and move toward light sources (Machesan et al. 2005).

Based on Lake Washington tagging data, Celedonia et al. (2009) indicate that juvenile Chinook salmon are attracted to areas where street lamps on the existing Evergreen Point Bridge cast light onto the water surface, suggesting that bridge lighting is at least partially responsible for the nighttime selection of near-bridge areas by Chinook salmon. It has been conjectured that the illuminated areas may allow juvenile Chinook salmon an opportunity to forage throughout the night when under normal, low light conditions they would normally stop feeding. Any increased abundance around illuminated areas may then also attract visual predators. Neither smallmouth bass nor northern pikeminnows appeared particularly attracted to the artificially illuminated area adjacent to the existing bridge. Other studies, however, suggest that predation rates by other salmonids such as cutthroat trout and rainbow trout may be higher due to increased visibility of the prey species in illuminated areas, even if th epredators on the whole do not select these areas (Mazur and Beauchamp 2003; Tabor et al. 2004c), although no information was presented regarding increased potential for predator detection by prey in artificially illuminated areas.

Salmonid prey items may also be affected by light intensities in Lake Washington. Juvenile Chinook and other young salmon prey on both benthic prey (Chironomids and other insect larvae) and pelagic prey (*Daphnia* spp. and other zooplankton). In Lake Washington, juvenile Chinook have been found to prey predominantly (99 percent) on zooplankton, primarily *Daphnia* spp., in the vicinity of the Evergreen Point Bridge (Celedonia et al. 2009). Moore et al. (2000) indicated that diel vertical migration of *Daphnia* was significantly reduced in both amplitude (2 meters lower) and magnitude (10 to 20 percent fewer individuals) by urban light pollution in a suburban lake. This response was characterized as negative phototaxis, or avoidance of higher light intensity, and may suggest that *Daphnia* are not concentrating in response to increased artificial light levels associated with the Evergreen Point Bridge.

According to the literature review performed by USFWS (1998), sockeye fry moved through experimental streams at a faster rate under complete darkness than under bright lights, and increased ambient light appeared to inhibit the migratory movement of the salmon fry. The same study also stated that, based on a previous study conducted by Fraser in 1994, salmon fry movements were significantly reduced at 2.0 lumens per square foot (2.0 foot-candles) (Fraser 1994). Tabor and Piaskowski (2002) recorded actual light levels along shallow littoral areas (0.4 meter deep) of Lake Washington and also snorkeled these areas to relate light intensity to salmonid presence and behavior. They documented that Chinook salmon became active when light intensities were 0.8 to 2.1 lumens per square meter (0.08 to 0.21 foot-candle), but few Chinook salmon were observed as light intensity increased between 22 and 65 lumens per square meter (2.2 to 6.5 foot-candles).

Ali (1958, 1959, 1962) reported threshold light intensities for different behaviors of juvenile chum, coho, sockeye, and pink salmon. These studies concluded that juvenile salmon feeding, minimum prey capture, and schooling behavior are dependent on specific light intensities no less than than 10^{-4} foot-candle (approximately equivalent to a clear night with a new moon) and that the lowest light intensities at which maximum prey capture for chum and pink fry occurs is between 0.1 and 1.0 foot-candle (equivalent to the light range of dawn and dusk).

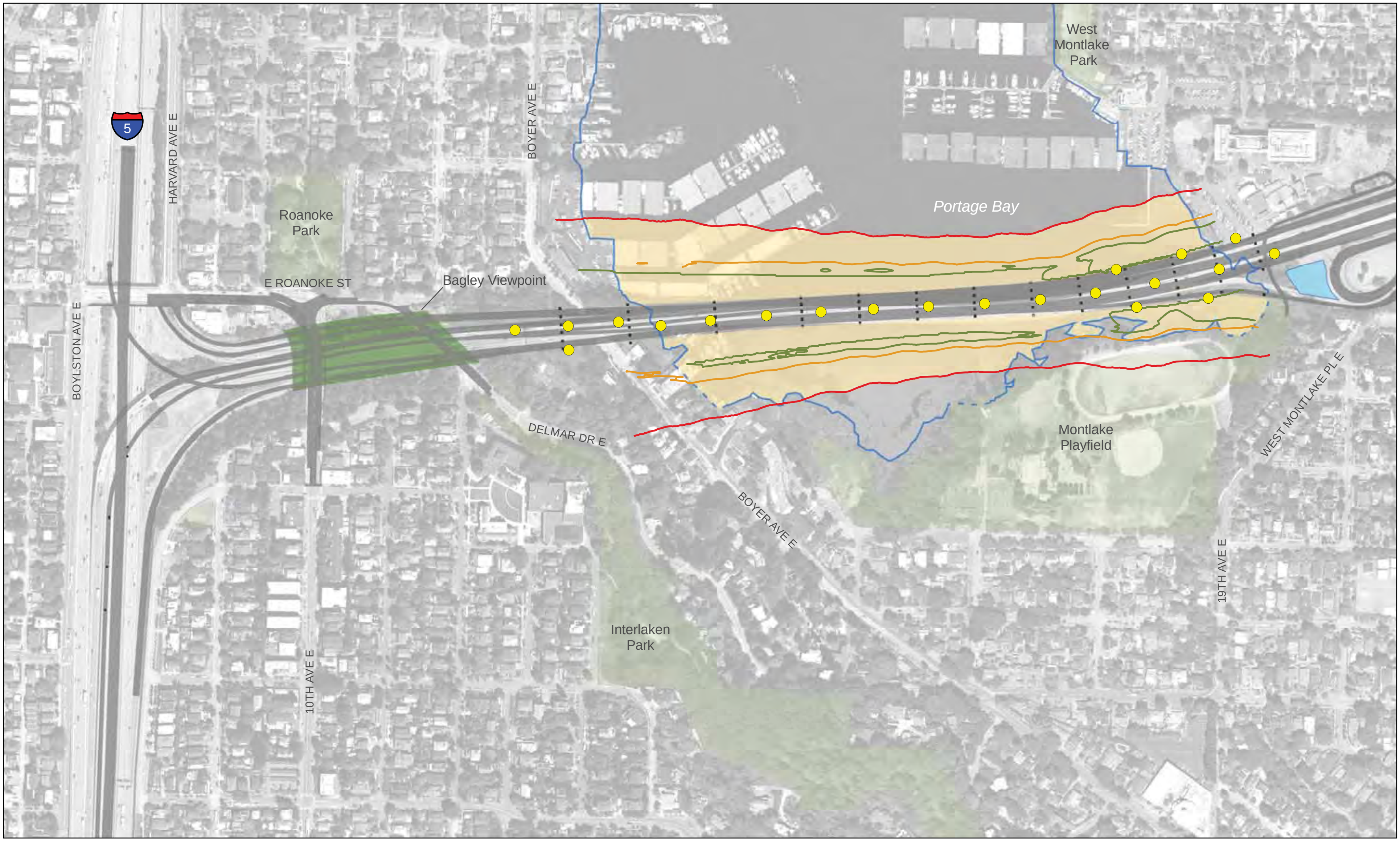
Based on the above studies, WSDOT has assumed that light levels greater than 2.0 foot-candles may elicit a behavioral response related to movement patterns or migration by juvenile Chinook salmon. Light levels between 0.1 and 2.0 foot-candles are expected to potentially elicit a behavioral response related to feeding. Additionally, predator feeding activity typically extends into periods of lower light levels, and predators may be able to exploit light levels less than 2.0 foot-candles.

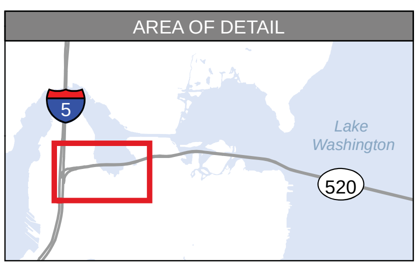
The roadway lighting will be designed such that light spillage into adjacent water surfaces is less than this threshold, if feasible. As mentioned above, simulated maximum light levels for the luminaires analyzed were between 0.6 and 1.6 foot-candles. Luminaires proposed along the west approach are expected to produce maximum light levels of 0.01 to 0.2 foot-candle. Security lighting for the maintenance dock should exhibit light levels less than about 0.1 foot-candle. The zone of effect from artificial light spillage was conservatively determined to be 0.01 foot-candle, a level between a new moon and full moon.

The extent of artificial light spillage in areas with proposed luminaires includes the following:

- Portage Bay – 17.9 acres
- Bascule bridge – 2.0 acre
- Union Bay – 13.4 acres
- West approach – 8.14 acres
- Floating bridge – 5.1 acres
- East appraoch – 4.6 acres

The above extents of nighttime light spillage are illustrated in Exhibits 6-63 through 6-66.





- Column
- Lighting Source
- Photometric Isoline (0.01)
- Photometric Isoline (0.1)
- Photometric Isoline (0.2)
- Area of Light Spillage to Water
- Ordinary High Water Mark
- Ordinary High Water Mark (Not Surveyed)
- Lid
- Proposed Edge of Pavement
- Park

N

0 200 400 800 Feet

Source: King County (2006) Aerial Photo, CH2M HILL (2008) GIS Data (Park). Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 6-63. **Nighttime Light Spillage in Portage Bay**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

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Exhibit 6-64. **Nighttime Light Spillage near the Bascule Bridge in the Montlake Area**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

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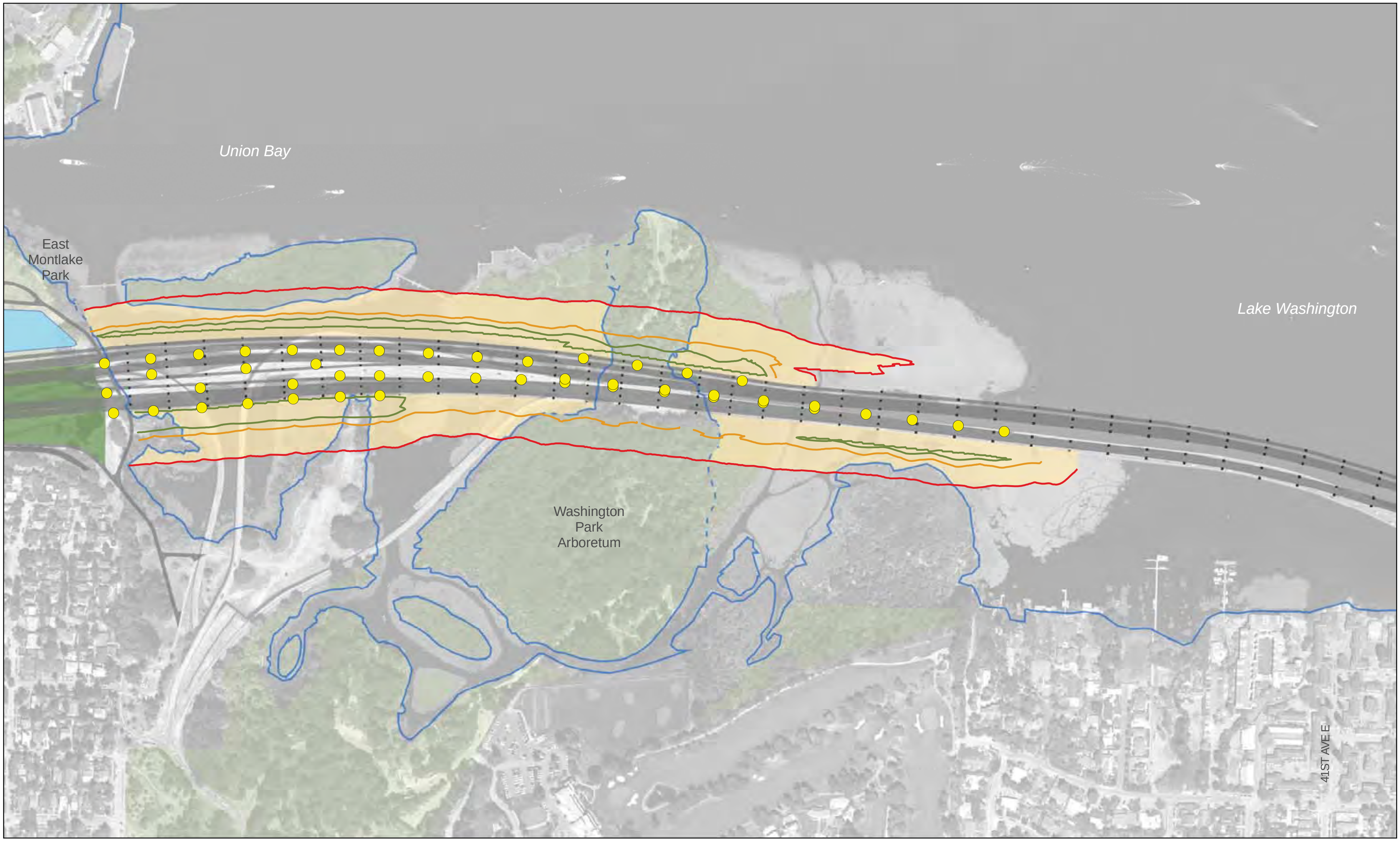

AREA OF DETAIL

- Column
- Lighting Source
- Photometric Isoline (0.01)
- Photometric Isoline (0.1)
- Photometric Isoline (0.2)
- Area of Light Spillage to Water
- Ordinary High Water Mark
- Ordinary High Water Mark (Not Surveyed)
- Lid
- Proposed Edge of Pavement
- Park

N

0 200 400 800 Feet

Source: King County (2006) Aerial Photo, CH2M HILL (2008) GIS Data (Park). Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 6-65. **Nighttime Light Spillage in Union Bay and the West Approach Area**

Sr 520, I-5 to Medina: Bridge Replacement and HOV Project

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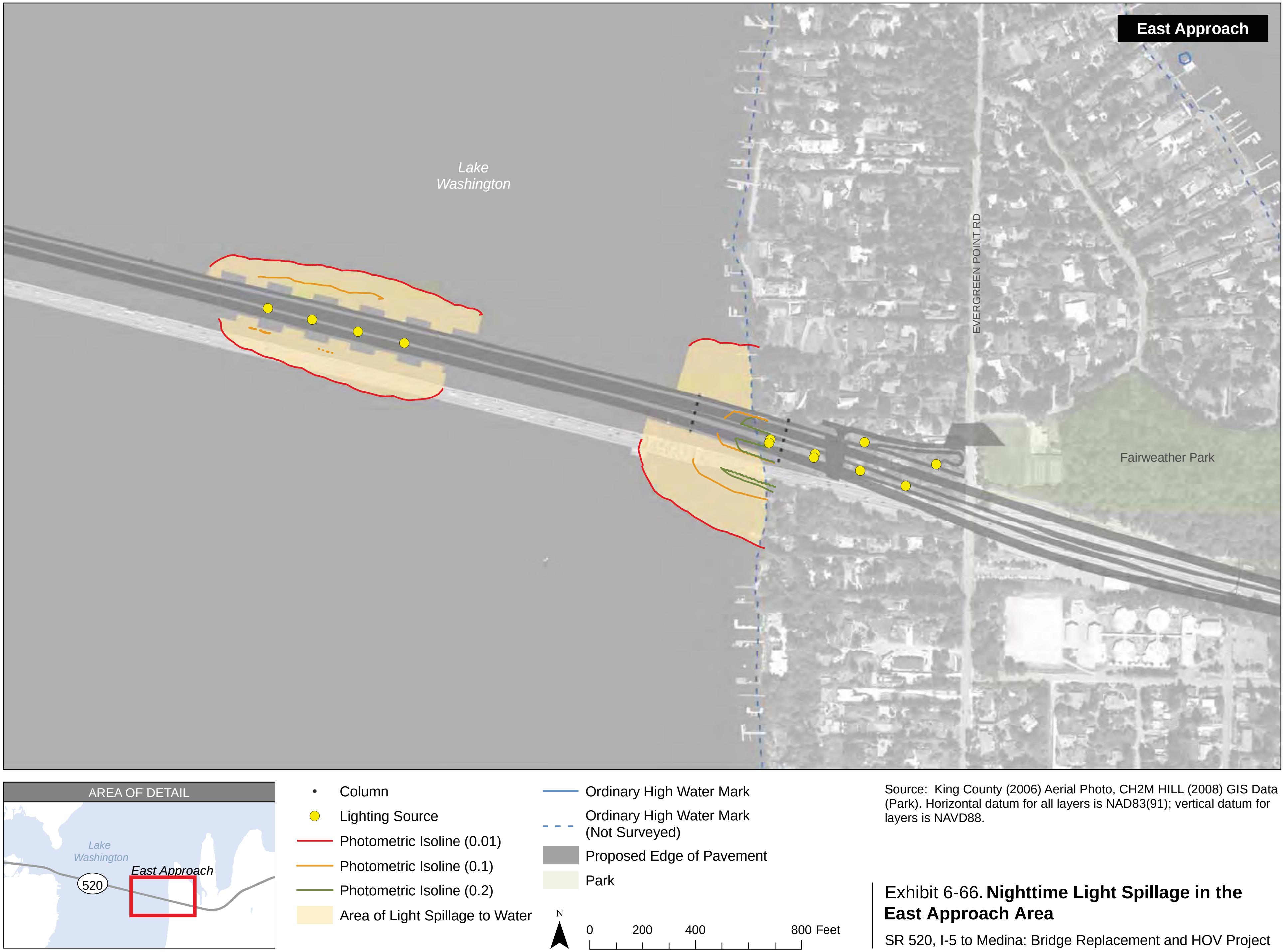

Source: King County (2006) Aerial Photo, CH2M HILL (2008) GIS Data (Park). Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 6-66. **Nighttime Light Spillage in the East Approach Area**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

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6.3.1.1 Species Response to Stressors

Puget Sound Chinook Salmon

It is unlikely that adult listed salmonids will be affected by the proposed illumination because they neither forage in Lake Washington nor are there available data to suggest a potential attraction to artificial lighting. Based on the available literature, including several studies of Lake Washington, it is reasonable to predict that juvenile Chinook salmon will exhibit an attraction to illuminated areas. Most of the proposed over-water lighting will occur in Portage Bay and the arboretum waterways, where juvenile salmonid use is limited. The proposed lighting on the bascule bridge over the Montlake Cut, the west approach, and the floating spans, and the east approach span and maintenance facility have the greatest potential to affect listed salmonids. Lighting associated with the bascule bridge will be similar to the lighting on the existing bridge; however, because there will be two new bridges, the illuminated area will be shifted to the east by approximately 100 feet. Lighting in the west approach and east approach structures will be less than under existing condition due to shielding, increased structure heights, and the lack of roadway lighting on portions of the west approach, the entire floating span, and portions of the east approach.

The potential attraction of juvenile Chinook salmon to increased light levels suggests a likely benefit due to increased foraging ability, although predators could also take advantage of these prey aggregations and the increased light conditions. Visual predators such as cutthroat trout may exploit higher light levels for increased predation success. It is unknown whether there would be a net change in the probability of predator encounters with aggregations of juvenile salmonids as opposed to dispersed individuals. Additional variables that would factor into the potential predator-prey interaction include the dispersal behavior of fish after a predator encounter, whether the aggregation of fish causes a predator swamping effect in which the prey occurring at high population densities reduces the probability of an individual organism being eaten, and whether the aggregation causes any degree of predator confusion regarding identification of an individual prey item.

It appears that piscivorous salmonids in large pelagic systems forage most effectively when conditions are dark enough to reduce the distances between predators and prey and time required for predator detections to occur by prey, yet light enough to allow a significant number of encounters (Mazur and Beauchamp 2003). For example, reaction distances for cutthroat and rainbow trout increased rapidly as light levels increased, reaching relatively constant reaction distances at higher light levels (Mazur and Beauchamp 2003). On the other hand, laboratory experimentation has shown the importance of low-light foraging by the piscivorous northern pikeminnow (*Ptychocheilus oregonensis*), with as much as five times more Chinook salmon captured during relatively dark periods than during periods with higher light intensity (Petersen et al. 2001). Data from this experminentation suggest that pikeminnow predation decreases substantially at light levels greater than 0.04 foot-candle, less than the predicted light levels associated with the proposed luminaires.

In conclusion, the overall reduction of artificial light reaching the water surface and the lack of permanent proposed lighting in the area of greatest concern along the west approach should result in an improvement related to light-induced predation of listed salmonids over the baseline condition. However, to the extent that juvenile salmon and steelhead congregate in illuminated areas, some direct mortality by predation is anticipated.

The amount of predation, or the potential difference in predation encounters compared to a condition without illumination, is difficult to quantify, but it can be expected to occur in those areas exceeding the 0.02-foot-candle threshold (equivalent to the full moon level). According to the aforementioned photometric simulation, this should represent an area approximately 160 feet in radius, waterward from each proposed roadway luminaire, and approximately less than about half that range from the security lighting on the maintenance dock.

Puget Sound Steelhead

No data are available to suggest that juvenile steelhead congregate in illuminated areas for increased feeding opportunities; however, they will not be prevented from engaging in this type of behavior. The potential effects of artificial lighting on Puget Sound steelhead are expected to be similar to the effects on Chinook salmon, although steelhead are expected to be present in substantially lower numbers.

Coastal-Puget Sound Bull Trout

The potential effects of artificial lighting on bull trout are expected to be insignificant. Adult and subadult bull trout that may make forays into artificially illuminated areas are extremely unlikely to be susceptible to predation and may benefit from an improved opportunity to feed on smaller fishes.

6.3.2 Maintenance Facility Operations

Related to the elements described above, the operation of the maintenance facility has the potential to affect listed salmonids by means of two primary mechanisms: water quality and vessel noise. These potential stressors are discussed below.

6.3.2.1 Water Quality

Several factors suggest that proposed operations at the maintenance facility will not present a likely mechanism of effect on listed salmonids. Standard operating procedures and implementation of BMPs related to handling and transport of petrochemicals are expected to reduce this risk to a very low probability.

Lastly, the potential for turbidity generated by propeller wash is considered to be negligible. In the vicinity of the facility and the berth, the maintenance vessel will be operated only at low speeds with minimal propeller thrust. Such operation is unlikely to produce propeller wash that will disturb bottom sediment.

6.3.2.2 Noise

Based on the anticipated type of maintenance vessel, noise levels generated by the vessel should be in the range of baseline noise levels in Lake Washington. Therefore, noise levels generated by the maintenance vessels are not expected to affect the aquatic environment or listed species.

6.3.2.3 Floating Span Maintenance Activities

While many standard road maintenance activities covered under the Regional Road Maintenance Program (RRMP) apply to the project, the unique characteristics of the floating bridge will result in some activities that are not covered under the RRMP . These activities are the only aspect of maintenance operations that are being analyzed for potential effects in this consultation. These activities include the following:

- Weekly maintenance-related vessel operations
- Vessel moorage along pontoons
- Pump maintenance requiring periodic pumping

The potential risk for listed salmonids includes elements related to vessel operations and moorage, the possibility of introducing petrochemicals to the lake, and direct entrainment of fish into pump intakes. BMPs such as an SPCC plan and those outlined in Part 2 of the RRMP are expected to minimize risks for listed species. Lake water is periodically pumped with the use of a perforated intake developed to prevent the entrainment of fish and debris into the pump.

6.3.2.4 Species Response to Stressors

Puget Sound Chinook Salmon

Adult salmonids are not anticipated to use the vicinity of the maintenance facility for migration. Because of the very small probability of adult salmonid exposure to potential effects, WSDOT expects that operational elements of the maintenance facility will present a discountable potential for effects on adult Chinook salmon, steelhead, or bull trout.

Given the minimization measures and other mitigating factors described above for water quality, WSDOT expects a very low probability of exposure to degraded water quality for listed juvenile salmonids. Therefore, water quality effects from the maintenance facility operation are expected to be discountable.

Only one spill incident has been recorded within the last 15 years (Allen 2010). Based on the efficacy of known BMPs and the low probability of risk, WSDOT expects the potential for exposure of listed species to a maintenance-related spill to be discountable.

Maintenance activities also ensure proper long-term performance of the facility, lessening risk for aquatic organisms and aquatic and riparian habitats. In this context, WSDOT expects a small, but unquantifiable, improvement over baseline conditions in the effects of maintenance actions on listed salmonids.

Puget Sound Steelhead

As indicated above, adult steelhead are not expected to occur in the vicinity of the maintenance facility, because there are no nearby natal streams, and adult steelhead enter the lake along the opposite shoreline. Juvenile steelhead typically spend a year or two in their natal streams before migrating downstream to the lake. Consequently, they are typically larger and less reliant on shoreline habitat than juvenile Chinook salmon, and they are unlikely to use the habitat near the maintenance facility for any substantial amount of time. Therefore, the operational activities at the maintenance dock are unlikely to affect juvenile steelhead, and the offshore operations are expected to be similar to the existing conditions. Therefore, the potential effects of the operational elements of the maintenance facility on Puget Sound steelhead are similarly expected to be either insignificant or discountable.

Coastal-Puget Sound Bull Trout

WSDOT expects that operational elements of the maintenance facility will present a discountable potential for effects on bull trout because they are not expected to use the area habitat.

6.3.3 Spill Control

The existing bridge has no provisions for containing spills that may occur on the roadway. The replacement bridge will improve these conditions by discharging spills into stormwater wells within the supplemental stability pontoons, allowing subsequent cleanup of floatable materials. The replacement bridge structures will provide a substantially improved means to control and clean up spills of petroleum or other floatable fluids, compared to the existing structures that discharge stormwater directly to water bodies in the area. This will substantially reduce the potential effects on ESA-listed species that are rearing or migrating through the action area.

6.3.3.1 Species Response to Stressors

Puget Sound Chinook Salmon

Fluid or material spills large enough to reach stormwater conveyances occur very infrequently (Allen 2010). Moreover, the SR 520 corridor is part of a core coverage area for the WSDOT Incident Response Team, which means that response times to accidents are minimal. Given the infrequency of occurrence and the mitigating factors related to incident response and stormwater management facilities, WSDOT expects a very low probability of spill exposure for listed juvenile salmonids. Therefore, water quality effects from the potential hazardous material spills are expected to be discountable.

Puget Sound Steelhead

The potential effects of spills on Puget Sound steelhead in the action area, like the potential effects on Chinook salmon, are expected to be discountable.

Coastal-Puget Sound Bull Trout

The potential effects of spills on bull trout in the action area, like the potential effects on Chinook salmon, are expected to be discountable.

6.3.4 Stormwater

The project consists of approximately 45.20 acres of new PGIS, 29.21 acres of replaced PGIS, and 16.64 acres of existing PGIS. Project-related PGIS includes segments of I-5, SR 520, and local streets in the jurisdictions of Seattle and Medina. Stormwater treatment for the 91.05 total acres of project-related PGIS includes the following areas:

- Approximately 7.80 acres are not effective PGIS because they are covered by the Montlake and 10th and Delmar lids.
- Discharge from 5.51 acres will be conveyed to the combined sewer system for treatment at the West Point Wastewater Treatment Plant and discharged into Puget Sound.
- Discharge from 43.27 acres will receive conventional basic or enhanced stormwater quality treatment.
- Discharge from 21.56 acres will receive treatment according to the AKART high-efficiency sweeping and modified catch basin treatment technology and maintenance frequencies.
- Discharge from 13.91 acres of existing effective PGIS will remain untreated after project construction.

All existing and proposed stormwater discharges will flow to flow-exempt water bodies (Lake Washington, Lake Union, and Puget Sound); therefore, no flow detention will be provided. Although increases in impervious surfaces are often associated with damage to urban watersheds (e.g., Booth and Jackson 1997), most of the PGIS associated with this project is associated with bridges that intercept rainfall falling on large lakes.

Stormwater is routed to 13 outfall locations and the combined sewer system. AKART, basic, or enhanced water quality treatment is provided for stormwater before discharge at 8 of the 13 outfall locations. New outfalls will discharge above OHW, with any flow dissipation structures provided upland of OHW. During storm events that exceed the design storm, flow exceeding the water quality design volume will be discharged from the Portage Bay Bridge and west approach bridge scuppers directly to Lake Washington, without water quality treatment.

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 2009i). 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. For untreated surfaces, those concentrations and (standard deviations) are TSS 106.6 (150.1); total copper 0.0222 (0.0216); dissolved copper 0.0053 (0.0050); total zinc 0.1351 (0.1351); and dissolved zinc 0.0429 (0.0507) with all concentrations in mg/L. For stormwater treated with basic or enhanced stormwater treatment BMPs, the values are TSS 11.8 (21.8); total copper 0.0058 (0.0035); dissolved copper 0.0038 (0.0024); total zinc 0.0288 (0.0190); and dissolved zinc 0.0200 (0.0137) with all cocentrations in mg/L. The reductions in pollutants resulting from treatment average 88.9 percent for TSS; 74.0 percent for total copper, 27.8 percent for dissolved copper, 78.7 percent for total zinc, and 53.5 percent for dissolved zinc. For the evaluations presented here, treatment with AKART or the combined sewer system are assumed to be comparable to basic or enhanced stormwater treatment and therefore the storwater concentrations

For the entire project, stormwater pollutant loads are predicted to decrease (P [exceed] values less than 0.5) for TSS, total copper, total zinc, and dissolved zinc. Dissolved copper loads may increase slightly as a result of the project, as suggested by a P (exceed) value of 0.52 (52 percent of the model runs for the proposed condition exceeded the loads for the current condition).

Pollutant loads of dissolved metals are projected to increase at three discharge locations:

- **WS-PR.** A large enhanced water quality stormwater treatment facility will be constructed to treat PGIS runoff from upland areas and the west approach bridge.
- **WS-BR2.** Stormwater treatment is infeasible for existing and proposed surfaces because the existing Montlake Cut bascule bridge is grated and does not collect stormwater, and the proposed bascule bridge will also be unable to collect stormwater for treatment.
- **RWB-C/RWB-D.** PGIS quantities in this area will increase slightly due to construction of new roadway surfaces.

All other discharge locations are predicted to either improve water quality conditions or remain the same as the existing conditions. Details of the stormwater analysis methodology are provided in Appendix J, and the Hi-Run results are summarized in Exhibit 6-67 and 6-68.

EXHIBIT 6-67.
MODELING RESULTS OF HI-RUN RECEIVING WATER END-OF-PIPE LOADING SUBROUTINE FOR OUTFALLS

Stormwater Discharge Point	Existing PGIS (acres)	Post-Project PGIS (acres)	Dissolved Zinc P (exceed) Value	Receiving Water Function	Median Change in Dissolved Zinc Loading (pounds per year)
East Garfield Street	2.45	2.45	0.50	Not properly functioning	0.00
East Allison Street	14.25	14.30	0.49	Not properly functioning	-0.21
WS-C	3.34	5.47 (2.94)[a]	0.29	Not properly functioning	-0.33
WS-D	6.47	9.29	0.48	Not properly functioning	-0.12
WS-BR2	0.19	0.27	0.60	Not properly functioning	0.02
RWB-C	0.02	1.09	1.00	Properly functioning	0.02
Union Bay	1.28	0.09	0.04	Properly functioning	-0.23
RWB-F	0.61	0.40	0.26	Properly functioning	-0.06
WS-PR	12.60	28.99 (23.72)[b]	0.54	Properly functioning	0.32
WS-BR4	17.28	20.56	0.38	Not properly functioning	-1.04
WS-G	1.75	1.70	0.32	Properly functioning	-0.16
WS-J	5.42	4.48	0.27	Properly functioning	-0.57
RWB-G	0.16	0.04	0.05	Properly functioning	-0.03
CSS	5.24	5.51	0.52	Properly functioning	0.03

N/A = not applicable
PGIS = pollutant-generating impervious surface
RWB = receiving water body
WS = Washington State Department of Transportation
[a] The 10th and Delmar lid will reduce effective PGIS by 2.53 acres, from 5.47 to 2.94 total acres requiring water quality treatment.
[b] The Montlake lid will reduce effective PGIS by 5.27 acres, from 26.58 to 21.31 total acres requiring water quality treatment.

EXHIBIT 6-68.
MODELING RESULTS OF HI-RUN RECEIVING WATER END-OF-PIPE LOADING SUBROUTINE FOR OUTFALLS

Threshold Discharge Area	Existing/ Proposed	TSS Median (25th–75th percentile)	Total Copper Median (25th–75th percentile)	Disssolved Copper Median (25th–75th percentile)	Total Zinc Median (25th–75th percentile)	Dissolved Zinc Median (25th–75th percentile)
East Garfield Street	Existing	978 (477-2004)	0.25 (0.14-0.45)	0.06 (0.04-0.11)	1.52 (0.85-2.71)	0.44 (0.23-0.84)
	Proposed	978 (477-2004)	0.25 (0.14-0.45)	0.06 (0.04-0.11)	1.52 (0.85-2.71)	0.44 (0.23-0.84)
East Allison Street	Existing	6445 (3148-13253)	1.68 (0.95-2.94)	0.40 (0.23-0.70)	10 (5.65-17.9)	2.91 (1.54-5.50)
	Proposed	5066 (2619-10042)	1.4 (0.86-2.30)	0.41 (0.27-0.63)	8.20 (4.9-14.0)	2.70 (1.70-4.70)
WS-C	Existing	1526 (746-3110)	0.39 (0.22-0.69)	0.10 (0.05-0.17)	2.33 (1.32-4.16)	0.69 (0.36-1.31)
	Proposed	122 (53-281)	0.11 (0.07-0.16)	0.07 (0.05-0.11)	0.52 (0.34-0.80)	0.36 (0.23-0.56)
WS-D	Existing	2946 (1430-6005)	0.76 (0.43-1.33)	0.18 (0.10-0.32)	4.56 (2.56-8.13)	1.32 (0.69-2.52)
	Proposed	758 (419-1397)	0.41 (0.29-0.58)	0.23 (0.16-0.34)	2.1 (1.40-3.00)	1.2 (0.83-1.8)
WS-BR2	Existing	86 (42-177)	0.02 (0.01-0.04)	0.01 (0.00-0.01)	0.13 (0.08-0.24)	0.04 (0.02-0.07)
	Proposed	123 (60-250)	0.03 (0.02-0.06)	0.01 (0.00-0.01)	0.19 (0.11-0.34)	0.06 (0.03-0.10)
RWB-C	Existing	7 (4-15)	0.00 (0.00-0.00)	0 (0-0)	0.01 (0.01-0.02)	0.00 (0.00-0.01)
	Proposed	45 (20-104)	0.04 (0.02-0.06)	0.03 (0.02-0.04)	0.19 (0.13-0.29)	0.13 (0.09-0.21)
Union Bay	Existing	583 (283-1198)	0.15 (0.09-0.26)	0.04 (0.02-0.06)	0.91 (0.51-1.61)	0.26 (0.14-0.50)
	Proposed	59 (29-121)	0.02 (0.01-0.03)	0.00 (0.00-0.01)	0.09 (0.05-0.16)	0.03 (0.01-0.05)
RWB-F	Existing	243 (119-498)	0.06 (0.04-0.11)	0.02 (0.01-0.03)	0.38 (0.21-0.67)	0.11 (0.06-0.21)
	Proposed	18 (7.7-41)	0.02 (0.01-0.02)	0.01 (0.01-0.02)	0.08 (0.05-0.12)	0.05 (0.03-0.08)

EXHIBIT 6-68.
MODELING RESULTS OF HI-RUN RECEIVING WATER END-OF-PIPE LOADING SUBROUTINE FOR OUTFALLS

Threshold Discharge Area	Existing/ Proposed	TSS Median (25th–75th percentile)	Total Copper Median (25th–75th percentile)	Disssolved Copper Median (25th–75th percentile)	Total Zinc Median (25th–75th percentile)	Dissolved Zinc Median (25th–75th percentile)
WS-PR	Existing	5748 (2792-11713)	1.48 (0.84-2.61)	0.36 (0.21-0.62)	8.81 (4.95-15.7)	2.58 (1.35-4.88)
	Proposed	981 (428-2244)	0.86 (0.58-1.30)	0.57 (0.37-0.85)	4.2 (2.7-6.4)	2.9 (1.9-4.5)
WS-BR4	Existing	7894 (3859-16090)	2.02 (1.15-3.57)	0.49 (0.28-0.85)	12.1 (6.83-21.5)	3.54 (1.87-6.76)
	Proposed	850 (371-1962)	0.75 (0.51-1.10)	0.49 (0.33-0.74)	3.70 (2.40-5.60)	2.50 (1.6-3.9)
WS-G	Existing	792 (388-1624)	0.21 (0.12-0.36)	0.05 (0.03-0.09)	1.23 (0.70-2.18)	0.36 (0.68-0.19)
	Proposed	69 (30-159)	0.06 (0.04-0.09)	0.04 (0.03-0.06	0.3 (0.2-0.46)	0.2 (0.13-0.32)
WS-J	Existing	2,476 (1210-5054)	0.63 (0.36-1.11)	0.15 (0.09-0.27)	3.84 (2.15-6.83)	1.11 (0.58-2.1)
	Proposed	184 (80-422)	0.16 (0.11-0.24	0.11 (0.07-0.16)	0.8 (0.52-1.20)	0.54 (0.35-0.84)
RWB-G	Existing	65.1 (31.8-133)	0.02 (0.01-0.03)	0 (0.00-0.00)	0.10 (0.06-0.18)	0.03 (0.02-0.06)
	Proposed	1.5 (0.7-3.5)	0 (0.00-0.00)	0 (0.00-0.00)	0.01 (0.00-0.01)	0.00 (0.00-0.01)
Combined Sewer System	Existing	215 (93.7-494)	0.19 (0.13-0.28)	0.13 (0.08-0.19)	0.93 (0.60-1.41)	0.64 (0.41-0.99)
	Proposed	226 (99-519)	0.20 (0.14-0.30)	0.13 (0.09-0.20)	0.98 (0.64-1.50)	0.67 (0.43-1.00)

RWB = receiving water body
TSS = total suspended solids
WS = Washington State Department of Transportation

Stormwater pollutant concentrations improve or remain the same at all locations because the only existing treatment is by the combined sewer system. All other outfalls currently convey water from PGIS that receives no water quality treatment.

For a subset of discharge locations, additional dilution modeling using CORMIX was used to assess the distance at which pollutant concentrations will remain greater than the thresholds of concern for listed salmonids. Dilution zones were calculated for five outfalls that receive flow from approximately 68.17 acres of effective PGIS and represent approximately 83 percent of the effective PGIS in the project vicinity. An additional two outfalls (WS-G and WS-J) were modeled as part of the Medina to SR 202 Project. Dilution zones around outfalls where pollutant concentrations may be more than 5.6 micrograms per liter (µg/L) greater than the background of 1 µg/L for dissolved zinc and 2 µg/L greater than the background of 0.96 µg/L for dissolved copper are the thresholds of concern identified for listed salmonids.

Model analysis suggests that dissolved copper and dissolved zinc concentrations in receiving water bodies are predicted to be less than the thresholds of concern for listed salmonids within approximately 13 feet of the outfalls for dissolved zinc and 7 feet for dissolved copper (Exhibit 6-69). Dilution zones are slightly larger during winter months when stormwater volumes are greater and the lake level is lower than during the summer months.

EXHIBIT 6-69.
SUMMARY OF STORMWATER DILUTION MODELING RESULTS FOR SELECTED OUTFALLS

		Distance for Dilution to Concentration Less Than Sublethal Effects Threshold	
Outfall Name	**Receiving Water Body**	**Dissolved Copper (feet)**	**Dissolved Zinc (feet)**
WS-C	Lake Union (Portage Bay)	2.2	10.3
WS-D	Lake Union (Portage Bay)	4.9	13.2
WS-PR	Lake Washington (Union Bay)	6.7	11.1
East Allison Street	Lake Union	4.4	7.9
BR-4	Lake Washington	>0 and <21	>21 and <71
WS-G	Lake Washington	14	2
WS-J	Lake Washignton (Fairweather Bay)	17	1

Note: Stormwater dilution modeling for outfall BR-4 is described in WSDOT 2009c.
WS = Washington State Department of Transportation

Combined sewer overflow events were evaluated for outfalls serving the project area. Since 2005, overflow events have been reported for the outfalls serving the project area A summary of the frequency and volume of overflow events for 2005–2009 is provided in Exhibit 6-70. Overflow events tend to be associated with large precipitation events (average event of more than 2 inches of precipitation) and are concentrated in the winter months (October through February), with only 6 of 56 events occurring in the months of May, August, or September. Storm events that trigger combined sewer overflow events are also likely to exceed the design condition of stormwater treatment BMPs. Although the total area of PGIS directed to the combined sewer system will increase slightly as a result of the project, because of bioretention and detention that will be provided for flows directed to the combined sewer system, it is expected that stormwater from the project vicinity will not be discharged to the combined sewer system at times when the combined sewer system pipes are full. Therefore, future overflow events will have no greater overflow frequency or volumes that the existing baseline, and overflow frequency and volume may be less.

EXHIBIT 6-70.
SUMMARY OF COMBINED SEWER OVERFLOW EVENTS (2005–2009) FOR OUTFALLS SERVING THE PROJECT AREA

Outfall	Receiving Water Body	Number of Overflow Events (2005–2009)	Combined Volume of Overflow Events (gallons)	Combined Duration of Overflow Events (hours)
Seattle 020	Union Bay (Lake Washington)	12	2,615,645	86.4
Seattle 132	Lake Union	4	628,002	5
Seattle 138	Portage Bay (Lake Union)	14	42,939,443	121.3
Seattle 139	Portage Bay (Lake Union)	7	4,318,762	25.2
Seattle 140	Portage Bay (Lake Union)	9	881,659	66.1
King County 014	Portage Bay/Montlake Cut (Lake Washington Ship Canal)	10	39,830,000	N/A
King County 015	Union Bay (Lake Washington)	12	310,110,000	N/A

N/A = not available

Project-related PGIS will contribute only a fraction of the total surface runoff directed to the combined sewer overflow outfalls in the project area. Exhibit 6-71 identifies the amount of PGIS in the project area versus the total area of the drainage basins contributing to each outfall. Furthermore, the total basin area of outfall Seattle 138 will decrease by approximately 1 acre as a result of the project, and the project will not contribute to an increase in the total basin area of any combined sewer system basins.

EXHIBIT 6-71.
TOTAL POLLUTANT-GENERATING IMPERVIOUS SURFACE IN THE PROJECT AREA AND TOTAL DRAINAGE BASIN AREA DISCHARGING TO ASSOCIATED OUTFALL

Outfall	Receiving Water Body	Project-Related PGIS (acres)	Total Basin Area (acres)
Seattle 020	Union Bay (Lake Washington)	0.63	115
Seattle 132	Lake Union	1.36	39
Seattle 138	Portage Bay (Lake Union)	0.29	54
Seattle 139	Portage Bay (Lake Union)	0.28	16
Seattle 140	Portage Bay (Lake Union)		70
King County 014	Portage Bay/Montlake Cut (Lake Washington Ship Canal)	1.36	N/A
King County 015	Union Bay (Lake Washington)	0.95	N/A

N/A = not applicable

Highways collect a variety of pollutants from traffic and are disproportionate contributors to overall pollutant loads in water bodies (Wheeler et al. 2005). Pollutants are mobilized and transported to nearby water bodies by runoff. Traffic residue contains several metals, including iron, zinc, lead, cadmium, nickel, copper, and chromium (Wheeler et al. 2005). These metals are shed from disintegrating tires, brake pads, and other vehicle parts and accumulate in roadside dust and soil (Wheeler et al. 2005).

Dissolved copper and dissolved zinc are the constituents of greatest concern because they are prevalent in stormwater, are biologically active at low concentrations, and have documented adverse effects on salmonids. Increased copper and zinc loading presents two pathways for possible adverse effects: direct exposure to water column pollutant concentrations in excess of biological effects thresholds; and indirect adverse effects resulting from the accumulation of pollutants in the environment over time, altered food web productivity, and possible dietary exposure.

Baldwin et al. (2003) found that 30- to 60-minute exposures to a dissolved copper concentration of 2.3 μg/L greater than background levels caused olfactory inhibition in coho salmon juveniles. Sandahl et al. (2007) found that a 3-hour exposure to a dissolved copper concentration of 2.0 μg/L caused olfactory inhibition in coho salmon juveniles. The toxicity of zinc is widely variable, depending on concurrent concentrations of calcium, magnesium, and sodium in the water column (De Schamphelaere and Janssen 2004). A review of zinc toxicity studies reveals effects including reduced growth, avoidance, reproduction impairment, increased respiration, decreased swimming ability, increased jaw and bronchial abnormalities, hyperactivity, hyperglycemia, and reduced survival in freshwater fish (Eisler 1993). Juveniles are more sensitive to elevated zinc concentrations than adults (U.S. EPA 1987). Sprague (1968) documented avoidance in juvenile rainbow trout exposed to dissolved zinc concentrations of 5.6 μg/L greater than background levels.

6.3.4.1 Puget Sound Chinook Salmon

Stormwater discharges during project operation are expected to result in effects on the chemical and/or biological environment of Lake Washington and the Lake Washington Ship Canal. However, during most of the project operation, pollutant concentrations in the discharges will not be great enough to significantly disrupt the normal behavior of adult or juvenile Chinook salmon, nor will they generally result in direct injury or mortality.

Discharge of operational stormwater could adversely affect adult and juvenile Chinook salmon in the immediate area of several outfalls through a modification of normal behavior or through direct sublethal effects. However, these effects would be limited to an extremely small portion of the action area.

Adult and juvenile salmonids will be migrating through the action area during project operation and storm events and could be exposed to pollutant concentrations in excess of the sublethal effect threshold. Most Lake Washington Chinook adult salmon are likely to migrate through the Evergreen Point Bridge area from June through late August. Also, individual adult salmonids are expected to migrate relatively quickly through the project area and in relatively deep water (where water temperatures are cooler), away from the land-based stormwater discharge locations. Discharge of operational stormwater will also affect juvenile Chinook salmon during spring and summer storm events that occur during the juvenile Chinook outmigration period (April through June).

There are no data indicating that adult salmon congregate adjacent to stormwater outfalls during their migration to spawning areas in the Lake Washington basin. Adverse effects on Chinook salmon due to sublethal effects from dissolved copper and dissolved zinc will be limited to areas listed in Exhibit 6-69.

6.3.4.2 Puget Sound Steelhead

The potential effects of the project activities in the project area on Puget Sound steelhead are expected to be similar to but somewhat less than the effects on Chinook salmon. Adult steelhead tend to migrate during the winter (November to March) but in much lower numbers, and their migration is spread out over the prolonged migration period. Juvenile steelhead tend to migrate out of the lake in generally the same time frame as Chinook salmon (April through June), with the majority migrating between May and July. The primary difference is the larger size of the steelhead in the lake, which indicates that they usually rear for a year in their natal stream and are less likely to show a preference for nearshore habitat and less likely to be affected by land-based stormwater discharges.

Generally speaking, any adverse effects of stormwater on Chinook salmon could also apply to steelhead. However, based on the older age classes and larger size of migrating juvenile steelhead and the generally lower numbers of steelhead in the system, the exposure of steelhead to potentially adverse effects will be more limited than the exposure of Chinook salmon.

6.3.4.3 Coastal-Puget Sound Bull Trout

The potential effects of the project activities in the action area on bull trout are expected to be similar to but substantially less probable than the effects on Chinook salmon. Juvenile bull trout are unlikely to occur in the action area. Additionally, it is only the subadult and adult life stages of bull trout that are likely to make forays into the action area and experience any type of exposure to project-related effects.

Generally speaking, any adverse effects on Chinook salmon could also apply to bull trout. However, based on the low probability of bull trout occurrence in the action area, the exposure of bull trout to potentially adverse effects will be much more limited than the exposure of Chinook salmon.

6.3.4.4 Primary Constituent Elements

Impaired water and sediment quality reduce the abundance and diversity of benthic macrofauna (Jones and Clark 1987) and could reduce the the availability of prey for juvenile Puget Sound Chinook salmon, steelhead, and bull trout in a small area near the outfalls. This will therefore impair the PCE that addresses forage. However, prey availability is not a limiting factor for listed salmonids in Lake Washington. Given the small area of habitat that will be affected and the abundance of prey resources in Lake Washington, the effects on prey species due to stormwater discharges are not expected to appreciably affect the growth or survival of listed salmonids.

6.3.5 Mitigation Actions

The project is required by local, state, and federal regulations to fully compensate for project effects on aquatic resources. Compensatory mitigation required by these regulations serve to benefit ESA-listed species. WSDOT conducted a rigorous screening exercise to determine suitable sites to offset aquatic effects. The screening exercise for aquatic sites, fully documented in the *Initial Aquatic Mitigation Report; I-5 to Medina: Bridge Replacement and HOV Project* (WSDOT 2009e), consisted of a three-part screening process that pared down all the potential parcels within the geographic study area (a large portion of the Lake Washington basin) to a manageable number that still would provide the types and quantity of aquatic functional uplift to adequately compensate for the estimated effects of the project on fish species and their habitat. Seven sites were selected and ranked by their potential to benefit aqautic species, with a focus on salmonids. The sites, and the specific mitigation actions at these sites, may be altered as a result of the field reconnaissance or further coordination with parcel landowners, regulatory agencies, and stakeholders.

6.3.5.1 Potential Natural Resource Mitigation Sites

The potential effects of the expected construction activities at the nine potential natural resource mitigation sites are described below. However, these activities and, therefore, the potential effects may change based on further field reconnaissance and coordination with parcel landowners, regulatory agencies, and stakeholders.

Effects of Aquatic Habitat Restoration Activities

Washington Department of Natural Resources Parcel

The primary potential effects on ESA-listed species would be short term and would occur during project construction, specifically, during the removal of the existing flume and regrading of the shoreline. The potential effects are (1) injury or death by physical trauma due to in-water work (or fish removal activities before in-water work), (2) behavioral effects associated with in-water work and shoreline disturbance, (3) deleterious physiological effects due to increased sedimentation and turbidity, and (4) exposure of listed fish species to potentially contaminated sediments disturbed during site rehabilitation. In addition, potential effects could result from construction debris entering Lake Washington or from chemical/fuel spills from construction equipment.

The primary habitat enhancement goal is to increase growth and survival of outmigrating salmon fry from the Cedar River, by creating suitable nearshore habitat at the site, including both shoreline and riparian habitat. This will be accomplished by restoring about 630 feet of shoreline habitat, which will involve removing an existing flume and regrading the shoreline to a constant, gentle slope. Additional substrate consisting of fine-grained materials and gravels will be installed. Any nonnative plant species will be removed within the lake buffer (200 feet) and replanted with native trees and shrubs. The riparian zone directly adjacent to the shoreline will be planted densely to provide overhead cover and shoreline stabilization. This will result in the restoration of about 3 acres of riparian habitat and about 0.5 acre of in-water habitat.

Cedar River Site

The primary potential effects on ESA-listed species will be short term and will occur during project construction, specifically, during the removal and setback of the existing levees and regrading of the shoreline to recreate natural floodplain habitat. The potential effects are (1) injury or death by physical trauma due to in-water work (or fish removal activities before in-water work), (2) behavioral effects associated with in-water work and shoreline disturbance, and (3) deleterious physiological effects due to increased sedimentation and turbidity. In addition, potential effects could result from construction debris entering the Cedar River or from chemical/fuel spills from construction equipment.

The habitat enhancement activities will consist of removing about 500 linear feet of existing levee on the right bank and about 400 linear feet on the left bank, excavating about 6 acres of upland area to functional floodplain elevation, and removing existing road fill associated with the abandoned bridge. The site will be regraded to mimic a naturally occurring floodplain and replanted with native vegetation, and new levees will be constructed away from the riverbank to protect adjacent properties and infrastructure. This will result in the restoration or improvement of about 12 acres of riparian habitat and about 3 acres of in-water habitat.

Seward Park Site

The primary potential effects on ESA-listed species will be short term and will occur during project construction, specifically, during the removal of shoreline riprap and debris, the resloping of shoreline habitat to create more natural beach habitat, the installation of substrate in restored shoreline habitats, and shoreline riparian planting. The potential effects are (1) injury or death by physical trauma due to in-water work (or fish removal activities before in-water work), (2) behavioral effects associated with in-water work and shoreline disturbance, and (3) deleterious physiological effects due to increased sedimentation and turbidity. In addition, potential effects could result from construction debris entering Lake Washington or from chemical/fuel spills from construction equipment.

The primary habitat enhancement goal is to increase growth and survival of outmigrating salmon fry from the Cedar River, by creating suitable nearshore habitat at the site, including both shoreline and riparian habitat.

Mitigation actions will include bulkhead removal, bank regrading, gravel installation, removal of nonnative plant species, and riparian revegetation. These activities will result in the enhancement of about 1,000 linear feet of shoreline habitat, consisting of about 1.8 acres of riparian buffer enhancements and about 0.4 acre of in-water habitat enhancement.

Magnuson Park Site

The primary potential effects on ESA-listed species will be short term and will occur during project construction, specifically, during the removal of shoreline riprap and debris, the resloping of shoreline habitat to create more natural beach habitat, the installation of substrate in restored shoreline habitats, and shoreline riparian planting. The potential effects are (1) injury or death by physical trauma due to in-water work (or fish removal activities before in-water work), (2) behavioral effects associated with in-water work and shoreline disturbance, and (3) deleterious physiological effects due to increased sedimentation and turbidity. In addition, potential effects could result from construction debris entering the Lake Washington or from chemical/fuel spills from construction equipment.

The mitigation opportunities on the Magnuson Park property include bulkhead removal, bank resloping, gravel augmentation, LWD installation, removal of nonnative vegetation, and revegetation of riparian habitat with native species. These activities will result in the enhancment of about 1,200 linear feet of shoreline habitat, consisting of about 4.6 acres of riparian buffer enhancement and about 0.3 acre of in-water habitat enhancement.

Beer Sheva Park Site

The primary potential effects on ESA-listed species will be short term and will occur during project construction, specifically, during the daylighting of Mapes Creek, the creation of a delta at the stream mouth (including the resloping of shoreline habitat to create more natural beach habitat), the installation of substrate in restored shoreline habitats, and shoreline riparian planting. The potential effects are (1) injury or death by physical trauma due to in-water work (or fish removal activities before in-water work), (2) behavioral effects associated with in-water work and shoreline disturbance, and (3) deleterious physiological effects due to increased sedimentation and turbidity. In addition, potential effects could result from construction debris entering the Lake Washington or from chemical/fuel spills from construction equipment.

Mitigation actions at the Beer Sheeva Park will include daylighting and restoring the lower 300 feet of Mapes Creek and a small delta along the park shoreline to enhance salmonid rearing and migration habitat. A narrow riparian zone compatible with park uses will be planted along the creek and delta, and additional substrate consisting of fish-friendly materials (small and medium gravels) will be installed in the channel and the delta areas. These activities will result in the restoration of about 0.2 acre of riparian habitat and about 0.1 acre of in-water habitat. Nonnative plant species will be removed and the riparian zone replanted with native species to provide overhead cover and bank stabilization.

Bear Creek Site

The Bear Creek Restoration Project has already undergone consultation with NMFS (NMFS Tracking No. 2009/04429 [NMFS 2009c]). See the biological opinion (NMFS 2009d) for a full discussion of the potential effects of the Bear Creek project on ESA-listed species, their critical habitat, and EFH; the terms and conditions, and the incidental “take” limits.

The primary habitat enhancement goal is to increase the long-term spawning and rearing success of the Bear Creek salmon populations by increasing the amount of available spawning habitat, improving habitat complexity, increasing riparian cover, improving water quality (temperature), and increasing the prey base. The project will construct a new 340-foot long channel north of the existing channel with connections spaced along the length, providing 1,440 feet of off-channel habitat. The project will fill the remainder of the existing stream channel with gravels excavated from the new channel. The new channel will include 1,300 linear feet of pool habitat, with bank stabilization provided by about 3,000 pieces of LWD. The riparian habitat will be replanted with native trees and shrubs, resulting in about 13 acres of restored riparian habitat, including about 1.3 acres of riparian wetlands that will contribute flood attenuation and storage functions. The project will also result in about 2.8 acres of new or restored in-water habitat.

Effects of Wetland Restoration Activities

Union Bay Natural Area Site

The primary potential effects on ESA-listed species will be short term and will occur during project construction, specifically, during the regrading of upland areas to provide increased shoreline habitat and the physical disturbance resulting from the removal of invasive species, and revegetation activities. The primary potential effects would be deleterious physiological effects due to increased sedimentation and turbidity, effects resulting from construction debris entering Union Slough or Union Bay, or effects of chemical/fuel spills from construction equipment. However, no in-water work in habitat occupied by ESA-listed species is proposed for this site, and appropriate BMPs will be applied to minimize or prevent sediment or pollutants from entering site surface waters. Therefore, any effects on ESA-listed species due to construction at this site are considered insignificant.

The primary habitat enhancement goal is to increase the quality and quantity of wetlands on the site and to connect the created wetlands to University Slough. WSDOT proposes a mixture of mitigation activities at the Union Bay Natural Area that includes wetland creation, restoration, and enhancements along the shoreline of several ponds, and shoreline and buffer enhancement activities throughout the other portions of the site. The wetland areas will be planted with native trees, shrubs, and emergent vegetation to increase the diversity and quality of wetland and upland habitats. These activities are expected to result in the creation or restoration of about 6 acres of wetland habitat at the site.

WSDOT-Owned Peninsula Site

The primary potential effects on ESA-listed species will be short term and will occur during project construction, specifically, during the regrading of upland areas to produce shoreline habitat areas and the physical disturbance resulting from the removal of invasive species and revegetation activities. The primary potential effects will be deleterious physiological effects due to increased sedimentation and turbidity, effects resulting from construction debris entering Willow Bay and the Arboretum waterways, or effects of chemical/fuel spills from construction equipment. However, no in-water work in habitat occupied by ESA-listed species is proposed for this site, and appropriate BMPs will be applied to minimize or prevent sediment or pollutants from entering site surface waters. Therefore, any effects on ESA-listed species due to construction at this site are considered insignificant.

The primary aquatic habitat enhancement goal is to generally increase nearshore habitat functions on the site, including functions associated with shoreline and riparian areas. The peninsula will be regraded to near lake level and planted with native species, creating a variety of wetland habitats. Existing wetlands on the site will be enhanced by the removal of nonnative species and the installation of native species that will increase the diversity of the habitat. The proposed activities will be similar to those described for the Union Bay Natural Area mitigation site (e.g. clearing, grading to remove excess fill, reestablishing elevations consistent with the water table, and replanting with native species). These activities are expected to result in the creation or restoration of about 4 acres of wetland habitat at the site.

Washington Park Arboretum Site

The primary potential effects on ESA-listed species will be short term and will occur during project construction, specifically, during upland regrading to produce shoreline habitat areas and the physical disturbance resulting rom the removal of invasive species and revegetation activities. The primary potential effects will be deleterious physiological effects due to increased sedimentation and turbidity, effects resulting from construction debris entering Arboretum Creek or the arboretum waterways, or effects of chemical/fuel spills from construction equipment. However, no in-water work in habitat occupied by ESA-listed species is proposed for this site, and appropriate BMPs will be applied to minimize or prevent sediment or pollutants from entering site surface waters. Therefore, any effects on ESA-listed species due to construction activities at this site are considered insignificant.

As a whole, the proposed mitigation activities are expected to enhance riparian buffer functions by removing invasive species; planting native trees, shrubs, and herbaceous species; increasing the shading of Arboretum Creek; and increasing the amount of native insects and detritus added to Arboretum Creek’s food web.

The proposed activities will be similar to those described for the other wetland mitigation sites (e.g. clearing, grading, and replanting with native species). These activities are expected to result in the creation or restoration of about 1 acre of wetland habitat at the site.

6.3.5.2 Potential Section 6(f) Resources Mitigation Site – Arboretum West Site

The primary potential effects of park mitigation activities at the proposed Section 6(f) mitigation site on ESA-listed species would be short term and would occur during project construction, specifically, during the removal of an existing failing wooden dock and associated support piles. The potential effects are (1) physical disturbance due to in-water work, (2) behavioral effects and in-water noise associated with in-water work, and (3) effects due to increased sedimentation and turbidity. In addition, potential effects could result from construction debris entering Union Bay or from chemical/fuel spills from construction equipment.

6.3.5.3 Timing and Duration of Effects

In-water construction at each habitat enhancement site will likely be completed in a single construction year, although several construction years may be required to complete all habitat enhancement projects. Implementation and vegetation monitoring will continue on each site for a period of approximately 5 to 10 years, depending on the permit conditions.

6.3.5.4 Species Response

While construction at the habitat enhancement sites could have short-term effects on juvenile salmonid present within the construction area, restricting construction to the in-water construction periods will minimize potential effects.

Temporary disruption of the physical and chemical environmental by in-water construction may result in effects on listed fish species related to habitat alterations, noise disturbance, and water quality degradation. Physical processes from construction activities could disturb the bottom sediment, increase turbidity, adversely affect prey such as bottom-dwelling aquatic organisms, remove submerged aquatic vegetation used for cover and foraging, and produce noise levels that could alter migration or foraging behavior. Chemical processes include water quality degradation caused by construction-related pollution (i.e., fuel, oil, grease, heavy metals, and debris) and a temporary reduction of oxygen concentrations associated with the oxidation of resuspended organic matter (Carrasquero 2001).

The suspension of some sediment in the water column is also an unavoidable effect of the project on water quality conditions, and indirectly on listed species. Increased turbidity can alter the behavior of aquatic species, impair their ability to capture prey or avoid predation, and, in severe cases, cause physical injuries, such as gill abrasion. However, the sediment suspension as a result of construction will occur as small periodic events, primarily during bulkhead and dock removal activities and shoreline grading. Implementing standard in-water and nearshore construction BMPs and restricting construction to the in-water construction periods will also limit other potential effects of construction activities on ESA-listed species.

Other potential short-term construction effects could include spills of hazardous materials. However, such materials will be handled in a manner that will not contaminate surface water in the action area. In addition, implementation of BMPs and an SPCC plan are expected to prevent water quality degradation; therefore, the risk of exposure for listed salmonids is expected to be discountable.

In summary, the aquatic restoration activities will result in long-term benefits for ESA-listed species and other salmonids within the action area, while the wetland restoration activities and park mitigation activities will not have a deleterious effect on these species. By positively affecting the growth and survival of juvenile salmonid species and in some cases (Cedar River site) increased spawning opportunities and success, the net result of the actions described above will be greater fry escapement. This effect could, in turn, result in greater spawner escapement, thereby directly benefitting Lake Washington salmonid populations, particularly Chinook salmon.

6.4 Effects on Designated Critical Habitat

6.4.1 Puget Sound Chinook Salmon Critical Habitat

The decision to designate critical habitat considers the range-wide condition and trends of those physical and biological features that are essential to the conservation of a given species. These features, referred to as the *primary constituent elements* (PCEs), may require special management considerations or protection (50 CFR 424.12[b]). Six PCEs have been identified for Puget Sound Chinook salmon. All of these, except for PCE 1 (freshwater spawning sites), occur to some degree within the action area, although most of the project activities will occur in freshwater rearing (PCE 2) and freshwater migration (PCE 3) areas (Exhibit 6-72).

EXHIBIT 6-72.
PRIMARY CONSTITUENT ELEMENTS FOR PUGET SOUND CHINOOK SALMON CRITICAL HABITAT, ESSENTIAL FEATURES, AND TARGET LIFE STAGES APPLICABLE TO THE PROJECT

PCE	Essential Features	Life Stage
PCE 2: freshwater rearing	Water quality and quantity, natural cover, and floodplain connectivity	Juvenile growth, development, mobility, and survival
PCE 3: freshwater migration	Free of obstructions and excessive predators; adequate water quality and quantity and cover	Juvenile and adult mobility and survival
PCE 4: estuarine areas	Free of obstructions and excessive predators; adequate water quality and quantity, natural cover, and forage	Juvenile and adult mobility, growth, survival, and transition between fresh and saltwater areas
PCE 5: nearshore marine areas	Free of obstructions and excessive predators; adequate water quality and quantity, cover, and forage	Juvenile growth, maturation, and survival
PCE 6: offshore marine areas	Water quality and forage	Juvenile and adult growth and maturation

PCE = primary constituent element

In-water construction areas will result in the alteration of critical habitat in the action area. The project is expected to affect designated critical habitat for Puget Sound Chinook salmon in the action area, including the following PCEs:

- **PCE 2.** Much of the project activities will occur in freshwater rearing sites with the potential to affect water quality and natural cover, as well as juvenile growth and mobility. Juvenile Chinook salmon within the action area may be temporarily displaced or may avoid rearing habitat located near pile-driving activities and other construction activities and areas affected by in-water and over-water structures. The timing of in-water work, methods of pile installation, and the implementation of sound attenuation devices (bubble curtains) will reduce, but not eliminate, these effects. These factors, when taken together, will result in an unavoidable adverse effect on Chinook salmon critical rearing habitat during the in-water construction period and the long-term operation of the project.

- **PCE 3.** A substantial portion of the freshwater areas within the project limits are within or adjacent to freshwater migration corridors, and the project will alter the complexity (cover) and predator habitat conditions, as well as water quality conditions and natural cover. The project will alter habitat complexity conditions that support juvenile growth and mobility, including the following:
  - The migration of juvenile and adult Chinook salmon may be altered due to the placement of permanent and temporary in-water structures within the project area.
  - The new substantially wider but higher bridge deck throughout much of the corridor may slightly increase the shaded area, which is likely to alter or disrupt migration behavior.
  - The displacement or avoidance of migration habitat by juvenile Chinook salmon may occur near the in-water construction activities due to noise-producing pile-driving activities. The timing of pile driving and the implementation of sound attenuation devices (bubble curtains) will reduce, but not eliminate, these effects.
  - The larger permanent in-water bridge columns will result in some loss of migration habitat. However, this habitat loss will be partially offset by the removal of the existing bridge columns.
  - Water quality and quantity will be periodically affected by construction activities in the action area, although long-term reductions in the rate of pollutant loading from stormwater are expected to occur.
- **PCE 4.** A portion of the pontoon towing route is located within estuarine habitat areas, although the project activities are expected to result in insignificant effects on this PCE.
- **PCE 5.** A small portion of the pontoon towing route is located within nearshore marine areas, although the project activities are expected to result in insignificant effects on this PCE.
- **PCE 6.** A substantial portion of the pontoon towing route is located in offshore marine areas, although the project activities are expected to result in insignificant effects on this PCE.

These factors, when taken together, will likely result in an unavoidable effect on one or more PCEs for Puget Sound Chinook salmon. However, many of these effects will be temporary and will cease when construction activities are completed. However, the project also includes a program to fully mitigate both temporary and permanent effects of the project, and the elements of that program will provide long-term benefits for the species.

6.4.2 Bull Trout Critical Habitat

Critical habitat units generally encompass one or more core areas and may include FMO areas that are outside the core areas and important to the survival and recovery of bull trout. The primary function of individual critical habitat units is to maintain and support core areas that (1) contain bull trout populations with the demographic characteristics needed to ensure their persistence, (2) provide habitat conditions that facilitate the movement of migratory fish, (3) are large enough to incorporate genetic and phenotypic diversity, and (4) are distributed throughout the historical range of the species to preserve both genetic and phenotypic adaptations.

The Lake Washington system is in the Coastal-Puget Sound Management Unit. It contains important FMO habitat necessary for bull trout recovery, although there is insufficient information available to assign the Lake Washington system to a specific core area. However, it is believed to be critical to the persistence of the anadromous life history form of this species, unique to the Coastal-Puget Sound Management Unit (USFWS 2010).

The critical habitat units contain marine nearshore and freshwater habitats, outside of core areas, that are used by bull trout from one or more core areas. These habitats, outside of core areas, contain PCEs that are essential for the primary biological needs of foraging, reproducing, rearing of young, dispersal, genetic exchange, and sheltering. Of the nine bull trout PCEs described in the bull trout critical habitat rule (USFWS 2010), six are applicable to the project action area (Exhibit-6-73).

EXHIBIT 6-73.
PRIMARY CONSTITUENT ELEMENTS FOR PUGET SOUND-COASTAL BULL TROUT CRITICAL HABITAT, ESSENTIAL FEATURES, AND TARGET LIFE STAGES APPLICABLE TO THE ACTION AREA

PCE	Essential Features	Life Stage
PCE 2: Migration habitat	Minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and foraging habitats	All life stages mobility, growth, survival, and transition between fresh and saltwater areas
PCE 3: Abundant food sources	Including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish	All life stages growth, maturation, and survival
PCE 4: Complex aquatic habitat	Large wood, side channels, pools, undercut banks, and substrates to provide a variety of depths, gradients, velocities, and structure	All life stages growth, development, mobility, and survival
PCE 5: Water temperature	Temperatures between 2°C and 15°C	All life stages growth, development, mobility, and survival
PCE 8: Permanent water of sufficient quality and quantity	Water quality and forage	All life stages growth and maturation
PCE 9: Limited nonnative predators and competiors	Adequate temporal and spatial separation to reduce negative interactions with nonnative species	All life stages growth, development, mobility, survival, and reproduction

PCE = primary constituent element

The project is expected to affect designated critical habitat for bull trout in the action area for the following reasons:

- **PCE 2.** The project will increase the width and height of over-water structures, thereby changing the shade characteristics of the adjacent aquatic habitat, which can affect the behavior and distribution of bull trout and their prey species. The project will result in the installation of temporary piles to support the work trestles, and permanent columns to support the replacement bridge. These structures will affect the habitat complexity in the Lake Washington migration corridor. In addition, the project will result in a substantial increase in the overall area shaded by the bridge, which is expected to affect the behavior of both bull trout and their prey species. Some displacement or avoidance of migration habitat by bull trout may also occur due to noise-producing pile-driving activities. The timing of pile driving and the implementation of sound attenuation devices (bubble curtains) will reduce, but not eliminate, the potential for these effects. Collectively, these changes are not expected to result in adverse effects on PCE 2 for bull trout.
- **PCE 3.** The project will potentially alter prey distribution in the area, as well as the aquatic and riparian vegetation. Bull trout prey species (juvenile salmonids) use Lake Washington and Portage Bay for migration, and their migration behavior may be affected by both the construction and operation of the project. The Grays Harbor and Puget Sound estuaries supports a variety of marine, estuarine, and freshwater prey populations for adult and subadult bull trout, and the proposed action is not expected to measurably diminish the productivity or availability of these resources in either the short or long term. As such, effects on PCE 3 will be insignificant.
- **PCE 4.** The project will alter habitat complexity by decreasing the number of in-water bridge support columns and increasing their size compared to the existing structures. Complex habitats within Lake Washington, Union Bay, and the Ship Canal have been severely reduced as a result of development and industrialization along these shorelines. Although the shoreline areas in Union Bay provide natural complexity, the dense aquatic vegetation in much of this area provides suboptimal habitat for bull trout. Much of the Ship Canal contains extensive armored or walled shorelines, eliminating complexity. While the project is expected to reduce the number of in-water structures in the area, it is likely to have an insignificant effect on PCE 4.
- **PCE 5.** The project includes a substantial increase in over-water cover and shading in the shallow areas of Union and Portage Bays, as well as the floating bridge section that bisects the lake and changes the water circulation. Surface water temperatures in Lake Washington range from 4^{o} to 6^{o} C in winter to over 20^{o} C in summer, with summer temperatures exceeding the optimal range for bull trout. Although the project will result in a substantial increase in the amount of over-water structures in the action area, this over-water area is insignificant relative to the overall size of Lake Washington. As a result, the project will likely have an insignificant effect on PCE 5.

- **PCE 8.** Water quality is degraded in the Lake Washington basin, and the project will alter the stormwater quality and discharge conditions. Construction and periodic dredging potentially occurring at the pontoon construction sites could also affect water quality in the adjacent marine habitat areas. Water quality and quantity will be affected by short-term increases in turbidity as a result of project construction activities, particularly by the removal of work trestle and the existing bridge support structures in Lake Washington and Union and Portage Bays. The implementation of appropriate BMPs will reduce, but not eliminate, the effects of these activities. In addition, project activities at the pontoon construction sites could have measurable effects on water quality. Although these water quality effects will be episodic, localized, and temporary, the proposed actions will have an adverse effect on PCE 8.
- **PCE 9.** Although the in-water structures used for bridge construction activities could provide suitable habitat for bull trout predators and temporarily increase potential predation rates, this type of habitat is not considered a limiting factor in the predator species in Lake Washington or the Ship Canal. Similarly, the relatively small reduction in permanent in-water structures provided by the project will have an insignificant effect on PCE 9.

These factors, when taken together, will likely result in an unavoidable effect on one or more PCEs for Puget Sound-Coastal bull trout. However, many of these effects will be temporary and will cease when construction activities are completed. The project includes a program to fully mitigate both temporary and permanent effects of the project, and the elements of that program will provide long-term benefits for the species. In addition, the use of the action area by bull trout is substantially limited, and this is not expected to change.

6.4.3 Puget Sound Steelhead Critical Habitat

Critical habitat for Puget Sound steelhead has not yet been designated.

6.4.4 Southern Resident Killer Whale Critical Habitat

The PCEs for SRKW critical habitat are (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; and (3) passage conditions to allow migration, resting, and foraging. Lake Washington, the Grays Harbor moorage site, and the Port of Olympia and Port of Tacoma facilities are not within the area designated as critical habitat for this species. The only project activities with the potential to affect SRKW critical habitat, therefore, are those related to pontoon transport through the marine waters of the Strait of Juan de Fuca and Puget Sound. Towing pontoons through the heavily used shipping channels in these areas is not expected to have any effects on water quality (PCE 1). The following analysis, therefore, addresses only prey species (PCE 2) and passage conditions (PCE 3).

The project is expected to affect designated SRKW critical habitat in the action area for the following reasons:

- **PCE 2.** Project activities are likely to adversely affect Chinook salmon and other salmonids, potentially reducing the availability of prey species for SRKWs. Adverse effects on fish species will be limited in duration and will not necessarily result in measurable decreases in the availability of prey for SRKWs. Salmonids from the Lake Washington system represent a negligible proportion of the Puget Sound salmonid populations overall. Therefore, the potential for project activities to result in a measurable decrease in the prey base for SRKWs is discountable, and the effects of any decreases will be insignificant.
- **PCE 3.** The passage of additional vessels through existing shipping channels could cause SRKWs to change how they move between important habitat areas, find prey, or fulfill other life history requirements. The potential for the proposed activities to interfere with the passage of SRKWs is expected to be insignificant. Activities that involve transit by tugboat are unlikely to result in behavioral disturbance and are extremely unlikely to affect SRKW passage. Sounds from the tugboats will occur for short periods at any particular location. For these reasons, the potential for pontoon transport to interfere with the passage of SRKWs is discountable and insignificant.

6.5 Indirect Effects

Indirect effects are effects that result from the proposed action, but that occur later in time, and that are reasonably certain to occur. Indirect effects of transportation projects, such as the SR 520, I-5 to Medina project, include changes in land use when those changes are induced by the proposed action or can reasonably be expected to result from the proposed action.

Indirect effects of induced growth from the project were assessed according to the guidance in *ESA, Transportation and Development: Assessing Indirect Effects* (WSDOT 2009i). The guidance provides a step-by-step approach for assessing indirect effects by posing a series of questions about the proposed project. The step-by-step process is provided in Appendix H.

Indirect effects of induced growth from the three other planned projects in the SR 520 Bridge Replacement and HOV Program—Medina to SR 202: Eastside Transit and HOV Project; Pontoon Construction Project; and Lake Washington Urban Partnership—are addressed as part of the ESA Section 7 consultations for these individual projects.

6.6 Effects of Interrelated and Interdependent Actions

ESA Section 7 regulations define “interrelated” and “interdependent” actions differently. Interrelated actions are defined as “those that are part of a larger action and depend on the larger action for their justification,” and interdependent actions are defined as “those that have no independent utility apart from the action under consideration” (50 CFR 402.02).

The proposed action—SR 520, I-5 to Medina project—is one of four projects in the SR 520 Bridge Replacement and HOV Program. The program includes the proposed action as well as the Medina to SR 202 Eastside Transit and HOV Project; the Pontoon Construction Project; and the Lake Washington Urban Partnership.

It was determined that these other actions, or projects, are independent of each other. Each action has independent utility—that is, each action serves a useful transportation purpose on its own. Because each project has independent utility, each project has undergone separate ESA Section 7 consultations. Section 7 consultations have been completed for the Medina to SR 202: Eastside Transit and HOV Project, the Lake Washington Urban Partnership, and the Pontoon Construction Project. Based on this information, no interdependent actions were identified for the SR 520, I-5 to Medina project.

As stated above, interrelated actions are actions that are part of the larger action and depend on the larger action for their justification. The proposed action includes mitigation for project-related effects on Section 4(f) and Section 6(f) resources. At this time, WSDOT is expected to purchase the site(s) selected for mitigation, but the design and construction of the site(s) will be the responsibility of the City of Seattle. There is uncertainty regarding the activities that will be involved in the construction of these site(s); however, if construction of the site(s) requires federal funding or federal permits, these actions will undergo ESA Section 7 consultation indepenently from the SR 520, I-5 to Medina project. For these reasons, these actions are not considered interrelated actions of the proposed action for purposes of Section 7 consultation. No other interrelated actions were identified for the SR 520, I-5 to Medina project.

6.7 Cumulative Effects

Under the ESA, cumulative effects are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation (50 CFR 402.02). It is the responsibility of the Services to review all federal actions and the cumulative effects of all state and private actions when making a jeopardy/no jeopardy determination for a species and preparing their biological opinions.

The action area for the SR 520, I-5 to Medina project encompasses portions of Lake Washington and the surrounding communities near the proposed bridge alignment. Areas within or near the action area include the cities of Seattle, Bellevue, Kirkland, Medina, Hunts Point, and Yarrow Point.

The following list summarizes a review of online planning documents and permits in process:

- Population projections and distribution according to the Washington Office of Financial Management and the Puget Sound Regional Council.

- Master plans or equivalent documents and capital facility updates for the University of Washington, Seattle Children's hospital, the Seattle Department of Transportation, and the City of Bellevue.
- Personal communications with staff from Seattle Parks and the Seattle Department of Planning and Development.
- Online permit databases for the cities of Seattle, Bellevue, and Kirkland.

The research is supplemented by the findings of a similar cumulative effects analysis prepared in conjunction with the biological assessment for the Pontoon Construction Project (WSDOT 2010e), for which a portion of the action area encompasses the same action area as the SR 520, I-5 to Medina project. The information drawn from that report included the general descriptions of the areas and personal communications with staff from the City of Medina and the cities of Yarrow Point and Hunts Point.

6.7.1 Overview of the Lake Washington Area

King County has an estimated population of 1,909,300 (OFM 2009). The Puget Sound region is expected to grow by an additional 1.7 million people between 2000 and 2040, with King County receiving the highest share of this forecasted growth (PSRC 2008). As the human population in and around the action area continues to grow, the demand for commercial, industrial, and residential development will also likely increase.

In general, most of the shoreline around Lake Washington is developed as high-value residential parcels, with some areas of public land and facilities, some institutional or business park developments, and some marinas. The residential areas are unlikely to redevelop because many of the values are already very high, and regional and national economic trends will likely maintain the current state of development for the near term. For the private residences, some pier or dock replacement will likely occur as needed, and some private efforts at removing shoreline armoring or bulkheads may also occur. Many of the communities along the shoreline are also in the process of revising their shoreline master plans.

The City of Kirkland's updated shoreline master program was approved by Ecology and became effective on August 4, 2010. Key features of Kirkland's updated program include the following:

- Requires innovative shoreline setbacks and buffers that range from 30 to 60 feet, depending on the lot configuration and the use of the property.
- Provides flexible options for reducing the required shoreline setback in exchange for improvements to the shoreline area and alternative approaches to required shoreline vegetation and tree replacement.
- Limits construction of new shoreline armoring and encourages the use of green shorelines and soft-bank erosion control methods.

- Provides a decision tree for determining the feasibility of using soft-bank erosion in lieu of hard stabilization, such as bulkheads or riprap.
- Includes a restoration plan indicating where and how voluntary improvements in water and upland areas can enhance the local shoreline environment.

The cities of Seattle, Bellevue, Medina, Hunts Point, and Yarrow Point are all within the local approval stages of program updates. These updates may change the patterns of development and redevelopment.

6.7.2 City of Seattle

Seattle has an estimated population of 602,000 (OFM 2009). The Lake Washington shoreline in Seattle is primarily a mix of high-value single-family residences and public spaces. Land uses encompassing relatively large areas within or near the shoreline area include the University of Washington, several City of Seattle park facilities, and Seattle Children's hospital.

6.7.2.1 University of Washington Seattle Campus

The University of Washington campus is located north of SR 520, on the north side of Portage Bay, the Montlake Cut, and Union Bay; it spans an area roughly from I-5 to 38th Avenue NE. Although some development will occur near the shoreline area, the development is intentionally scaled smaller toward the shoreline. Campus projects that increase impervious surface area (especially new PGIS) could also potentially affect these water bodies.

University facilities are expected to grow by approximately 1.35 million gross square feet between 2007 and 2013 to accommodate the projected growth of the Washington population seeking higher education (University of Washington 2003). The 2007–2009 Capital Facilities Update includes the following projects that would occur relatively close to the shoreline:

- **University of Washington Medical Center expansion.** Construction of Phase 1 (a roughly 178,000-foot expansion) began in 2009 and is expected to be completed in 2012. Future phases will complete the build out of expanded areas (University of Washington 2010a).
- **Car-top boat launch and Portage Bay vista.** The university is constructing a new car-top boat launch in Portage Bay. Because of the site's proximity to the alignment of Sound Transit's University Link light rail, the City of Seattle and the University of Washington have agreed to complete the construction within 18 months of the completion of the University Link project (see Section 6.7.8).
- **Athletic facility improvements such as changes to Husky Stadium, Hec Edmondson Pavilion, the baseball stadium, and the soccer stadium.** Design is currently under way for the renovation of Husky Stadium and the construction of a new football operations and support facility (University of Washington 2010b). Other improvements will be made as funding becomes available.

University of Washington projects are regulated, not only by City of Seattle development codes, but by the guiding principles of the university. A stated goal of the master plan is that “The Campus Master Plan should value the environment and strive to promote the conservation of natural resources and goals of the Growth Management Act and Shoreline Management Act.” Other City of Seattle regulations that protect the environment include Seattle Municipal Code (SMC), Title 25 (Environmental Protection and Historic Protection), which addresses environmental policies and procedures, tree protection, floodplain development, and environmentally critical areas such as fish and wildlife habitat conservation areas. SMC Title 22 (Building and Construction Codes) includes the stormwater code, with regulations to protect water quality. Based on the combination of the university’s goals and policies and the City’s development regulations, the University of Washington projects are not expected to substantially affect ESA-listed species or their critical habitat.

6.7.2.2 City of Seattle Park Facilities

The City of Seattle manages a number of park facilities within or near the shoreline of Lake Washington, including Magnuson Park, West Montlake Park, Interlaken Park, McCurdy Park, the Montlake Playfield, and th eWashington Park Arboretum. Of these, capital improvement projects are proceeding in accordance with the associated master plans at Magnuson Park and the Washington Park Arboretum (Sheffer 2009). Magnuson Park is located approximately 1 mile north of the proposed replacement bridge alignment, along the western shore of Lake Washington. An initial phase of improvements at Magnuson Park, adding ball fields and constructing a wetland, was completed in September 2009. A second phase of improvements includes more ball fields, that are expected to be open in late 2010 (City of Seattle 2010a). The 2011 Capital Improvement Program includes funding for three renovation/restoration-type projects within the park.

Seattle Parks also owns most of the land and buildings that constitute the Sand Point Historic District, located within Magnuson Park. The district has been undergoing and will continue to undergo renovations and redevelopment. For example, in 2008, the Mountaineers completed renovations to an existing building, transforming it into a new clubhouse. The Seattle City Council is currently reviewing land use amendments to the Sand Point Overlay District that will provide the framework for future renovations. The amendments include support for building redevelopment by permitting additional principal land uses and reconstruction of buildings on existing footprints (City of Seattle 2010b). The Washington Park Arboretum is located immediately south of SR 520 and Union Bay. At the arboretum, the development of Pacific Connections—a series of ecogeographic forests—will occur in three phases over 2 decades.

City of Seattle park facilities are subject to the City’s development regulations, as identified above. As part of its mission, Seattle Parks works with all citizens to be good stewards of the environment. Based on the combination of the development regulations and the nature of proposed improvements, which include primarily upland activities, these projects are not expected to substantially affect listed species or critical habitat.

6.7.2.3 Seattle Children's Hospital

On April 5,2010, the Seattle City Council approved Seattle Children's hospital's Major Institution Master Plan (Seattle Children's 2010a). The plan includes the approval of a 20-year physical development plan in four phases, a new transportation management plan regulating commuting and parking, development standards governing new construction, an increase in the amount of allowed parking provided at the campus, and rezoning to expand the existing boundaries of the Major Institution Overlay district and increase the permitted height of buildings within this district. Total development on the existing and expanded campus will not exceed 2,125,000 gross square feet, excluding above- and below-grade parking and rooftop mechanical equipment.

Construction will begin in fall 2010 and continue through spring 2013. This estimated timeline depends on approval of the Phase 1 Master Use Permit, which was submitted to the City of Seattle on July 13, 2010. Seattle Children's estimates that approval will occur in late 2010 (Seattle Children's 2010b).

The facility is also more than 0.25 mile from Lake Washington. As a result, hospital expansion is not expected to result in any changes to aquatic resources in the Lake Washington watershed and is therefore unlikely to affect listed species or critical habitat.

6.7.2.4 Residential and Commercial Areas

In September 2008, the Seattle Department of Transportation updated its transportation plan for the large and dynamic area that includes all or parts of the University District, University Heights, Ravenna, Roosevelt, and Montlake neighborhoods. The update, called the University Area Transportation Action Strategy, was developed in response to changes in major projects such as Sound Transit's North Link light rail, improved planning resources, and the desire for a better implementation strategy. The goals of the strategy include improving existing planning to provide a comprehensive, multimodal transportation plan for the area and serving as the blueprint for financing and prioritizing capital improvements in the University area for the next 25 years. Many of the highest priority projects, such as adding turn lanes, bicycle lanes, and transit lanes, do not require expanding the roadway footprint. The idea is to implement all the recommended projects by 2030, subject to funding availability.

Infrastructure improvements will be subject to City of Seattle environmental and development regulations. Because most of the proposed improvements do not involve expanding the footprint of the roadway and largely focus on developing more efficient transportation project to minimize or reduce the need for future expansions, the proposed improvements are unlikely to result in substantial adverse effects on listed species or critical habitat.

Much of the western Lake Washington shoreline north and south of SR 520 consists of single-family residential areas, interspersed with some multifamily residential areas. Based on an online review of active and issued construction permits in the area, residential construction consists mostly of renovation and remodeling projects. A few residential projects include in-water work such as piling replacement and new moorage construction. Otherwise, no major redevelopment projects have been identified at this time (Hauger 2009).

Most new commercial construction and commercial alterations and renovations are associated with the University of Washington facility improvements (generally described above) or Sound Transit's University Link light rail (discussed in Section 6.7.8).

6.7.3 City of Bellevue

The City of Bellevue has an estimated population of 120,600 (OFM 2009). Bellevue is located along the eastern shoreline of Lake Washington, south of SR 520. It has an almost completely developed shoreline, most of it privately held and developed as high-value single-family residences.

The current development review reports show few projects along the shoreline. Most development is primarily in the downtown core area. One of the projects along the shoreline, scheduled to begin in late 2010, involves placing washed rock on top of exposed sewer lines in the lake to protect them from damage by wave action and boat propellers.

Only two planning initiatives pertain to or will occur near the action area for the SR 520, I-5 to Medina project—one is the update of the City of Bellevue's shoreline master program. The other is the Meydenbauer Bay Project, which is located near downtown on the eastern shore of Lake Washington. The park will provide the public more access to the water and areas for picnicking, swimming, or walking on a boardwalk with views of the city. On April 13, 2010, the Bellevue Parks and Community Services Board voted 6 to 1 to recommend that the Bellevue City Council adopt the plan. The Bellevue Parks and Community Services Board presented its recommendation to city council on June 7, 2010. However, if the city council adopts a master plan for the park, work is not expected to begin for at least 5 years because no city money is budgeted and the permitting required for waterfront property is "extensive" (Matrix Real Estate 2010).

6.7.4 City of Kirkland

The City of Kirkland has an estimated population of 49,010 (OFM 2009). Kirkland includes several miles of shoreline north of SR 520 on the eastside of Lake Washington. The neighborhoods nearest SR 520 are known as Lakeview and Moss Bay (City of Kirkland 2009). The Lakeview neighborhood west of Lake Washington Boulevard includes parks, single-family and multifamily dwellings, commercial uses, and marinas. The primary policy direction for the area is to continue the primarily low-density residential uses. However, offices and limited freeway commercial use would also be allowed at the southern end of the neighborhood near Yarrow Bay. The Moss Bay neighborhood is the central neighborhood of Kirkland and encompasses the downtown business district. A major policy emphasis for the Moss Bay neighborhood is to encourage commercial activities in the downtown area and to expand “close-in” housing opportunities by encouraging medium- to high-density residential uses in the perimeter of the downtown corridor.

Much of the shoreline in Kirkland is currently developed to its maximum. However, a retail strategy recently prepared for downtown Kirkland recommends the development of a master plan for core and waterfront areas to coordinate public and private initiatives for creating additional retail space. Consequently, some downtown redevelopment can reasonably be expected in the foreseeable future.

In addition, a number of major development projects (primarily mixed-use redevelopment) are in various stages of permitting (City of Kirkland 2010a). Noteworthy projects include the following:

- A new four-story, 47,101-gross-square-foot office building constructed within a surface parking lot of the existing Plaza at Yarrow Bay office development. The permit for this project was issued in December 2009.
- The redevelopment of Parkplace Center to create a mixed-use project, including seven buildings up to eight stories high and containing approximately 1.8 million square feet of office, retail, hotel, sports club, supermarket, and movie theater space, as well as public open space and parking. The existing buildings would be removed. At its September 21, 2009 meeting, the Kirkland City Council reaffirmed the ordinances it approved in late 2008 that amended the City’s Comprehensive Plan and Zoning Code to allow for the Parkplace redevelopment. Also, the city council adopted an ordinance amending the Comprehensive Plan to include necessary capital improvements and a multiyear financing plan. The city council’s reaffirmation of the ordinances does not constitute approval of the project, only the reapproval of amendments to the Comprehensive Plan’s Downtown Plan and to the Zoning Code and Zoning Map for the proposal. The proposal has been under review by the City’s Design Review Board since early 2009. The review board expects to complete its review of the proposal by end of 2010 (City of Kirkland 2010b).
- On Lake Street, a new four-story mixed-use office building with ground floor retail and restaurant uses and five levels of underground parking.
- Widening of Third Street to accommodate the construction of a new transit center and related structures at Peter Kirk Park. Between fall 2009 and fall 2010, new bus bays and passenger shelters, enhanced pedestrian crossings, widened sidewalks, landscaping, bicycle amenities, and public art will be constructed and installed. Construction started in October 2009 and is expected to be completed by January 2011 (Sound Transit 2010a).

Marsh Park, Houghton Beach Park, and Yarrow Bay wetlands occur along the shoreline at the south end of Kirkland. Of these, the Yarrow Bay wetlands constitute the largest property, covering 73 acres. Kirkland's capital improvement program identifies a dock renovation project for Marsh Park, potentially starting in 2011. However, no major redevelopment or capital improvement projects are identified for these park properties.

City of Kirkland regulations that protect the environment include Kirkland Municipal Code, Title 24 (Environmental Procedures), which include shoreline regulations, and Title 23 (Zoning Code), which addresses critical areas and tree management. Redevelopment projects offer an opportunity to upgrade stormwater systems. Based on these factors, the projects identified in Kirkland are not expected to have substantial effects on listed species or critical habitat.

6.7.5 City of Medina

The current Evergreen Point Bridge comes ashore in Medina on the east side of Lake Washington. With an estimated population of 2,970, Medina consists primarily of single-family homes along the shoreline (OFM 2009).

Based on telephone conversations with the city planner, there are no planned or anticipated private or public developments along the shoreline (Clem 2009). No capital projects or other projects were identified along the shoreline. Therefore, foreseeable shoreline activities are likely to consist primarily of maintaining the existing development such as docks or piers. These maintenance activities may cause localized and temporary disruptions to foraging and/or migration behavior of salmonids within the area. The SR 520, I-5 to Medina project will contribute to these construction effects, and long-term effects of the project are expected to maintain existing conditions for this portion of the action area for the SR 520, I-5 to Medina Project.

6.7.6 City of Hunts Point

Hunts Point, with an estimated population of 465 (OFM 2009), is located east of Medina; SR 520 runs along the southern boundary of the city. The shoreline is fully developed and primarily consists of single-family residences (Green 2009).

Some shoreline actions may occur as homeowners replace docks or piers. Some owners are also voluntarily removing shoreline bulkheads (Green 2009). The only shoreline development under way is the WSDOT stormwater treatment facility. Therefore, limited changes in conditions for listed species and critical habitat are expected to occur in this portion of the action area for the SR 520, I-5 to Medina Project.

6.7.7 City of Yarrow Point

Yarrow Point, with an estimated population of 965 (OFM 2009), is located west of Kirkland and east of Hunts Point; SR 520 runs along the southern boundary of the city. The shoreline is fully developed and primarily consists of single-family residences (Green 2009).

Some shoreline actions may occur as homeowners replace docks or piers. Some owners are also voluntarily removing shoreline bulkheads. The City of Yarrow Point is planning a citywide stormwater facility replacement and improvement program as part of the current capital improvement plan (Green2009). The SR 520, I-5 to Medina project consists primarily of lane restriping in the Yarrow Point area, resulting in little or no potential for affecting aquatic habitat in this portion of the action area. Therefore, the SR 520, I-5 to Medina project is not expected to result in additional effects on listed species or critical habitat.

6.7.8 Federal Projects (for Reference)

For reference only, several major projects that involve federal action have been identified in the vicinity. Because of the federal involvement, these projects will undergo (or have undergone) separate review under the ESA. They are listed below for information only:

- University Link light rail (federal action involving the Federal Transit Authority) which will extend light rail from downtown Seattle to the University District. It will consist of 3.15 miles of tunnels and two stations, one of which will be on the University of Washington campus near Husky Stadium. Sound Transit initiated construction in 2009, and construction is expected to take 6 years (Sound Transit 2010b).
- I-5 reconstruction improvements, including the option of the addition of a lane on southbound I-5, south of SR 520 (WSDOT 2010d).

6.8 Conclusion

Based on the above projections, additional development is likely to further reduce habitat quality within the action area through water withdrawals, increased stormwater volumes, decreased water quality, loss of riparian functions, and modifications to the migration routes of listed salmonids. These activities may cause localized and short-term disruption to foraging and/or migration behaviors of salmonids, although the already highly modified shorelines in the action area are not expected to be substantially altered. As a result, the long-term conditions are expected to remain similar to the existing conditions, with some instances of further degradation and other instances of habitat restoration. Overall, the highly developed upland areas in the action area and the overall Lake Washington watershed are expected to continue to hinder the recovery goals for listed salmonids.

7. EFFECT DETERMINATIONS FOR LISTED SPECIES

7.1 Puget Sound Chinook Salmon

The project will result in both short- and long-term alterations to Chinook salmon habitat in the action area. These alterations will result from the installation of work bridges, construction of permanent in-water support structures, construction of over-water structures, and demolition of existing bridge structures. These construction activities will result in conditions that can directly or indirectly affect Chinook salmon, such as increased turbidity due to disturbance of the substrate and increased underwater noise due to pile driving. The project is also expected to alter fish behavior because of changes in shade, artificial lighting, and structural complexity, which can lead to increased predation, migration delays, or changes in foraging success.

These construction activities will occur over a period of about 8 years and will extend over a large area of aquatic habitat. The aquatic areas that will be altered by the construction activities are used by various life stages of Chinook salmon. Therefore, the spatial and temporal extent of construction activities will increase the potential effects (stressors) on multiple life stages and age classes of Chinook salmon.

Despite the extent and duration of the construction activities, some stressors are considered to have insignificant or discountable effects on Chinook salmon. These stressors and the reasons they are considered insignificant or discountable are indicated in Exhibit 7-1.

EXHIBIT 7-1.
STRESSORS ON CHINOOK SALMON

Stressor	Reason Considered Insignificant or Discountable
Pollutants	No known areas of contamination are present in the project area, and project BMPs will substantially reduce the potential for pollutants reaching the aquatic environment.
Physical debris	Construction BMPs are expected to prevent construction and demolition debris from entering the aquatic environment and allow swift retrieval if any material inadvertently enters.
Riparian disturbance	Most riparian habitat areas subject to disturbance by project activities do not occur in areas of preferred Chinook salmon habitat.
Benthic disturbance	Most benthic habitat in the action area consists of dense aquatic vegetation beds that are not expected to provide substantial Chinook salmon habitat.
Limnological processes	Proposed replacement bridge is not expected to measurably alter the limnology of Lake Washington.

7.1.1 Species

The project *may affect* Puget Sound Chinook salmon for the following reasons:

- It is expected that some portion of the Lake Washington Chinook salmon population exhibits a “stream type” life cycle, meaning that smoltification does not occur until age 1+.

Therefore, it can be assumed that some number of juvenile Chinook may be within the action area year-round, including periods of project construction and demolition.

- Some number of adult Chinook salmon will be present within the action area during the in-water construction period.
- Pile driving will increase the underwater noise levels during times that juvenile and adult Chinook salmon could occur in the action area.
- Project activities will result in temporary and long-term alterations of Chinook salmon habitat and potential behavior alterations. These habitat alterations include the following:
    - Increased over-water shading due to a wider bridge structure and extensive low-elevation work trestles
    - Decreased shade intensity due to an increase in the height of some over-water structures
    - Increased habitat complexity due to in-water structures
    - Increased nighttime illumination of the aquatic habitat due to construction lighting
    - Disturbance of benthic and riparian habitat during construction

The project is *likely to adversely affect* Puget Sound Chinook salmon for the following reasons:

- Chinook salmon will likely occur in the action area during the in-water construction period, when construction and habitat-disturbing activities will occur, likely resulting in behavioral disturbances and, in some cases, direct mortality.
- Extensive pile-driving activities will expose some adult and juvenile Chinook salmon to underwater noise levels that are greater than the thresholds for disturbance (150 dB_{RMS}) and/or injury (183 or 187 dB_{SEL}) for salmonid species.
- Increased over-water shading will alter the migration behavior of juvenile Chinook salmon, potentially resulting in direct mortality due to predation or reduced survival due to delayed entry to estuarine waters.
- Increased intensity and distribution of artificial lighting during construction will attract juvenile Chinook salmon to areas potentially occupied by predators.
- Juvenile Chinook salmon could potentially be trapped by the installation of cofferdams and drilled shaft casings, or at casting facilities, requiring their removal or resulting in mortality if they cannot be removed.
- The in-water installation of the construction work trestles and permanent bridge support structures will result in a net temporary and permanent loss of migration and rearing habitat in the action area.
- Adult and juvenile Chinook salmon will be migrating through the action area during project operation and storm events and could be exposed to copper or zinc concentrations in excess of the sublethal effect threshold.

7.1.2 Critical Habitat

Designated critical habitat for Puget Sound Chinook salmon occurs in the action area; the project *may affect* this habitat, because the following PCEs occur in the action area:

- Freshwater migration corridors, which are free of obstruction and excessive predation, 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.
- 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, logjams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.
- Estuarine areas free of obstruction and excessive predation with (i) water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between freshwater and saltwater; (ii) natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and (iii) juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.
- Nearshore marine areas free of obstruction with water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels.
- Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.

The project is *likely to adversely affect* designated Puget Sound Chinook salmon critical habitat for the following reasons:

- In-water construction areas will result in alteration of critical habitat in the area.
- Juvenile Chinook salmon occurring within the action area may be temporarily displaced or may avoid rearing habitat near pile-driving activities and other construction activities and areas affected by in-water and over-water structures. The timing of in-water work, methods of pile installation, and the implementation of sound attenuation devices (bubble curtains) will reduce, but not eliminate, these effects. These factors, when taken together, will result in an unavoidable adverse effect on Chinook salmon critical habitat during the in-water construction period and during the long-term operation of the project.
- The project will alter habitat complexity conditions that support juvenile growth and mobility.

- The migration of juvenile and adult Chinook salmon may be altered due to the placement of permanent and temporary in-water structures within the project area. The new, substantially wider but higher bridge deck throughout much of the project area may slightly increase the shaded area, which could disrupt migration behavior. The displacement or avoidance of migration habitat by juvenile Chinook salmon may occur near the in-water construction activities due to noise-producing pile-driving activities. The timing of pile driving and the implementation of sound attenuation devices (bubble curtains) will reduce, but not eliminate, these effects.
- The larger permanent in-water bridge columns will result in some loss of migration habitat. However, this habitat loss will be partially offset by the removal of the existing bridge columns.
- Water quality and quantity will be periodically affected by construction activities in the action area, although long-term reductions in the rate of pollutant loading from stormwater are expected to occur.

These factors, when taken together, will likely result in an unavoidable effect on one or more Puget Sound Chinook salmon PCEs.

7.2 Puget Sound Steelhead

As for Chinook salmon, the project will result in both short- and long-term alterations of steelhead habitat in the action area. The project activities and stressors that could affect steelhead and their responses to the stressors are also similar to those described above for Chinook salmon.

7.2.1 Species

The project *may affect* Puget Sound steelhead for the following reasons:

- A substantial proportion of Lake Washington steelhead are believed to have extended freshwater rearing phases, and it is assumed that steelhead will occur within the action area year-round, including periods of project construction and demolition.
- Pile driving will increase the underwater noise levels during times that juvenile and adult steelhead are likely to occur in the action area.
- Project activities will result in temporary and long-term alterations of steelhead habitat and potential behavior alterations. These habitat alterations include the folllowing:
    - Increased over-water shading due to a wider bridge structure and extensive low-elevation work trestles
    - Decreased shade intensity due to an increase in the height of some over-water structures
    - Increased habitat complexity due to in-water structures
    - Increased nighttime illumination of the aquatic habitat due to construction lighting

- Disturbance of benthic and riparian habitat during construction

The project is *likely to adversely affect* Puget Sound steelhead for the following reasons:

- Steelhead will likely occur in the action area during the in-water construction period, when pile-driving and habitat-disturbing activities will occur, likely resulting in behavioral disturbances.
- Extensive pile-driving activities will expose some adult and juvenile steelhead to underwater noise levels that are greater than the thresholds for disturbance (150 dB_{RMS}) and/or injury (183 or 187 dB_{SEL}) for salmonid species.
- Increased over-water shading could alter juvenile steelhead migration behavior, potentially resulting in direct mortality due to predation or reduced survival due to delayed entry into estuarine waters, although the relatively large steelhead are more likely to occur in deeper-water areas, away from the immediate construction areas.
- Increased intensity and distribution of artificial lighting during construction will likely attract juvenile steelhead to areas potentially occupied by predators.
- Juvenile steelhead could potentially be trapped by the installation of cofferdams and drilled shaft casings, requiring their removal or resulting in mortality if they cannot be removed.
- The in-water installation of the construction work trestles and permanent bridge support structures will result in a net temporary or permanent loss of potential migration and rearing habitat in the action area.
- Adult and juvenile steelhead will be migrating through the action area during project operation and storm events and could be exposed to copper or zinc concentrations in excess of the sublethal effect threshold.
- The alteration of aquatic habitat, which could result in direct and indirect mortality, will be similar to that discussed above for Chinook salmon.

7.2.2 Critical Habitat

NMFS has neither proposed nor designated critical habitat for Puget Sound steelhead.

7.3 Coastal-Puget Sound Bull Trout

As for Chinook salmon, the project will result in both short- and long-term alterations of Coastal-Puget Sound bull trout habitat in the action area. The project activities and stressorsthat could affect bull trout and their responses to the stressors are similar to those described above for Chinook salmon.

In addition, the quality of estuarine habitat in Grays Harbor may be altered due to the potential long-term storage of project pontoons and the potential limited dredging activities in the area. However, estuarine habitat factors (water quality, water quantity, salinity, large wood abundance, aquatic vegetation, large rocks and boulders, and side channels) are lacking within the action area, and these parameters will not be adversely altered by project construction.

7.3.1 Species

The project *may affect* Coastal-Puget Sound bull trout for the following reasons:

- Although few adult and subadult bull trout occur in Lake Washington and water bodies in the area, the extent and duration of the project activities will increase the possibility of affecting bull trout. Bull trout could occur within the action area year-round, including periods of project construction and demolition.
- Pile driving will increase the underwater noise levels during times that subadult and adult bull trout are suspected of occurring in the action area.
- Project activities will result in temporary and long-term alterations of bull trout habitat and potential behavior alterations. These habitat alterations include the following:
    - Increased over-water shading due to a wider bridge structure and extensive low-elevation work trestles
    - Decreased shade intensity due to an increase in the height of some over-water structures
    - Increased habitat complexity due to in-water structures
    - Increased nighttime illumination of the aquatic habitat due to construction lighting
    - Disturbance of benthic and riparian habitat during construction

The project is *likely to adversely affect* Coastal-Puget Sound bull trout for the following reasons:

- Bull trout could occur in the action area, although likely in limited numbers, during the in-water construction period, when construction and potential habitat-disturbing activities will occur. Their occurrence will result in some potential for behavioral disturbances.
- Extensive pile-driving activities will expose some adult and subadult bull trout to underwater noise levels that are greater than the thresholds for disturbance (150 dB_{RMS}) and/or injury (183 or 187 dB_{SEL}) for salmonid species.
- Adult and subadult bull trout will be migrating through the action area during project operation and storm events and could be exposed to copper or zinc concentrations in excess of the sublethal effect threshold.

7.3.2 Critical Habitat

The project *may affect* designated Coastal-Puget Sound bull trout critical habitat for the following reasons:

- Bull trout critical habitat occurs in the Lake Washington portion of the action area. Lake Washington is not directly connected to bull trout spawning habitat, but it provides potential FMO habitat for the few bull trout expected to occur in the lake. The lake also provides FMO habitat for amphidromous bull trout produced outside the WRIA 8 watershed in designated core areas (e.g., the Stillaguamish River, the Snohomish-Skykomish River, and possibly others).

- Within the designated critical habitat areas, the PCEs for bull trout are those habitat components that are essential for the primary biological needs of foraging, reproducing, juvenile rearing, dispersal, genetic exchange, or sheltering (USFWS 2005b). The specific PCEs that apply to bull trout in the action area are the following:
    - Migratory corridors with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and foraging habitats, including intermittent or seasonal barriers induced by high water temperatures or low flows
    - An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish
- Bull trout prey species (juvenile salmonids) use Lake Washington and the action area for migration and rearing, and these activities are likely to be affected by the project. Therefore, bull trout foraging activities and effectiveness are also likely to be affected.

The project is *likely to adversely affect* designated Coastal-Puget Sound bull trout critical habitat for the following reasons:

- Some displacement or avoidance of migration habitat by bull trout may occur in the overall action area due to noise-producing pile-driving activities and altered habitat. The timing of pile driving and the implementation of sound attenuation devices (bubble curtains) will reduce, but not eliminate, the potential for these effects.
- Water quality and quantity will be periodically affected by construction activities in the action area, although long-term reductions in the rate of pollutant loading from stormwater are expected to occur.

7.4 Puget Sound/Georgia Basin Rockfish

The quality of nearshore marine and estuarine habitat at the Port of Olympia and CTC pontoon construction will not be altered by the operation of these facilities to construct and launch the project pontoons. The pontoon construction activities will be similar to existing operations at these facilities. The pontoon construction cycles at CTC involve flooding the casting basin and opening the gates to allow the constructed pontoons to be floated out and towed to Lake Washington, followed by closing the gates and dewatering the facility. These pontoon launch cycles have the potential to entrain fish occurring in the vicinity.

7.4.1 Species

The project *may affect* Puget Sound/Georgia Basin yelloweye rockfish, canary rockfish, and bocaccio for the following reasons:

- Although the nearshore habitat is not likely preferred by adult and juvenile rockfish, larvae and early juveniles could be transported to these areas by tidal and wind-driven currents.
- The operation of pumps and intake/outlet ports at the pontoon construction facilities has the potential to entrain the larval and early juvenile life stages of these rockfish species.

The project is *not likely to adversely affect* Puget Sound/Georgia Basin yelloweye rockfish, canary rockfish, and bocaccio for the following reasons:

- The areas adjacent to the pontoon construction sites are less than 120 feet deep; therefore, adult ESA-listed rockfish are not expected to be present and thus will not be affected by project activities.
- There are no steep gradients or kelp beds near the proposed pontoon construction sites to attract juvenile rockfish.
- The low numbers of these rockfish species occurring in south Puget Sound, and the length of time that larval stages are dispersed by currents will make it unlikely that concentrations will occur near the pontoon construction sites.
- The relatively protected areas adjacent to the pontoon construction sites will likely result in limited tidal or wind-driven currents to transport larval fish to these areas.
- The reproductive strategy used by these rockfish species includes production of very large numbers of eggs and larval stages. Fecundity of females of these species ranges up to 2,000,000 eggs. Therefore loss of a few rockfish larvae would be considered insignificant.

7.4.2 Critical Habitat

NMFS has neither proposed nor designated critical habitat for Puget Sound/Georgia Basin yelloweye rockfish, canary rockfish, and bocaccio.

7.5 Southern Resident Killer Whale

Proposed project activities in the marine environment have the potential to affect SRKWs and their designated critical habitat. Pathways of potential effects include vessel activity and changes in prey quantity.

7.5.1 Species

The project *may affect* SRKWs for the following reasons:

- While the pontoons are being towed, SRKWs may be present in portions of the towing route from Grays Harbor to Puget Sound and from the Port of Olympia and the Port of

Tacoma facilities to Lake Washington. Pontoon transport to Puget Sound, and subsequently to Lake Washington, is currently scheduled to occur over a 2-year time frame between August 2012 and August 2014.

- Activity of vessels engaged in pontoon transport has the potential to cause behavioral responses or interfere with communication or prey location.
- Project activities are likely to adversely affect Chinook salmon and other salmonids, potentially reducing the availability of prey species for SRKWs.

The project is *not likely to adversely affect* SRKWs for the following reasons:

- SRKWs are extremely unlikely to be present in the vicinity of most project activities during most months. The pontoon towing route will avoid the areas of greatest summer concentration, near the San Juan Islands and Haro Strait. The only portions of the towing route where SRKWs have more than a negligible likelihood of occurrence are the central and southern portions of Puget Sound, where some observation blocks have six or more unique sighting days during the fall and winter months (primarily October through January). No open-ocean towing is anticipated during the months of November through February, effectively eliminating the potential for effects related to pontoon transport from Grays Harbor to Puget Sound during that period. It is possible, however, that SRKWs may be present in the vicinity of pontoon transport activities within Puget Sound (e.g., from the Port of Olympia or the Port of Tacoma facility to the Lake Washington Ship Canal).
- Maximum sound levels produced by tugboats towing pontoons occur at frequencies around 500 hertz, which is less than the frequencies of peak hearing sensitivity for killer whales (18 to 42 kilohertz [Szymanski et al. 1999]). Pontoon transport will occur within existing shipping channels, which are characterized by high levels of use by commercial and recreational vessels. Sound pressure levels a short distance from the towing tugboats are expected to be less than ambient levels. Therefore, noise generated by the towing vessels is unlikely to mask the acoustic signals of biological significance to SRKWs. Sound pressure levels from vessel transit are also likely to be less than the behavioral threshold for disturbance, even at the source. Therefore, disturbance of SRKWs by vessel noise is expected to be insignificant.
- Vessels engaged in pontoon transport will be easily detected and avoided by killer whales. The vessels will be slow-moving (the expected speed is 4 knots), will follow a predictable course within existing shipping lanes, and will not target whales. Consequently, vessel strikes are extremely unlikely and are, therefore, discountable as a potential pathway of effects; any potential encounters with SRKWs are expected to be sporadic and transitory in nature.
- Adverse effects on fish species will be limited in duration and will not necessarily result in measurable decreases in the availability of prey for SRKWs. Construction activities are expected to result in temporary adverse effects on habtiat for Pacific salmon, but improvements in habitat conditions are expected over the long term. Such improvements

include a reduction in the number and spacing of in-water structures, an increase in stormwater treatment, and a potential decrease in the over-water shading effects of the proposed replacement bridge. In addition, the proposed conservation measures and project BMPs will further limit the scope and scale of any potential effects. As a result, no measurable long-term deleterious effects on salmon habitat are expected. Any short-term decreases in productivity from the Lake Washington system will likely represent a minute portion of the total population of salmonids in Puget Sound. For all these reasons, the potential effects associated with changes in prey availability are expected to be insignificant.

7.5.2 Critical Habitat

The project *may affect* designated SRKW critical habitat, which includes the following PCEs:

- Water quality to support growth and development
- Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth
- Passage conditions to allow migration, resting, and foraging

The project is *not likely to adversely affect* designated SRKW critical habitat for the following reasons:

- Project activities will have no effect on water quality within any areas designated as SRKW critical habitat.
- Adverse effects on fish species will be limited in duration and are not expected to result in measurable decreases in the availability of prey for SRKWs. Salmonids from the Lake Washington system represent a negligible proportion of the Puget Sound salmonid populations overall. Therefore, the potential for project activities to result in a measurable decrease in the prey base for SRKWs is discountable, and the effects of any decreases will be insignificant.
- Actions that include transit by tugboats are unlikely to result in behavioral disturbance and are extremely unlikely to affect SRKW passage. Peak sound levels produced by towing tugboats occur at frequencies well below the peak hearing sensitivity of killer whales. In addition, sound pressure levels from the tugboats are expected to be less than ambient levels a short distance from the towing vessel and will occur for short periods at any particular location. For these reasons, the potential for pontoon transport to interfere with SRKW passage is discountable and insignificant.

Taken together, these factors are not likely to result in any adverse effects on the PCEs of SRKW critical habitat.

7.6 Essential Fish Habitat

EFH for Pacific salmon, groundfish, and coastal pelagic species is present in or adjacent to the action area. The project may result in effects on EFH: (1) possible temporary effects at pontoon construction and outfitting sites in Puget Sound and in locations of bridge replacement activities such as pile driving and in-water bridge construction within Lake Washington (including Portage Bay and Union Bay), and (2) permanent effects due to over-water/in-water structures in Lake Washington (including Portage Bay and Union Bay) and the bridge maintenance facility. The determination of effect is highly dependent on the efficacy of minimization and mitigation measures proposed for the project (see Appendix C).

Based on the EFH requirements of Pacific Coast salmon species, the BMPs, and the conservation and mitigation measures proposed as part of the project, the determination is that the project may adversely affect freshwater EFH for Pacific salmon in Lake Washington and the Ship Canal. However, the project will not adversely affect EFH for groundfish or coastal pelagic species (see AppendixC).

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APPENDIX A: SPECIES LISTS

Endangered Species Act Status of West Coast Salmon & Steelhead

(Updated July 1, 2009)

Species[1]			*Current Endangered Species Act Listing Status*[2]	*ESA Listing Actions Under Review*
Sockeye Salmon (*Oncorhynchus nerka*)	1	Snake River	*Endangered*	
	2	Ozette Lake	*Threatened*	
	3	Baker River	*Not Warranted*	
	4	Okanogan River	*Not Warranted*	
	5	Lake Wenatchee	*Not Warranted*	
	6	Quinalt Lake	*Not Warranted*	
	7	Lake Pleasant	*Not Warranted*	
Chinook Salmon (*O. tshawytscha*)	8	Sacramento River Winter-run	*Endangered*	
	9	Upper Columbia River Spring-run	*Endangered*	
	10	Snake River Spring/Summer-run	*Threatened*	
	11	Snake River Fall-run	*Threatened*	
	12	Puget Sound	*Threatened*	
	13	Lower Columbia River	*Threatened*	
	14	Upper Willamette River	*Threatened*	
	15	Central Valley Spring-run	*Threatened*	
	16	California Coastal	*Threatened*	
	17	Central Valley Fall and Late Fall-run	*Species of Concern*	
	18	Upper Klamath-Trinity Rivers	*Not Warranted*	
	19	Oregon Coast	*Not Warranted*	
	20	Washington Coast	*Not Warranted*	
	21	Middle Columbia River spring-run	*Not Warranted*	
	22	Upper Columbia River summer/fall-run	*Not Warranted*	
	23	Southern Oregon and Northern California Coast	*Not Warranted*	
	24	Deschutes River summer/fall-run	*Not Warranted*	
Coho Salmon (*O. kisutch*)	25	Central California Coast	*Endangered*	
	26	Southern Oregon/Northern California	*Threatened*	
	27	Lower Columbia River	*Threatened*	• Critical habitat
	28	Oregon Coast	*Threatened*	
	29	Southwest Washington	*Undetermined*	
	30	Puget Sound/Strait of Georgia	*Species of Concern*	
	31	Olympic Peninsula	*Not Warranted*	
Chum Salmon (*O. keta*)	32	Hood Canal Summer-run	*Threatened*	
	33	Columbia River	*Threatened*	
	34	Puget Sound/Strait of Georgia	*Not Warranted*	
	35	Pacific Coast	*Not Warranted*	
Steelhead (*O. mykiss*)	36	Southern California	*Endangered*	
	37	Upper Columbia River	*Threatened*	
	38	Central California Coast	*Threatened*	
	39	South Central California Coast	*Threatened*	
	40	Snake River Basin	*Threatened*	
	41	Lower Columbia River	*Threatened*	
	42	California Central Valley	*Threatened*	
	43	Upper Willamette River	*Threatened*	
	44	Middle Columbia River	*Threatened*	
	45	Northern California	*Threatened*	
	46	Oregon Coast	*Species of Concern*	
	47	Southwest Washington	*Not Warranted*	
	48	Olympic Peninsula	*Not Warranted*	
	49	Puget Sound	*Threatened*	• Critical habitat
	50	Klamath Mountains Province	*Not Warranted*	
Pink Salmon (*O. gorbuscha*)	51	Even-year	*Not Warranted*	
	52	Odd-year	*Not Warranted*	

1 The ESA defines a "species" to include any distinct population segment of any species of vertebrate fish or wildlife. For Pacific salmon, NOAA Fisheries Service considers an evolutionarily significant unit, or "ESU," a "species" under the ESA. For Pacific steelhead, NOAA Fisheries Service has delineated distinct population segments (DPSs) for consideration as "species" under the ESA.

Other ESA-Listed Species

Under the jurisdiction of NOAA Fisheries that may occur off Washington & Oregon:

- distinct population segment, or DPS, of bocaccio *(Sebastes paucispinis)* (E) in Puget Sound
- distinct population segment, or DPS, of canary rockfish *(Sebastes pinniger)* (T) in Puget Sound
- distinct population segment, or DPS, of yelloweye rockfish *(Sebastes ruberrimus)* (T) in Puget Sound
- southern distinct population segment, or DPS, of eulachon (Columbia River smelt) *(Thaleichthys pacificus)* (T)
- southern distinct population segment, or DPS, of north American green sturgeon (*Acipenser medirostris*) (T), listed in the NOAA Fisheries Southwest Region

(E) = Endangered
(T) = Threatened

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NOAA's National Marine Fisheries Service

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ESA-Listed Marine Mammals

Under the jurisdiction of NOAA Fisheries that may occur:

off Washington & Oregon

- Southern Resident killer whale (*Orcinus orca*) (E); critical habitat
- humpback whale *(Megaptera novaeangliae)* (E)
- blue whale *(Balaenoptera musculus)* (E)
- fin whale (*Balaenoptera physalus)* (E)
- sei whale (*Balaenoptera borealis)* (E)
- sperm whale (*Physeter macrocephalus)* (E)
- Steller sea lion *(Eumetopias jubatus)* (T); critical habitat

in Puget Sound

- Southern Resident killer whale *(Orcinus orca*) (E); critical habitat
- humpback whale *(Megaptera novaeangliae)* (E)
- Steller sea lion *(Eumetopias jubatus)* (T); critical habitat

(E) = Endangered
(T) = Threatened

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NOAA's National Marine Fisheries Service

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Home > Other Marine Species > ESA Turtle List

Search

ESA-Listed Marine Turtles

Under the jurisdiction of NOAA Fisheries that may occur off Washington & Oregon:

- leatherback sea turtle *(Dermochelys coriacea)* (E)
- green sea turtle (*Chelonia mydas)* (E)
- olive ridley sea turtle (*Lepidochelys olivacea)* (E)
- loggerhead sea turtle *(Caretta caretta)* (T)

Sightings and strandings of these animals are very rare, and there are no breeding beaches in the Northwest Region.

(E) = Endangered
(T) = Threatened

Search NOAA Fisheries

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Feb. 19, 2010: NOAA Fisheries extended the comment period on the proposed revision to existing critical habitat for the leatherback turtle under the Endangered Species Act. See the *Federal Register* notice *(PDF 49KB)* for details.

Jan. 5, 2010: NOAA Fisheries proposed to revise and expand critical habitat for the leatherback turtle under the Endangered Species Act. Additional information about this proposal can be found in the links below and on NOAA Fisheries' Office of Protected Resources Website.

- News Release *(PDF 73KB -- links to NOAA Fisheries Website)*
- *Federal Register* notice *(PDF 711KB)*

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Page last updated: June 17, 2010

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

(Revised November 1, 2007)

LISTED

Brown pelican (*Pelecanus occidentalis*) [outer coast]

Bull trout (*Salvelinus confluentus*)

Marbled murrelet (*Brachyramphus marmoratus*)

Northern spotted owl (*Strix occidentalis caurina*)

Oregon silverspot butterfy (*Speyeria zerene hippolyta*)

Short-tailed albatross (*Phoebastria albatrus*) [outer coast]

Western snowy plover (*Charadrius alexandrinus nivosus*)

Major concerns that should be addressed in your Biological Assessment of project impacts to listed 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.

DESIGNATED

Critical habitat for bull trout

Critical habitat for the marbled murrelet

Critical habitat for the northern spotted owl

Critical habitat for the western snowy plover

PROPOSED

None

CANDIDATE

Streaked horned lark (*Eremophila alpestris strigata*)
Yellow-billed cuckoo (*Coccyzus americanus*)

SPECIES OF CONCERN

Aleutian Canada goose (*Branta canadensis leucopareia*)
Bald eagle (*Haliaeetus leucocephalus*)
Cascades frog (Rana cascadae)
Coastal cutthroat trout (*Oncorhynchus clarki clarki*) [southwest Washington DPS]
Columbia torrent salamander (Rhyacotriton kezeri)
Long-eared myotis (*Myotis evotis*)
Long-legged myotis (*Myotis volans*)
Makah=s copper (butterfly) (*Lycaena mariposa charlottensis*)
Newcomb=s littorine snail (*Algamorda newcombiana*)
Northern goshawk (*Accipiter gentilis*)
Northern sea otter (*Enhydra lutris kenyoni*)
Olive-sided flycatcher (*Contopus cooperi*)
Olympic torrent salamander (*Rhyacotriton olympicus*)
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*)
Tufted puffin (*Fratercula cirrhata*)
Van Dyke=s salamander (*Plethodon vandykei*)
Western gray squirrel (*Sciurus griseus griseus*)
Western toad (*Bufo boreas*)
Aster curtus (white-top aster)
Cimicifuga elata (tall bugbane)
Dodecatheon austrofrigidum (frigid shootingstar)
Sanicula arctopoides (footsteps of spring; bear's-foot sanicle)

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 WESTERN WASHINGTON FISH AND WILDLIFE OFFICE

(Revised November 1, 2007)

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 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.
3. 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

None

CANDIDATE

Oregon spotted frog (*Rana pretiosa*)
Yellow-billed cuckoo (*Coccyzus americanus*)

SPECIES OF CONCERN

Bald eagle (*Haliaeetus leucocephalus*)
Beller's ground beetle (*Agonum belleri*)
California wolverine (*Gulo gulo luteus*)
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)

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

(Revised November 1, 2007)

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 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.

Arenaria paludicola (marsh sandwort) [historic]

Castilleja levisecta (golden paintbrush) [historic]

Howellia aquatilis (water howellia)

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.
3. 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

None

CANDIDATE

Mardon skipper (*Polites mardon*)
(Roy Prairie and Tacoma) Mazama pocket gopher (*Thomomys mazama* ssp. *glacialis* and *tacomensis* [historic])
Oregon spotted frog (*Rana pretiosa*)
Streaked horned lark (*Eremophila alpestris strigata*)
Taylor's checkerspot (*Euphydryas editha taylori*)
Yellow-billed cuckoo (*Coccyzus americanus*)

SPECIES OF CONCERN

Bald eagle (*Haliaeetus leucocephalus*)
California wolverine (*Gulo gulo luteus*)
Cascades frog (*Rana cascadae*)
Fender's soliperlan stonefly (*Soliperla fenderi*)
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*)
Oregon vesper sparrow (*Pooectetes gramineus affinis*)
Pacific lamprey (*Lampetra tridentata*)
Pacific Townsend=s big-eared bat (*Corynorhinus townsendii townsendii*)
Peregrine falcon (*Falco peregrinus*)
River lamprey (*Lampetra ayresi*)
Slender-billed white-breasted nuthatch (*Sitta carolinensis aculeata*)
Tailed frog (*Ascaphus truei*)
Valley silverspot butterfly (*Speyeria zerene bremeri*)
Western gray squirrel (*Scirius griseus griseus*)
Van Dyke=s salamander (*Plethodon vandykei*)
Aster curtus (white-top aster)

Botrychium ascendens (triangular-lobed moonwort)
Castilleja cryptantha (obscure paintbrush)
Cimicifuga elata (tall bugbane)
Cypripedium fasiculatum (clustered lady=s slipper)
Lathyrus torreyi (Torrey's peavine)

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

(Revised November 1, 2007)

LISTED

Bull trout (*Salvelinus confluentus*)

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 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) which may result in disturbance to listed species and/or their avoidance of the project area.

Castilleja levisecta (golden paintbrush)

Howellia aquatilis (water howellia)

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 habitat loss.

3. Changes in hydrology where taxon is found.

DESIGNATED

Critical habitat for the bull trout

Critical habitat for the marbled murrelet

Critical habitat for the northern spotted owl

PROPOSED

None

CANDIDATE

Mardon skipper (*Polites mardon*)
(Olympia, Tenino, and Yelm) Mazama pocket gopher (*Thomomys mazama* ssp. *pugetensis*, *tumuli*, and *yelmensis*)
Oregon spotted frog (*Rana pretiosa*)
Streaked horned lark (*Eremophila alpestris strigata*)
Taylor's checkerspot (*Euphydryas editha taylori*)

SPECIES OF CONCERN

Bald eagle (*Haliaeetus leucocephalus*)
California wolverine (*Gulo gulo luteus*)
Cascades frog (*Rana cascadae*)
Coastal cutthroat trout (*Oncorhynchus clarki clarki*) [southwest Washington DPS]
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*)
Oregon vesper sparrow (*Pooecetes gramineus affinis*)
Olive-sided flycatcher (*Contopus cooperi*)
Pacific lamprey (*Lampetra tridentata*)
Pacific Townsend=s big-eared bat *(Corynorhinus townsendii townsendii*)
River lamprey (*Lampetra ayresi*)
Slender-billed white-breasted nuthatch (*Sitta carolinensis aculeata*)
Tailed frog (*Ascaphus truei*)
Valley silverspot butterfly (*Speyeria zerene bremeri*)
Van Dyke=s salamander (*Plethodon vandykei*)
Western gray squirrel (*Sciurus griseus griseus*)
Aster curtus (white-top aster)
Cimicifuga elata (tall bugbane)
Sidalcea malviflora ssp. *virgata* (rose checker-mallow)

APPENDIX B: SPECIES LIFE HISTORIES AND CRITICAL HABITAT

SPECIES LIFE HISTORIES AND CRITICAL HABITAT

Chinook Salmon

Name of Species: Chinook salmon (*Oncorhynchus tshawytscha*)

Evolutionarily Significant Unit (ESU) or Distinct Population Segment (DPS): Puget Sound

Life History

In general, summer- and fall-run Chinook salmon migrate into freshwater in August and September (Wydoski and Whitney 1979). Spawning begins in late September and peaks in October, similar to other Chinook salmon stocks in south Puget Sound (Washington Department of Fisheries et al. 1993). Adult Chinook migrate upstream through Lake Washington from August through early October, spawning in major tributaries in the autumn.

After emergence, juvenile Chinook salmon rear in freshwater from a few days to several years (Wydoski and Whitney 1979). Puget Sound Chinook salmon generally migrate to the marine environment during their first year (Myers et al. 1998). These ocean-type Chinook salmon have a short freshwater residence and make extensive use of the Puget Sound nearshore habitat for rearing. They generally migrate downstream in the spring within 3 months of emerging from the gravel and after a brief freshwater rearing period (Healey 1991; Myers et al. 1998). Cedar River Chinook salmon migrate to Lake Washington. These juvenile Chinook salmon usually migrate in April or May and most Chinook salmon would have moved to Puget Sound by July, as seen in other Puget Sound systems (Hayman et al. 1996).

Juvenile Chinook salmon that remain in freshwater after emergence may migrate to the ocean any time of year, although most Chinook salmon within a population tend to migrate at similar times and ages (Healey 1991). Migration commonly occurs during the night under the cover of darkness, although some fish may migrate during the day (Healey 1991). Chinook salmon fry tend to migrate along the banks, but move offshore as they grow (Healey 1991).

Factors Affecting Puget Sound Chinook Salmon

Primary factors contributing to the declining abundance in the Puget Sound ESU include habitat blockages, hatchery introgression, urbanization, logging, hydropower development, harvests, and flood control and flood effects (NMFS 1998).

Status and Abundance of Puget Sound Chinook Salmon

The Puget Sound ESU of Chinook salmon originally included 31 historically quasi-independent populations, of which 22 are believed to be extant (PSTRT 2001, 2002). Many Puget Sound Chinook populations consist primarily of hatchery-origin fish (Myers et al. 1998). Long-term trends show approximately one-half of the populations declining and one-half generally increasing in abundance over the length of the available time series (Myers et al. 1998). Eight of the 22 extant populations also show a declining trend over the short term. Nehlsen et al. (1991) identified four stocks as extinct, four stocks as possibly extinct, six stocks at high risk of extinction, one stock at moderate risk, and one stock of special concern. A recent estimate of natural-origin spawners indicates that adult returns have declined from over 600,000 fish historically (Myers et al. 1998) to an average of about 30,000 fish between 1998 and 2002 (NMFS 2005).

Overall, the abundance of the Puget Sound Chinook ESU has declined substantially from historical levels, with many populations now small enough that genetic and demographic risks are relatively high (63 Federal Register 11494). Both long- and short-term trends in abundance are predominantly downward, and several populations are exhibiting severe short-term declines. Spring-run Puget Sound Chinook populations throughout this ESU are all depressed (Nehlsen et al. 1991).

Critical Habitat

As part of the designation of critical habitat, the National Marine Fisheries Service (NMFS) (2005) defined specific primary constituent elements (PCEs) for Chinook salmon critical habitat. PCEs include sites that are essential to supporting one or more life stages of the ESU and which contain physical or biological features essential to the conservation of the ESU. Specific sites and features designated for Puget Sound Chinook salmon critical habitat include the following:

1. Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning incubation and larval development.
2. Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions that support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.
3. Freshwater migration corridors free of obstruction with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival.
4. Estuarine areas free of obstruction, with water quality, quantity, and salinity conditions supporting juvenile and adult physiological transitions between freshwater and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.
5. Nearshore marine areas free of obstruction with water quality and quantity conditions and forage, including aquatic invertebrates and fishes supporting growth and maturation; and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels.

6. Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes supporting growth and maturation.

Steelhead Trout

Name of Species: Steelhead trout (*Oncorhynchus mykiss*)

ESU or DPS: Puget Sound

Life History

Steelhead trout are the anadromous form of freshwater resident rainbow or redband trout species. The present distribution of steelhead extends from Asia to Alaska, and south to the United States/Mexico border (Busby et al. 1996; 67 Federal Register 21586, May 1, 2002). Unlike many salmonid species, steelhead exhibit extremely complex and plastic life-history characteristics, such that their offspring can exhibit different life-history forms from the parental generation. For example, offspring of resident fish may migrate to sea, and offspring of anadromous steelhead may remain in streams as resident fish (Burgner et al. 1992).

Those that are anadromous can spend up to 7 years in freshwater prior to smoltification (the physiological and behavioral changes required for the transition to saltwater), and then spend up to 3 years in saltwater before returning to freshwater to spawn. However, they typically return to their natal stream to spawn as 4- or 5-year-old fish. Unlike Pacific salmon, steelhead trout are iteroparous, or capable of spawning more than once before they die. However, it is rare for steelhead to spawn more than twice before dying, and those that do are usually females (Busby et al. 1996).

Over their entire range, Pacific steelhead spawning migrations occur throughout the year, with seasonal peaks of migration activity varying by location. However, even in a given river basin there might be more than one seasonal migration peak, typically referred to as winter, spring, summer, or fall steelhead runs. Although there are generally four migration seasons, steelhead are typically divided into two basic reproductive ecotypes (summer and winter), based on the state of sexual maturity at the time they enter freshwater and the duration of spawning migration (Burgner et al. 1992). The summer ecotype, or stream-maturing type, enters freshwater in a sexually immature condition between May and October, and sexually matures in freshwater over several months. In contrast, the winter ecotype, or ocean-maturing type, enters freshwater in a sexually mature condition between November and April, and spawns shortly thereafter. In basins with ecotypes, the summer-run fish generally spawn farther upstream than winter-run fish. However, the winter run of steelhead is the predominant run in Puget Sound.

Depending on water temperature, fertilized steelhead eggs may incubate in redds for 1.5 to 4 months before hatching as alevins. Following yolk sac absorption, young juveniles, or fry, emerge from the gravel and begin active feeding. As they grow, steelhead move to deeper parts of the stream, establish territories, and change diets from microscopic aquatic organisms to larger organisms such as isopods, amphipods, and aquatic and terrestrial insects primarily associated with the stream bottom (Wydoski and Whitney 1979). Riparian vegetation and submerged cover (logs, rocks, and aquatic vegetation) are important for providing cover, food, temperature stability, and protection from predators. As a result, densities of juvenile steelhead are highest in areas containing in-stream cover (Reiser and Bjornn 1979; Johnson and Kucera 1985).

Factors Affecting Puget Sound Steelhead

The ESA-listing was based on the threatened destruction, modification, or curtailment of steelhead habitat or range; the inadequacy of existing regulatory mechanisms; and other natural and manmade factors affecting their continued existence. Factors contributing to the declining abundance in the Puget Sound ESU include habitat blockages, hatchery introgression, urbanization, logging, hydropower development, harvests, and flood control and flood effects.

Status and Abundance of Puget Sound Steelhead

The Washington Department of Fisheries (WDF) et al. (1993) identified 53 stocks within the Puget Sound ESU of steelhead. The ESU is composed primarily of winter-run populations (37 of the 53 populations). Steelhead are most abundant in northern Puget Sound, with winter-run steelhead in the Skagit and Snohomish rivers supporting the two largest populations (approximately 3,000 and 5,000, respectively). Summer-run populations are concentrated in northern Puget Sound and Hood Canal and all appear to be small, with most averaging less than 200 spawners annually (NMFS 2008).

Of the 53 stocks, 31 stocks were considered to be of native origin and predominantly naturally produced. WDF et al. (1993) found 11 of the 31 native/naturally produced stocks to be healthy, 3 depressed, 1 critical, and 16 of unknown status. Of the 22 nonnative/naturally produced stocks, WDF et al. (1993) determined 3 stocks to be healthy, 11 depressed, and 8 of unknown status. Since 1992, however, the number of estimated healthy populations has declined from 14 to 5, and the number of stocks estimated to be depressed increased from 14 to 19 (NMFS 2008).

Puget Sound steelhead historically occurred in all accessible large tributaries to Puget Sound and the eastern Strait of Juan de Fuca (WDFG 1932). Historical records (1889 to 1920) indicate a peak catch of 163,796 steelhead, with an estimated run size of between 327,592 and 545,987 fish in 1895 (NMFS 2008). By 1898, the run size was depressed by as much as 50 percent from the 1898 peak and continued to decline through the 1920s. In 1925, the Washington State Legislature classified steelhead as a game fish (no commercial catch allowed in the river habitat areas), prompting the commercial harvest levels to fall generally below 10,000 fish.

The total Puget Sound steelhead run sizes (catch and escapement) in the early 1980s (100,000 winter-run and 20,000 summer-run fish) consisted of an estimated 70 percent hatchery-origin fish (Light 1987). However, the escapement to spawning grounds was substantially lower due to differential harvest and hatchery returns (NMFS 2008). Busby et al.

(1996) estimated that 5-year average natural escapements ranged from fewer than 100 fish to about 7,200 fish, with corresponding total run sizes of 550 to 19,800 fish.

The trend towards declining abundance in recent years shows only 21 percent of the populations with an increase in average escapement from 1999 through 2004, compared to 1994 through 1998, and 67 percent of the populations with a reduction in the average escapement (WDFW 2008). Greatest reductions occurred in the stocks of the Carbon River (-50 percent), Pilchuck River (-51 percent), Snohomish/Skykomish River (-55 percent), and Lake Washington (-79 percent). The geometric means of most populations have declined in the last 5 years; recent mean abundance for many populations is 50 to 80 percent of the corresponding long-term means (NMFS 2008).

Overall, marked declines in the natural run sizes are evident in all areas of the ESU, reflecting a widespread reduction in productivity of natural steelhead. Throughout the ESU, natural steelhead production has shown, at best, a weak response to reduced harvest since the mid-1990s (NMFS 2008). Median population growth rates were estimated at less than one, indicating a declining population growth for nearly all populations in the ESU (Hard et al. 2007).

Critical Habitat

NMFS has not proposed or designated critical habitat for Puget Sound steelhead.

Bull Trout

Name of Species: Bull trout (*Salvelinus confluentus*)

ESU or DPS: Coastal-Puget Sound

Life History

The amphidromous life history form of bull trout is poorly studied (USFWS 1999). Unlike strict anadromy, as exhibited by Pacific salmon, amphidromous individuals often return seasonally to freshwater as subadults, sometimes for several years, before returning to spawn (Wilson 1997). For bull trout, the amphidromous life history form is unique to the Coastal-Puget Sound population. For many years, it was thought that amphidromous char in Washington were Dolly Varden (*Salvelinus malma*) and that freshwater char were bull trout. However, there is conclusive evidence that amphidromous bull trout populate Puget Sound (Kraemer 1994); anecdotal evidence suggests these native char were once much more abundant (USFWS 1999). In Washington state, bull trout and Dolly Varden, two closely related native char species, co-exist and are managed as a single species. Separate inventories are not maintained by the Washington Department of Fish and Wildlife (WDFW) due to the considerable biological similarities in life history and habitat requirements that exist between the two species. Although historical reports of char may have specified either bull trout or Dolly Varden, methodologies for reliably distinguishing between the two have only recently been developed and have not yet been widely applied (WDFW 1998).

Bull trout are considered to be optionally amphidromous (i.e., the survival of individuals is not dependent upon whether they can migrate to sea) in contrast to obligate anadromous species such as pink (*Oncorhynchus gorbuscha*) and chum (*O. keta*) salmon (Pauley 1991). Nonetheless, the amphidromous life history form is important to the long-term persistence of bull trout and their metapopulation structure. Amphidromous fish are generally larger and more fecund than their freshwater counterparts, and migratory forms play an important role in facilitating gene flow among subpopulations.

Bull trout are believed to be restricted in their spawning distribution by water temperature. Bull trout spawn in late summer and early fall (Bjornn 1991). Locally, amphidromous forms typically return to freshwater in late summer and fall to spawn in upper tributaries and headwater areas. In the Lake Washington system, all known spawning occurs in the upper portions of the Cedar River. Puget Sound stocks typically initiate spawning in late October or early November as water temperature falls below 42° to 46°F (7° to 8°C). Spawning habitat almost invariably consists of very clean gravel, often in areas of groundwater upwelling or cold spring inflow (Goetz 1994). Neither of these conditions exists in the action area. Egg incubation temperatures needed for survival have been shown to range from 36° to 39°F (2° to 4°C) (Willamette National Forest 1989). Bull trout eggs require approximately 100 to 145 days to hatch, followed by an additional 65 to 90 days of yolk sac absorption during alevin incubation. Thus, in-gravel incubation spans more than 6 months. Hatching occurs in winter or late spring, and fry emergence occurs from early April through May (Rieman and McIntyre 1993).

Generally, for the first 1 to 2 years, bull trout juveniles rear near their natal tributary and exhibit a preference for cool water temperatures (Bjornn 1991), although they appear less restricted by temperature than adult spawners. Newly emerged bull trout fry are often found in shallow, backwater areas of streams that contain woody debris. Later, or in other habitats lacking woody debris for refugia, fry are bottom dwellers and may occupy interstitial spaces in the streambed (Brown 1992). Because all known spawning occurs in the upper Cedar River, these habitat requirements are not pertinent in the action area.

Resident forms of bull trout spend their entire lives in small streams, while migratory forms live in tributary streams for several years before migrating to larger rivers (fluvial form) or lakes (adfluvial form). Migratory individuals typically move downstream in the summer and often congregate in large, low-velocity pools to feed (Bjornn 1991). Anadromous bull trout usually remain in freshwater 2 or 3 years before migrating to saltwater in spring (Wydoski and Whitney 1979).

Bull trout life histories are plastic (i.e., variable and changeable between generations), and juveniles may develop a life history strategy that differs from their parents. The shift between resident and migratory life forms may depend on environmental conditions. For example, resident forms may increase within a population when survival of migratory forms is low

(Rieman and McIntyre 1993). Char are generally longer-lived than salmon, and bull trout up to 12 years of age have been identified in Washington (Brown 1992).

Factors Affecting Coastal-Puget Sound Bull Trout

The current condition of bull trout populations is due in large part to factors related to human activities, which have affected bull trout and their habitat, and continue to do so. The factors that contribute to degrade PCEs include: 1) Fragmentation and isolation of local populations due to the proliferation of dams and water diversions that block access to important habitat, alter water flow and temperature regimes, and impede migratory movements (Rieman and McIntyre 1993; Dunham and Rieman 1999); 2) degradation of spawning and rearing habitat in upper watershed areas, from forest and rangeland practices and intensive development of roads that alter sediment loading and water temperature conditions (Fraley and Shepard 1989; MBTSG 1998); 3) introduction and spread of nonnative species (i.e., brook and lake trout) from fish stocking programs and habitat degradation conditions (Leary et al. 1993; Rieman et al. 2006); and 4) degradation of freshwater and nearshore marine FMO (feeding, migration, and overwintering) habitat due to human development activities.

Status and Abundance of Coastal-Puget Sound Bull Trout

Bull trout in the Coastal-Puget Sound interim recovery unit exhibit anadromous, adfluvial, fluvial, and resident life history patterns. The anadromous life history form is unique to this interim recovery unit. The Coastal-Puget Sound interim recovery unit contains 14 core areas and 67 local populations. Bull trout are distributed throughout most of the large rivers and associated tributary systems within this interim recovery unit (USFWS 2004). The Coastal-Puget Sound interim recovery unit includes subpopulations in the Nisqually, Puyallup, Green, Snohomish, Stillaguamish, Skagit, and Nooksack rivers, and the Lake Washington watershed. Within King County, self-sustaining populations of native char have been found in the South Fork Skykomish River (upper Snohomish River drainage), the upper Cedar River drainage (including the Cedar and Rex rivers and Chester Morse Lake), and the White River drainage (King County 2000). Surveys have also documented bull trout in the Green River, Chester Morse Reservoir, and Snohomish River-Skykomish River subpopulations. Incidental observations of native char have also occurred in the Tolt River, Issaquah Creek, the lower and middle Cedar River, Lake Washington, Lake Sammamish, Shilshole Bay, and the lower Green River.

The abundance of the Coastal-Puget Sound DPS of bull trout has declined from historical levels throughout their range. Bull trout continue to be present in nearly all major watersheds where they likely occurred historically, although local extirpations have occurred throughout this interim recovery unit. Many remaining populations are isolated or fragmented and abundance has declined, especially in the southeastern portion of the interim recovery unit (USFWS 2004).

Critical Habitat

As part of the designation of critical habitat, the U.S. Fish and Wildlife Service (USFWS) (2005) defined specific PCEs for bull trout critical habitat. PCEs designated for Coastal-Puget Sound bull trout critical habitat include the following:

1. Water temperatures that support bull trout use. Bull trout have been documented in streams with temperatures from 32° to 72°F (0° to 22°C) but are found more frequently in temperatures ranging from 36° to 59°F (2° to 15°C). These temperature ranges may vary depending on bull trout life history stage and form, geography, elevation, diurnal and seasonal variation, shade (such as that provided by riparian habitat), and local groundwater influence.
2. Complex stream channels with features such as woody debris, side channels, pools, and undercut banks to provide a variety of depths, velocities, and in-stream structures.
3. Substrates of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. This should include a minimal amount of fine substrate less than 0.25 inch (0.63 centimeter) in diameter.
4. A natural hydrograph, including peak, high, low, and base flows within historical ranges or, if regulated, currently operate under a biological opinion that addresses bull trout; or a hydrograph that demonstrates the ability to support bull trout populations by minimizing daily and day-to-day fluctuations and minimizing departures from the natural cycle of flow levels corresponding with seasonal variation.
5. Springs, seeps, groundwater sources, and subsurface water to contribute to water quality and quantity as a coldwater source.
6. Migratory corridors with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and foraging habitats, including intermittent or seasonal barriers induced by high water temperatures or low flows.
7. An abundant food base including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.
8. Permanent water of sufficient quantity and quality such that normal reproduction, growth, and survival are not inhibited.

Proposed Critical Habitat

On January 14, 2010, the USFWS announced a proposal to revise designated critical habitat for bull trout (75 Federal Register 2269). The proposal renumbers and rewords PCEs, and one PCE has been added. The proposed PCEs are as follows:

1. Springs, seeps, groundwater sources and subsurface connectivity to contribute to water quality and quantity and provide thermal refugia. (Formerly #5 and revised)

2. Migratory 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. (Formerly #6 and revised)
3. An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates and forage fish. (Formerly #7)
4. Complex river, stream, lake, reservoir, and marine shoreline aquatic environments and processes with features such as large wood, side channels, pools, undercut banks, and substrates to provide a variety of depths, gradients, velocities, and structure. (Formerly #2 and revised)
5. Water temperatures ranging from 36° to 59°F (2° to 15°C) with adequate thermal refugia available for temperatures at the upper end of this range. (Formerly #1 and revised)
6. Substrates of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. A minimal amount (e.g., less than 12 percent) of fine substrate less than 0.85 millimeter (0.03 inch) in diameter and minimal embeddedness of these fines in larger substrates are characteristic of these conditions. (Formerly #3 and revised)
7. A natural hydrograph, including peak, high, low, and base flows within historical and seasonal ranges or, if flows are controlled, departures from a natural hydrograph are minimized. (Formerly #4 and revised)
8. Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited. (Formerly #8 and revised)
9. Few or no nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass), inbreeding (e.g., brook trout), or competitive (e.g., brown trout) species present. (New)

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APPENDIX C: ESSENTIAL FISH HABITAT

ESSENTIAL FISH HABITAT

Introduction

Public Law 104-267, the Sustainable Fisheries Act of 1996, amended the Magnuson-Stevens Fishery Conservation and Management Act (MSA) to establish new requirements for essential fish habitat (EFH) descriptions in federal fishery management plans and to require federal agencies to consult with National Marine Fisheries Service (NMFS) on activities that may adversely affect EFH (PFMC 1999, pg. A-1). Adverse effects include any impact that reduces the quality and/or quantity of EFH, which can include direct (e.g., contamination or physical disruption), indirect (e.g., loss of prey, reduction in species' fecundity), site-specific, or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions.

Cumulative impacts are incremental impacts occurring within a watershed or marine ecosystem context that may result from individually minor but collectively significant actions that adversely affect the quantity and ecological structure or function of EFH. The assessment should specifically consider the habitat variables that control or limit a managed species' use of a habitat.

EFH has been defined for the purposes of the MSA as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (PFMC 1999, pg. A-2). NOAA Fisheries has further added the following interpretations to clarify this definition:

- "Waters" include aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate;
- "Substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities;
- "Necessary" means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and
- "Spawning, breeding, feeding, or growth to maturity" cover the full life cycle of a species (NMFS 1999).

The MSA requires consultation for all actions that may adversely affect EFH, and it does not distinguish between actions in EFH and actions outside EFH. Any reasonable attempt to encourage the conservation of EFH must take into account actions that occur outside EFH, such as upstream and upslope activities that may have an adverse effect on EFH. Therefore, EFH consultation with NMFS is required by federal agencies undertaking, permitting, or funding activities that may adversely affect EFH, regardless of its location. Wherever possible, NMFS utilizes existing interagency coordination processes to fulfill EFH consultations with federal agencies. For the proposed action, this goal is being met by incorporating EFH consultation with the Endangered Species Act (ESA) Section 7 consultation, as represented by this biological assessment (BA).

The consultation requirements of section 305(b) of the MSA (16 USC 1855(b)) provide that:

- Federal agencies must consult with NMFS on all actions, or proposed actions, authorized, funded, or undertaken by the agency, that may adversely affect EFH.
- NMFS will provide conservation recommendations for any federal or state activity that may adversely affect EFH.
- Federal agencies will, within 30 days after receiving conservation recommendations from NMFS, provide a detailed response in writing to NMFS regarding the conservation recommendations. The response will include a description of measures proposed by the agency for avoiding, mitigating, or offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the conservation recommendations of NMFS, the federal agency will explain its reasons for not following the recommendations (NMFS 1999).

Identification of Essential Fish Habitat

The Pacific Fishery Management Council (PFMC) has designated EFH for Pacific salmon, Pacific Coast groundfish, and coastal pelagic species. The proposed action area and associated habitat features that may contain EFH species for this consultation is described in this BA. The action area potentially includes areas designated as EFH for various life-history stages of over 56 species of Pacific Coast groundfish (PFMC 2008, pgs. 14-15), five coastal pelagic species (PFMC 1998, pgs. 1-2), and three Pacific Coast salmon species (PFMC 1999, pg. A-12). A summary of potential EFH species that may occur in the action area is shown in Exhibit C-1.

EXHIBIT C-1.
PACIFIC COAST EFH SPECIES POTENTIALLY PRESENT IN THE ACTION AREA

Groundfish Species		Coastal Pelagic Species	Pacific Salmon Species
Soupfin shark	Sablefish	Northern anchovy	Chinook salmon
Spiny dogfish	Bocaccio	Pacific sardine	Coho salmon
California skate	Brown rockfish	Pacific (chub) mackerel	Pink salmon
Ratfish	Copper rockfish	Jack mackerel	
Lingcod	Quillback rockfish	Market squid	
Cabezon	English sole		
Kelp greenling	Pacific sanddab		
Pacific cod	Rex sole		
Pacific whiting (hake)	Starry flounder		

Source: NMFS (2006)

The Pacific salmon freshwater EFH includes all streams, lakes, ponds, wetlands, and other water bodies currently or historically accessible to salmon in Washington, except those above the impassable barriers identified by PFMC. Salmon EFH also excludes areas upstream of longstanding naturally impassable barriers (i.e., natural waterfalls in existence for several hundred years). In the estuarine and marine areas, salmon EFH extends from the nearshore and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone (EEZ), 200 miles (370 kilometers) offshore of Washington.

EFH for Pacific Coast groundfish and coastal pelagic species includes all waters from the mean high water line along the coast of Washington, upstream to the extent of saltwater intrusion and seaward to the boundary of the United States EEZ 200 miles (370 kilometers).

Pacific Coast Salmon

Pacific salmon EFH is established for Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), and pink salmon (*O. gorbuscha*). Chinook salmon and coho salmon may use the Grays Harbor, Puget Sound, Lake Washington, and Lake Washington Ship Canal (Ship Canal) portions of the action area for adult migration to river and stream spawning grounds, juvenile out-migration, and rearing where suitable habitat is present. This includes the pontoon transportation routes in the open ocean and within Puget Sound for migration to and from available food sources.

Coastal Pelagic Species

In addition to being established for Pacific salmon, EFH has been established for the coastal pelagic species fishery. This includes four finfish (Pacific sardine [*Sardinops sagax*], Pacific [chub] mackerel [*Scomber japonicus*], northern anchovy [*Engraulis mordax*], and jack mackerel [*Trachurus symmetricus*]) and one invertebrate—market squid (*Loligo opalescens*). For the purposes of defining EFH, NMFS has treated the four coastal pelagic finfish as a single species complex because of similarities in their life histories and habitat requirements. Market squid are also treated in this same complex because they are similarly fished above spawning aggregations.

Coastal pelagic species generally occur in the water column near the surface, above the thermocline in the upper mixed layer. Coastal pelagic species are schooling fishes that migrate in coastal waters; thus, they may occur within the action area.

Pacific Coast Groundfish

In contrast to the Pacific salmon and coastal pelagic species, Pacific Coast groundfish make up a much more diverse set of organisms. The Pacific Coast Groundfish Fishery Management Plan manages more than 82 species over a large and ecologically diverse area. Groundfish are fish such as rockfish, roundfish, flatfish, sharks, and skates that are often (but not exclusively) found on or near the ocean floor or other structures. Pacific Coast groundfish species that may occur within the action area are summarized in Exhibit C-1.

Habitat Areas of Particular Concern

Habitat areas of particular concern (HAPC) are discrete subsets of EFH that provide important ecological functions or are especially vulnerable to degradation based on one or more of the following considerations:

- The importance of the ecological function provided by the habitat.
- The extent to which the habitat is sensitive to human-induced environmental degradation.
- Whether, and to what extent, development activities are or will be stressing the habitat type.
- The rarity of the habitat type (PFMC 2008, pg. 65).

The HAPC designation does not confer additional protection or restrictions upon an area, but can help prioritize conservation efforts.

The waters of Washington, including portions of the pontoon transport route, encompass HAPCs such as areas of seagrass, rocky reef habitat, estuarine areas, and areas of interest. Areas of interest are discrete areas that are of special interest due to their unique geological and ecological characteristics (PFMC 2008, pg. 68). Off the coast of Washington, areas of interest include all waters and sea bottom shoreward from the 3–nautical-mile boundary of the territorial sea shoreward to mean higher high water (PFMC 2008, pg. 68). However, project activities (primarily pontoon towing) are not expected to affect these habitat areas.

Description of Proposed Activities

Project activities that may affect the EFH are summarized in Exhibit C-2, and a detailed description of the proposed activities is in Section 2, Description of Proposed Action, of the BA.

Effects of the Proposed Actions on EFH

Based on information provided in the BA, the proposed action(s) may affect the EFH of Pacific Coast groundfish, coastal pelagic species, and Pacific salmon. Although all activities associated with the proposed action are assessed in this document, many of the impact vectors associated with the project are linked to temporary in-water work, such as the operation of the pontoon construction facility, pontoon towing, installation of work bridges and falsework (pile-driving), and in-water and overwater construction activities. In addition to these temporary effects, permanent effects would occur from operation of the in-water and overwater structures of the Evergreen Point Bridge. Improvements in stormwater treatment of highway runoff would improve water quality conditions in Lake Washington and portions of Portage Bay. Project components with the potential to affect EFH are summarized in Exhibit C-2 with a detailed description of potential project impacts located in Section 6, Effects Analysis, of the BA.

EXHIBIT C-2.
SUMMARY OF PROJECT ACTIONS THAT MAY AFFECT EFH

Project Activities	Analysis	Temporary Impacts to EFH	Long-term Impacts to EFH	Conservation/Minimization Measures
Operation of ancillary facilities and launch channel at the pontoon construction sites.	In-water sedimentation and turbidity.	✓		Approved site best management practices (BMPs) will be used for the duration of the project.
	Water quality effects (i.e., contaminants, dissolved oxygen [DO]).	✓		Site operators will follow existing permit requirements, such as in-water work windows, water quality/noise BMPs, and monitoring.
	Interruption of migration corridors (noise, turbidity).	✓		
Offsite outfitting, short-term storage, and transport of pontoons.	Interruption of migration/foraging corridors (noise).	✓		Pontoon outfitting will occur at existing facilities and pontoon transport will occur only within existing shipping channels, consistent with existing uses.
	Water quality effects (i.e., contaminants, DO).	✓		Site operators will follow existing permit requirements, such as in-water work windows, water-quality/noise BMPs, and monitoring.
	Disruption of benthic areas.	✓		Pontoons will be stored in deep-water locations and/or within existing facilities; however, anchor installation and removal may cause temporary localized impacts to the benthos.
Bridge replacement activities and maintenance facility construction.	Riparian alteration.	✓	✓	Replace or restore lost functions and values through mitigation.
	In-water sedimentation and turbidity.	✓		Project BMPs will be used by Washington State Department of Transportation (WSDOT) for the duration of the project.
	Water quality effects (i.e., contaminants).	✓		
	Interruption of migration/foraging corridors (noise).	✓		WSDOT will be required to follow in-water work windows and water quality/noise BMPs.
	Disruption or loss of benthic areas (piles, cofferdams, columns, and footings).	✓	✓	The number of temporary and permanent in-water structures will be minimized.
	Interruption of migration/foraging corridors (overwater/in-water structures).	✓	✓	The number of permanent in-water structures will be minimized.
Site restoration and mitigation activities at various locations in the Lake Washington watershed.	In-water sedimentation and turbidity.	✓		Project BMPs will be used by WSDOT for the duration of the project.
	Riparian alteration.	✓		

Summarizing Exhibit C-2, the project may affect EFH in the following ways within their respective portions of the action area[1]:

Operation of Pontoon Construction Facilities

- **Short-term disturbance of benthic habitats from launch channel maintenance**. This could affect foraging and migration patterns of the Pacific salmon species and groundfish that may be present within the project action area habitat, particularly Chinook salmon, coho salmon, Rex sole, English sole, Pacific sanddab, Starry flounder, spiny dogfish, ratfish, and California skate.
- **Reducing water quality adjacent to the facility and launch channel through temporary increases in turbidity, contaminants, and noise during operations**. An increase in turbidity and noise could affect EFH species' (groundfish, coastal pelagic, and Pacific salmon) migratory and rearing habitats, as well as foraging opportunities that may be present within the vicinity of construction-related activities.
- **Potential of fish entrainment in the facility when the launch channel gates are opened and closed.**

Onsite Outfitting and Short-Term Moorage

- **Short-term disturbance of habitat from pontoon and material transport and the installation/removal of anchors during the short-term moorage of pontoons**. However, most onsite pontoon outfitting is expected to occur after the pontoons are permanently anchored in the lake (see Bridge-Replacement Activities below).

Bridge-Replacement Activities (Lake Washington and Ship Canal)

- **Reducing riparian habitat.** Riparian conditions within much of the Lake Washington portion of the action area are functioning properly. Although the riparian conditions in the project action area will remain largely intact, construction activities will alter, reduce, or remove riparian vegetation in the project action area of Lake Washington.
- **Reducing water quality through temporary increases in turbidity during bridge-replacement activities such as pile-driving.** An increase in turbidity could affect Pacific salmon EFH species' (Chinook and coho salmon) migratory and rearing habitats, as well as foraging opportunities that may be present within the vicinity of construction-related activities.
- **Reducing habitat quality through temporary increases in noise.** The production of high sound pressure levels during impact pile-driving could affect Chinook and coho salmon migratory and rearing habitats, as well as foraging opportunities that may be present within the vicinity of pile-driving-related activities.

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[1] Environmental baseline features within the action area that may be affected by project actions are outlined in detail within the *Environmental Setting* and *Effects Analysis* sections of the BA.

- **Removing the benthic invertebrate community and substrate within Chinook and coho salmon habitat.** Construction of permanent columns and mudline footings to support the new Evergreen Point Bridge, and anchors associated with the floating portion of the bridge, will permanently displace substrate habitat.
- **Temporarily removing substrate area from work bridge and falsework piles.**
- **Removing the benthic invertebrate community and substrate within Chinook and coho salmon habitat by installing columns for the maintenance facility dock.**

Restoration Activities

- Activities within the restoration areas may include wetland, riverine, shoreline, and nearshore habitat enhancements. Temporary water quality and riparian impacts may occur; however, restoration activities will result in a long-term benefit to EFH species.

Direct, Indirect, and Cumulative Effects

No detectable direct effects of pontoon-towing activities from Grays Harbor and Puget Sound pontoon sites are anticipated on EFH-managed species, because towing will be limited to established shipping channels and will be consistent with existing or permitted uses. The areas affected will also be very small compared with the greater rearing and foraging areas of the Pacific Coast, Elliott Bay, and Puget Sound, where these species occur. Similarly, no direct effects are expected for the operation of supplemental stability pontoon construction and outfitting sites, which will be consistent with existing permitted operations of these sites (with appropriate BMPs to protect aquatic habitat).

In Lake Washington and the Ship Canal, potential impacts of bridge-construction activities on ESA-listed fish species and critical habitat are discussed in Section 6, Effect Analysis, of the BA. These potential effects will also generally apply to Pacific salmon EFH in these areas. However, adherence to the BMPs discussed in Section 2, Mitigation Measures, will minimize impacts to water quality and habitat conditions in the lake or in Portage Bay during project construction.

Construction activities will result in temporary effects on EFH, and many of the long-term effects are expected to be an improvement over existing conditions. Such improvements include reducing the number and spacing of in-water structures, increasing stormwater treatment, and potentially decreasing overwater shading effects of the replacement bridge. In addition, many of the in-water work activities will occur in areas with moderate or extensive densities of aquatic vegetation or deep lake bottom habitat, which is not considered typical salmonid habitat. Overall, the habitat characteristics in the project action area will limit the potential for construction activities to have direct and indirect effects on Pacific salmon EFH. The proposed conservation measures and project BMPs will further limit the scope and scale of any potential impacts, and no measurable long-term deleterious effects on EFH are expected to occur.

Despite the increased size of the new bridge structures in and over Pacific salmon EFH, current research indicates that the food resources and habitat availability are more than adequate to support the existing populations of salmon.

Conservation and Mitigation Measures

Conservation measures designed to protect listed species and those proposed as threatened or endangered will also help avoid and minimize impacts of project activities on EFH species. A complete list of conservation measures is provided in Section 2 of the BA.

Conclusions

EFH for Pacific salmon, groundfish, and coastal pelagic species is present in or adjacent to the action area. The project may affect EFH, with possible effects occurring at pontoon construction and outfitting sites in Puget Sound, bridge-replacement activities such as pile-driving and in-water bridge construction activities within Lake Washington (including Portage Bay and Union Bay), and permanent effects from overwater/in-water structures within Lake Washington (including Portage Bay and Union Bay, and the bridge maintenance facility). Minimization and mitigation measures proposed for the project measures are described in Section 2.10, Avoidance and Minimization Measures, of the BA. A detailed description of potential project impacts is also provided in Section 6, Effects Analysis, of the BA.

Determination

Based on the EFH requirements of Pacific Coast salmon species, BMPs, and proposed conservation and mitigation measures, the determination is that the project may adversely affect Pacific salmon freshwater EFH in Lake Washington and the Ship Canal. However, the project will not adversely affect EFH for groundfish or coastal pelagic species.

References

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APPENDIX D: UNDERWATER NOISE ANALYSIS

UNDERWATER NOISE ANALYSIS

Introduction

This document summarizes the available information on the potential effects that underwater noise from in-water pile-driving activities, associated with the SR 520, I-5 to Medina: Bridge Replacement and HOV Project (SR 520, I-5 to Medina project), could have on Endangered Species Act (ESA)-listed species and critical habitat within Lake Washington, Union Bay, Portage Bay, Lake Union, and the Lake Washington Ship Canal (Ship Canal). Extensive pile-driving would occur in these areas to construct work trestles and detour bridges to support the construction activities needed to build the replacement bridge, as well as the installation of a permanent maintenance facility dock.

Impact pile-driving in aquatic environments produces sound energy or variable pressures transmitted within the water column that may injure aquatic life. This document summarizes some of the available information on pile-driving regulations, sound propagation processes, and the potential effects that the high sound levels can have on aquatic species. In addition, the report summarizes the results of the Pile Installation Test Program for the SR 520 Bridge Replacement and HOV Project. The primary focus of the report is to assess the potential effects on fish from pile-driving activities associated with the bridge replacement project. This project will replace the existing Evergreen Point Bridge across Lake Washington and the corresponding access and approach structures.

In planning for the proposed project, the Washington State Department of Transportation (WSDOT) implemented a study to evaluate site-specific sound characteristics related to pile-driving in the project site. This evaluation occurred in those areas that require a temporary work trestle for constructing the proposed new bridge. Numerous factors influence the magnitude and propagation of underwater sound generated by pile-driving (e.g., substrate, water depth), and the project site has physical settings that present unique issues related to site geology and sound propagation.

The pile-driving study used hydroacoustic monitoring to gather site-specific data on the noise generated from pile-driving in the project site. The purpose was to gather site-specific data to allow WSDOT to better predict the potential effects of the eventual SR 520, I-5 to Medina project and assess the “best available science” related to minimizing the effects of these underwater sound levels on aquatic species.

In addition to discussing the available information on pile-driving noise levels, and potential effects of these levels on aquatic species, this report discusses available best management practices (BMPs) or conservation and minimization measures to maximize the protection of aquatic species from the potential effects of in-water construction. The results of the recent pile installation test program also provide site-specific information on the effectiveness of three typical BMPs at minimizing potential effects.

Regulatory Environment

Pile-driving is regulated under several federal and state authorities, including the ESA, Clean Water Act, Rivers and Harbors Act, Washington Hydraulic Code, and Tribal Trust and Treaty obligations. For several years, permits and approvals for projects involving impact pile-driving have included the required use of underwater sound attenuation devices, including bubble curtains. Many of these projects also typically include physical containment systems around groups of or individual piles to increase the attenuation effectiveness and reduce the potential dispersion of suspended sediments caused by the pile-driving activities.

ESA Consultation. The National Marine Fisheries Service and U.S. Fish and Wildlife Service (the Services) currently include non-discretionary terms and conditions during Section 7 consultations, requiring sound attenuation methods (typically bubble curtains) and performance standard verification monitoring. The terms and conditions can also include contingency procedures if noise levels exceed the defined performance standards, including stop-work orders and reconsultation. WSDOT has also recently entered into an Agreement in Principle or Memorandum of Understanding with the Federal Highway Administration (FHWA) and the Services to utilize interim criteria establishing underwater noise thresholds likely to injure fish (FHWG 2008).

Clean Water Act and Rivers and Harbors Act. The U.S. Army Corps of Engineers (USACE) has also required noise attenuation devices as a “special condition” in most permits issued for projects that include impact pile-driving.

Hydraulic Project Approval. The Washington Department of Fish and Wildlife (WDFW) has recently decided to include a standard “provision” requiring the use of noise attenuation devices for all projects that include impact pile-driving.

Sound Measurement

Sound measurements in water are reported as decibel (dB) readings, relative to a reference value of 1 microPascal (µPa), a measure of absolute pressure. Decibels have a logarithmic relationship to µPa. Sound energy is commonly reported as SPL, which is the average sound intensity for a single sound-producing event. Sound energy is commonly reported as either peak sound pressure level (dB_{peak}), or as root mean square (RMS) pressure level (dB_{RMS}). Peak SPL is the ratio of the absolute maximum sound pressure to a pressure of 1 µPa for a single sound-producing event.

Impact pile-driving typically consists of multiple strikes (events), resulting in a cumulative sound energy effect. Hastings and Popper (2005) describe how sound exposure level (SEL) is a means of recording and reporting such cumulative in-water sound and is based on the cumulative sum of the squares of the sound pressure values in a sound wave. This metric defines exposure to sound with both the received energy level and duration of the signal. It is a time-integrated, sound pressure-squared level value that allows for comparison and accumulation of multiple, transient sound events having different pressure levels and temporal characteristics.
This squaring process gives the positive and negative pressure values equivalent contributions to

the cumulative energy, and it is always a positive value. An SEL is the constant sound level over 1 second that has the same amount of acoustic energy as the original sound.

Interim Criteria

The Fisheries Hydroacoustic Working Group agreement (FHWG 2008) established interim criteria to minimize potential effects to ESA-listed fish species from elevated underwater sound levels resulting from pile-driving activities.Given the current uncertainties and limited direct empirical measurements, the Services anticipate that these exposure criteria would likely be modified according to the results of continued evaluations. The agreed-upon interim criteria include the following peak SPL and SEL injury threshold limits:

- Peak SPL: 206 dB from a single hammer strike
- SEL: accumulated SELs of 187 dB for all listed fish except those that are less than 2 grams, or 183 dB for fish less than 2 grams

Accounting for the cumulative energy from multiple successive pile driver strikes, the criteria establish a simple summation formula:

Cumulative SEL = Single Strike SEL + 10 log (# of strikes)

Cumulative SEL is intended as a measure of the risk of injury from exposure to multiple pile strikes (NMFS 2007). The number of pile strikes is also estimated per continuous work period, and assumes that there will be a break of at least 12 hours between work periods. This approach provides a conservative estimate of potential effects of in-water pile-driving, because it assumes that all the strikes have the same SEL, that fish are continuously exposed to pulses with the same SEL, and that no tissue recovery occurs between successive hammer strikes or pile-driving events. Although these conditions are unlikely to occur, there are currently no data to quantify or effectively evaluate variations of these factors. Therefore, the Services have assumed this conservative approach until appropriate data become available. The current criteria also include the disturbance threshold of 150 dB_{RMS} for potentially altering fish behavior.

Sound Effects Threshold

The effects of underwater sound on organisms is difficult to predict because, in addition to the variables affecting transmission loss and attenuation of the sound energy in water, there is also some uncertainty about how sound levels affect fish and other aquatic species. Turnpenny et al. (1994) observed that brown trout exhibited an avoidance reaction at sound levels above 150 dB_{RMS} and other reactions (e.g., a momentary startle) at 170 to 175 dB_{RMS}. This is similar to the 150 dB_{RMS} threshold recommended by Hastings (2002) as providing a reasonable safety margin below the sound levels observed to injure fish. Turnpenny and Nedwell (1994) and Feist et al. (1992) also suggest that sound levels in this range appear adequate to prevent injury, but that behavioral effects could still occur.

Hastings (2002) recommended 180 dB_{peak} as the thresholds for salmonid injury and behavioral effects, respectively. However, due to differences between species and variations in exposure type and duration, uncertainty remains as to the degree of potential adverse effects from SPLs between 180 and 190 dB_{peak} (Turnpenny et al. 1994). As a result, Popper et al. (2006) proposed an approach using dual criteria of 187 dB_{SEL} and 208 dB_{peak} to be protective of fish. They concluded that the key characteristics for pile-driving are likely to be the peak positive and negative pressures and their time durations, which are combined to calculate the cumulative pressure squared and SEL. They considered the SEL metric superior to the peak SPL metric, because it allows summing of the energy produced over multiple hammer strikes. However, due to the integral nature of the SEL metric, very brief and high peak pressure transients may not exceed the criteria threshold, but could still be damaging. Therefore, protecting fish from these brief sound exposures is accomplished with the SPL threshold metric. The Fisheries Hydroacoustic Working Group agreement (FHWG 2008) described above establishes conservative criteria for protecting aquatic species from injury due to in-water pile-driving activities.

The behavior responses from exposure to sound levels above 150 dB_{RMS} include startle response, feeding disruption, and avoidance behavior. Generally, these sound levels are not expected to rise to the level of take, and are not expected to cause direct permanent injury. However, they could indirectly affect individual survival by behavior modifications, such as impairing predator detection and avoidance behavior, in which case take may occur.

Zone of Effect for Pile Driving

The potential zone of effect for pile-driving projects is determined by the distance from the pile-driving activity where the behavioral effects threshold criteria are exceeded, based on spreading and attenuation of sound with range. The zone of effect includes the disturbance and injury threshold limits. In simple terms, the practical spreading model assumes that SPLs decrease at a rate of 4.5 dB per doubling distance. Therefore, the distance that the noise from pile-driving could exceed the criteria thresholds is determined by the initial sound levels, which is governed in large part by the type and size of the pile being driven. Exhibit D-1 shows generalized single strike sound levels for a variety of pile sizes and materials.

EXHIBIT D-1.
ESTIMATED SINGLE-STRIKE SOUND LEVELS PRODUCED BY IN-WATER PILE-DRIVING OF VARIOUS TYPES AND SIZES OF PILES, TYPICALLY MEASURED AT A DISTANCE OF 10 METERS FROM THE PILE

Pile Type	Sound Pressure Levels (single strike)		
	Peak	Average	SEL
Wood piles	180 dB_{peak}	170 dB_{RMS}	160 dB_{SEL}
Concrete piles	192 dB_{peak}	176 dB_{RMS}	174 dB_{SEL}
Steel H-piles	190 dB_{peak}	175 dB_{RMS}	155 dB_{SEL}
Steel piles of:			
12-inch diameter	208 dB_{peak}	191 dB_{RMS}	175 dB_{SEL}
14-inch diameter	195 dB_{peak} @ 30 m	180 dB_{RMS} @ 30 m	
16-inch diameter	200 dB_{peak} @ 9 m	187 dB_{RMS} @ 9 m	
24-inch diameter	212 dB_{peak}	189 dB_{RMS}	181 dB_{SEL}
30-inch diameter	212 dB_{peak}	195 dB_{RMS}	186 dB_{SEL}
36-inch diameter	214 dB_{peak}	201 dB_{RMS}	186 dB_{SEL}
60-inch diameter	210 dB_{peak}	195 dB_{RMS}	185 dB_{SEL}
66-inch diameter	210 dB_{peak}	195 dB_{RMS}	
96-inch diameter	220 dB_{peak}	205 dB_{RMS}	195 dB_{SEL}
126-inch diameter	213 dB_{peak} @ 11 m	202 dB_{RMS} @ 11 m	
150-inch diameter	200 dB_{peak} @ 100 m	185 dB_{RMS} @ 100 m	

Source: WSDOT (2010)

In addition to the gradual decrease in sound level associated with spreading and attenuation, underwater sound waves are blocked by land forms and other solid structures, and sound propagation is limited in very shallow water. Because the dominant frequencies generated in pile- driving are between 50 and 1,000 Hz, most of the energy has limited propagation in water depths of 0.4 meters (1.3 feet) or less (WSDOT 2010). These conditions limit the extent of the area affected by the noise from in-water pile-driving. Similarly, additional sound reductions can be achieved using sound attenuation measures, such as installing bubble curtains or solid barriers, or by dewatering the immediate site of pile-driving.

Despite the typical effect of land forms blocking sound, sound can transmit through the ground under certain conditions, especially with harder sediments such as clay and rock. This sound energy can also escape into, or back into, the water column through a process known as noise flanking. This process can also occur when driving piles in an upland location near a water body results in some of the sound being transmitted into the water column. Less dense material, such as the organic soils in the action area, are considered to attenuate sound levels to a greater degree than denser sediments, reducing the flanking potential.

NMFS developed a tool to estimate sound levels (peak, RMS, and accumulated SEL) received by fishes exposed to elevated levels of underwater sound produced during pile-driving (WSDOT 2010). Using the practical spreading loss model and the single strike and cumulative criteria discussed earlier, the model estimates the distance from the location of pile-driving at which the resulting sound levels (including the accumulated SEL from multiple pile strikes) attenuate to below the injury or disturbance threshold levels.

Based on ESA compliance guidance documentation (WSDOT 2010), the disturbance threshold should be considered the “may affect” threshold, particularly if the threshold level is above ambient noise levels. However, noise levels below the injury threshold are not necessarily considered a “not likely to adversely affect” determination. Other factors, such as timing and duration of the pile-driving activities and species life history stages potentially affected, need to be considered in the effects determination. Also, regardless of the existing criteria, there is considerable uncertainty regarding the noise levels from pile-driving, the effects of site-specific conditions, and the effectiveness of BMPs and minimization methods. Although the NMFS model provides a general estimate of the area where fish could be negatively affected by pile-driving activities, considerable variability can occur from site-specific environmental conditions. As indicated above, the attenuation of acoustic noise is affected particularly by shallow water conditions and non-reflective or sound-absorbing substrate material. Other highly variable conditions occur in areas with dense aquatic vegetation, which can block, reflect, or refract sound waves. Even greater sound reduction can occur in confined spaces, with nearby landmasses that completely block sound transmission. These highly variable conditions often warrant site-specific evaluations to assess both the conditions that influence the pile-driving activities and the sound propagation conditions in the action area. NMFS and USFWS encourage the use of site-specific data whenever possible.

Review of Pile-Driving Conservation and Minimization Measures

Project proponents and/or regulatory agencies typically include timing restrictions or sound attenuation measures for pile-driving projects. These sound attenuation measures are intended to minimize the potential effects of these and other noise-generating activities on various species by avoiding time periods when specific species would likely occur in the action area, and/or minimizing the sound levels to which species are exposed.

The in-water work closure period coincides with the timing of juvenile salmonids migrating downstream to marine waters and a major portion of the adult salmonid run timing in Lake Washington. While some leeway is sometimes allowed for some construction activities, activities that are likely to exceed the underwater noise level thresholds or substantially affect water quality are typically not allowed outside of the established in-water work window.

Various measures have been developed to reduce underwater sound levels generated by pile-driving. One of the most effective approaches to reducing underwater noise is to use vibratory pile-driving to the extent practical. If impact pile-driving is necessary, common noise-reducing measures include using pile caps, bubble curtains, fabric barriers, and isolation piles or cofferdams.

Bubble curtains can attenuate underwater sound pressure levels at some frequencies by as much as 30 dB, although results are highly variable (Illingworth and Rodkin 2010). This variability occurs because of the variety of designs available, and whether the bubble curtains are properly installed. Bubble curtains are also not universally effective at all frequencies, but they are particularly effective in the moderate-to-high frequency range (Gisiner 1998). The maximum potential reduction obtainable with a bubble curtain is about 36 dB, based on approaching the theoretical impedance of an air/water interface (Caltrans 2009).

The components of a bubble curtain typically include a high-volume air compressor, primary and secondary feed lines, and air distribution manifolds. Longmuir and Lively (2001) recommended that manifolds should have 1/16-inch air release holes every 3/4-inch along their entire length. The air distribution manifolds are placed surrounding the pile below the water surface where the pile meets the sediment. An effective bubble curtain system should distribute air bubbles that completely surround the perimeter of a pile to the full depth of the water column. Reducing the size of the bubbles greatly enhances the sound attenuation of the bubble curtain (Vagle 2003).

The bubbles absorb and reflect the sound pressure waves, attenuating the pressure intensities. Bubble curtains come in a variety of forms, resulting in a range of effectiveness. Spacing of the bubble manifolds, size and spacing of holes in the manifold, air pressure, water currents, depth, site conditions, and contractor implementation are all factors influencing effectiveness.

However, one prominent variation is whether the bubble stream is contained or uncontained. A contained system uses a physical structure (e.g., silt curtain) surrounding the air bubble wall to contain the bubbles within a confined area. Contained systems are necessary in areas with strong currents or flowing water to keep the bubbles concentrated around the location of pile-driving, although they can also improve the effectiveness of a system in still waters (Reyff et al. 2002). Unconfined bubble curtains are most effective in low current areas, such as the SR 520, I-5 to Medina project site.

Isolation casings are cylinders slightly larger in diameter than the driven pile, which are inserted into the water column and bottom substrate surrounding the pile to be driven. The pile is then driven inside the isolation casing to separate the driven pile from the open water. Isolation casings can be used alone, with a bubble curtain system inside, or with the interior dewatered. Isolation casings alone do not appear to be effective, while those used in conjunction with a bubble curtain or dewatering provide substantial sound attenuation. However, the dewatered or combination systems are expected to provide greater attenuation than simple bubble curtains in areas with currents, and are likely similar to other properly designed and installed confined bubble systems.

Reyff et al. (2002) evaluated the effectiveness of several isolation casing systems and found a dramatic reduction in sound pressure levels of up to about 30 dB_{peak} and 20 dB_{SEL} for a system with an air manifold inside, and similar results with the isolation casing dewatered during pile-driving. However, no measureable reductions were observed with just the isolation casing. Most of the reduction in sound energy occurred at frequencies above 100 Hz. In contrast, a system using a fabric barrier was estimated to reduce SPLs by up to about 10 to 15 dB (Caltrans 2001).

Regardless of isolation type, the attenuation system needs to be carefully designed and installed to maximize effectiveness. Laughlin (2005) found that an improperly installed system produced little or no sound attenuation, while the same system with a canvas skirt attached to the bottom to allow the system to conform to the substrate achieved up to 12 dB sound attenuation. However, even if properly designed and installed, attenuation systems still vary in effectiveness. Evaluations indicate that they can be effective at reducing sound pressure levels by more than 17 dB (Laughlin 2006; Longmuir and Lively 2001), and even as much as a 30 dB reduction in some instances (Vagle 2003; Illingworth and Rodkin 2010), while other installations have resulted in reductions of 10 dB or less, including situations where no reduction occurred. Although substantial variability can occur with these systems, available data indicate that correctly designed and installed bubble curtains can substantially reduce the extent of potential adverse effects of pile-driving (Teachout 2007).

Cofferdams function similarly to isolation casings, except that they encompass a larger area than the casings. Unlike the casings, which need to be deployed at each location of pile-driving, cofferdams allow multiple piles to be driven in an isolated area before needing to move the cofferdam to the next area. Like the isolation casings, however, the area within the cofferdam can be dewatered. Although this might increase the sound attenuation rate, turbidity concerns typically increase due to the amount of in-water activity associated with installation and removal. The advantage of using cofferdams increases as the number of piles within the isolation area increases. The disadvantages include the large area of the bottom potentially disturbed, the entrapment of fish within the structure, and the time and difficulty associated with installation.

Project-Specific Environmental Effects of Pile-Driving

Project Setting

The Portage Bay shoreline south of the existing bridge consists of vegetated shallows, with a gradually sloping shoreline and a fringe marsh riparian zone. Docks, houseboats, and other structures cover most of the remaining Portage Bay shoreline areas. White water lily (*Nymphaea odorata*) and Eurasian watermilfoil (*Myriophyllum spicatum*) are the dominant aquatic vegetation in Portage Bay, as well as in much of the other areas of pile-driving, with particularly dense patches occurring within the Portage Bay, Union Bay, and Arboretum construction areas. Little aquatic vegetation is present in the east approach area.

The sediments in the Portage Bay area have a high depth of over-burden soils above the underlying competent soils, compared to the other general areas of pile-driving. The areas around Marsh and Foster islands are expected to have moderately deep over-burden conditions, with the over-burden depth generally decreasing toward the east. The area under the east approach likely has the least over-burden soil depth of all the proposed areas of pile-driving, based on the conditions of the surface layer of the bottom. The surface layer in this area consists primarily of gravel and sandy material, compared to the high organic content observed in the surface layer along the west approach and Portage Bay areas.

Marsh and Foster islands have undeveloped shorelines that emerged when the elevation of the lake was lowered, after the completion of the Ship Canal. The Marsh and Foster islands area is generally characterized by gradually sloping bathymetry, with some cut-bank or armored shorelines, patchy woody debris, and dense aquatic vegetation. The aquatic vegetation is also commonly the nonnative species of white water lily and Eurasian watermilfoil. Much of the shallowest water habitat also has dense growths of cattail.

As indicated above, most pile-driving will occur in shallow water near the northern shoreline of Portage Bay, as well as areas on and around Marsh and Foster islands and McCurdy Park. Much of this area is less than 20 feet deep. Lake substrate material throughout much of the area is dominated by silt and saturated organic peat, with soft clay layers.

Along with the generally shallow water depths and typical dense aquatic vegetation occurring in the area, the Portage Bay area and some of the Marsh and Foster islands area occur in relatively confined bays. These environmental conditions are expected to limit the propagation of underwater noise generated by pile-driving activities. Although the Union Bay area (east of Foster Island) is shallow and has dense aquatic vegetation, it is broadly open to Lake Washington. To reduce the potential effects of pile-driving on aquatic species in these areas, site-specific BMPs can be implemented.

Project Pile-Driving Activities

The SR 520, I-5 to Medina project will consist of constructing a six-lane bridge across Lake Washington, immediately north of the existing bridge structures. This project generally includes replacing the existing structures in Portage and Union bays, the east and west bridge approach structures, and the floating span of the Evergreen Point Bridge. With the exception of the floating portion of the bridge, most of the in-water and overwater bridge replacement construction activities will occur from work trestles constructed along portions of the bridge corridor. These work trestles are temporary structures supported by piles in areas that are considered too shallow for work barges to operate effectively. As a result, most of the pile-driving activities associated with these temporary trestles will occur in relatively shallow water (typically 8 to 15 feet deep). The floating portion of the new bridge, and fixed sections occurring in deeper water areas, will primarily be constructed from barges. The permanent support structures for the fixed portions of the SR 520, I-5 to Medina project will use drilled shaft techniques instead of pile-driving, although some vibratory pile-driving is required in order to install the template to support the drill rig.

All piles will undergo initial installation using vibratory pile methods, although in order to achieve bearing capacity, impact pile-driving will be used to complete driving each pile to target elevation and determine/verify bearing capacity. This method involves impacting the top (head) of the pile with a large hammer until it develops the desired bearing strength and/or tip elevation. Impact driving is the most common and versatile type of pile installation and is almost certainly the method that will be used to achieve final bearing capacity for this project. Impact driving can be performed on a wide variety of pile types and sizes and in almost any soil type. It can also be used successfully where there are many different soil types encountered during the driving of a single pile. Impact driving is one of the only commonly used installation methods that allows for a bearing capacity estimation of the pile. Several widely used methods are available for correlating the hammer input energy and corresponding pile displacement with the ultimate bearing capacity of the pile.

Temporary work trestles will be built in four general areas along the bridge corridor: Portage Bay, the Washington Park Arboretum (including Marsh and Foster islands), the west bridge approach, and the east bridge approach. The first three of these shallow water areas is expected to need two temporary trestles, one on either side of the alignment, while the east approach will require only a single trestle. For the paired structures, it is possible that contractor requirements may necessitate that each of the two temporary structures could be installed simultaneously. In addition, two of the work areas (Portage Bay and Union Bay) could have construction of work trestles proceed from both ends of the trestles (east and west) simultaneously. In addition, it is expected that construction would occur in more than one of the in-water work areas at the same time.

Overall, the temporary work trestles are expected to require a total of about 3,565 temporary piles. The piles will be 24- to 30-inch-diameter, hollow steel pipes, with 1/2- to 1-inch-thick walls. It is anticipated that most of the pile-driving installation can be accomplished using a vibratory hammer to minimize in-water noise levels, although some impact pile-driving is assumed to be required for all piles in order to achieve and demonstrate adequate load-bearing capacities. The temporary piles will be removed with a vibratory hammer. Each pile-driving crew is expected to install a maximum of 16 piles a day at a single geographic location, with an average of 500 pile-driving strikes required for each pile in Portage Bay, Union Bay, and the west approach, and an average of 1,000 pile-driving strikes required for each pile in the east approach area. However, to optimize the use of the in-water work windows, several pile-driving crews would likely be working at the same time, and pile-driving could occur concurrently at multiple locations within a geographic area. It is assumed that pile-driving may occur at up to four locations concurrently, indicating a range of from 8 to 32 piles installed per day depending on location within the project site. In this scenario, which represents the maximum extent of pile-driving required in any given day, a range of between 8,000 and 16,000 pile strikes would occur in a single day, depending on location.

Avoidance and Minimization Measures

The SR 520, I-5 to Medina project will incorporate both timing restrictions and sound attenuation requirements to minimize the potential effects of these and other noise-generating activities on various species. Timing restrictions will minimize impacts by avoiding time periods when specific species (e.g., juvenile salmonids) would likely occur in the action area. Although overwater work and some nearshore construction activities can occur throughout the year, the general preliminary allowable work window for in-water pile-driving identified for the Portage

Bay area is October 1 to April 15 yearly, while the in-water work period for the other three areas is July 16 to March 15 yearly. The in-water work closure period coincides with the timing of juvenile salmonids migrating to marine waters, and a portion of the adult salmonid run timing in Lake Washington. However, based on the known habitat use and distribution of listed salmonids within the areas affected by pile-driving, as well as discussions with the Services, WSDOT is proposing that no constraints be placed on pile-driving and other in-water work associated with construction of work bridges within the area south of Marsh Island, west of Foster Island, and east of Montlake (Union Bay work bridge area). Both juvenile and adult life-history forms of ESA-listed species show extremely limited use of the relatively low quality habitat in Union Bay and Portage Bay areas. The general in-water work windows primarily focus on protection of juvenile salmonids because this is generally the life-stage most vulnerable to watershed stressors. Because the Union Bay work bridge area is unlikely to provide suitable habitat of this life stage for Chinook salmon or steelhead and is physically separated from the primary migration route by three landmasses and dense aquatic invasive species, the timing of unconstrained pile-driving is not expected to substantially increase noise-based impacts on listed species.

In-water pile-driving BMPs will include the following measures:

- All pile-driving activities within the Portage Bay, west approach, and east approach work areas will occur within the approved in-water work windows, outside of the primary timeframe for juvenile outmigration of Lake Washington salmonids.
- Vibratory pile-driving will be used for initial installation of piles (prior to proofing) where substrate conditions allow.
- All impact pile-driving will incorporate a confined or unconfined bubble curtain noise attenuation device to reduce in-water sound levels. The specific design of the noise attenuation device to be used on the SR 520, I-5 to Medina project will be submitted to the Services for review, prior to the initiation of pile-driving activities.
- Pile-driving activities will be confined to the minimum area necessary to complete the SR 520, I-5 to Medina project.
- Prior to entering in-water or overwater areas, pile-driving equipment will be checked for leaks and completely cleaned of any external petroleum products, hydraulic fluid, coolants, and other deleterious materials.
- Hydroacoustic monitoring will be conducted according to the standards and specifications contained in the WSDOT *Underwater Noise Monitoring Plan*. The results of the monitoring will be submitted to the Services in report format after monitoring is complete.

Project-Specific Pile-Driving Analysis

Test Pile Project

WSDOT conducted a geotechnical and sound propagation study related to pile-driving to assess site-specific characteristics related to temporary work trestles in Lake Washington, in support of the SR 520 Bridge Replacement and HOV Project. The pile-driving evaluation occurred in those areas requiring temporary work trestles for the future construction of the Portage Bay, Union Bay, and west approach bridge sections of the Evergreen Point Bridge. The study verified the geotechnical and sound propagation characteristics of the project site and provided information necessary for a contractor to design the temporary work trestles for constructing the Evergreen Point Bridge across Lake Washington. In particular, the pile installation test program allowed WSDOT to determine the most effective installation method to minimize the pile-driving process and associated biological effects, and the effectiveness of selected sound attenuation methods at reducing underwater sound.

The pile-driving study consisted of installing a total of nine hollow steel piles to bearing capacity at three separate locations in Lake Washington and Portage Bay adjacent to the existing Evergreen Point Bridge corridor. Between one and four piles were installed at each location, and the locations were selected to represent typical conditions in the different in-water construction segments for the new bridge. The three proposed test pile locations are referred to as locations A, B, and C (Exhibit D-2). Two of the test pile locations were north of the existing west approach span of the Evergreen Point Bridge, while the third was located north of the existing bridge in Portage Bay. No test piles were driven at the east approach.

During pile installation underwater and airborne noise were measured. Unattenuated noise levels were recorded at all locations to determine the maximum noise generation in obtaining the ultimate bearing capacity. Two additional sound attenuation BMPs were also tested—a confined bubble curtain and a double-walled noise attenuation pile (DNAP).

EXHIBIT D-2.
NOISE LEVELS PRODUCED BY PILE-DRIVING WITH NOISE ATTENUATION BEST MANAGEMENT PRACTICES [A]

	Parameter	Location		
		Union Bay and Portage Bay (Locations B and C)	West Approach (Location A)	East Approach
Unattenuated (no BMPs)	dB_{peak}	199	197	212
	dB_{RMS}	185	186	195
	dB_{SEL}	169	174	186
Attenuated (BMPs Applied)	dB_{peak}	169	178	202
	dB_{RMS}	155	167	185
	dB_{SEL}	139	155	176
Reduction in Sound Levels due to Attenuation Device	dB_{peak}	-30	-19	-10
	dB_{RMS}	-30	-19	-10
	dB_{SEL}	-30	-19	-10

[a] The data source for attenuated and unattenuated sound levels in Portage Bay, Union Bay, and the west approach are Illingsworth and Rodkin (2010), while sound levels in the east approach are based on general literature values as summarized in WSDOT (2010).

The unconfined bubble curtain BMP consisted of an air manifold encircling the base of the pile, supplied with air from hoses connected to a compressor on the work barge. The manifold had a specified arrangement of holes to produce an appropriate density of air bubbles throughout the water column, based on the best available data. The confined bubble curtain system was selected based on available data from other evaluations. Available systems include various types of isolation pipe systems and systems with a more flexible confinement barrier. The intent of the containment barrier was to minimize the dispersion of air bubbles, maximize the attenuation effectiveness, and contain turbidity generated by the pressurized flow. The analysts evaluated a DNAP that consisted of a larger containment system, consisting of a double-walled containment structure similar to a cofferdam.

The results of the SR 520 Test Pile Project are reported in Illingworth and Rodkin (2010) and are applied below.

Aquatic Noise Analysis

The proposed in-water pile-driving will involve impact driving of 24- and 30-inch-diameter steel piles. Based on the data from the SR 520 Test Pile Project generated during pile-driving in Portage Bay (location C) and the western portion of the west approach (location B), the analysts assumed that the impact driving of this size of piles in these areas will result in peak sound levels of approximately 199 dB, a typical single-strike SEL of about 169 dB, and a root mean square sound level of 185 dB_{RMS}—all measured at a 10-meter distance (see Exhibit D-2) (Illingworth and Rodkin, Inc. 2010). Additionally, the results from the SR 520 Test Pile Project indicated that the expected sound level reductions from attenuation devices would be -30 dB.

Based on results from the SR 520 Test Pile Project generated in the eastern portion of the west approach (location A), the analysts assumed that the impact driving of this size of piles will result in peak sound levels of approximately 197 dB, a typical single-strike SEL of about 176 dB, and a root mean square sound level of 185 dB_{RMS}—all measured at a 10-meter distance (see Exhibit D-2) (Illingworth and Rodkin, Inc. 2010). The effectiveness of sound attenuation devices in this location is expected to be -19 dB.

Both 24- and 30-inch-diameter steel piles will be driven in the east approach area (see Exhibit D-2). However, no test piles were driven in this area and the physical conditions onsite differ substantially from the west side of the lake. For example, average water depths at the east approach pile-driving sites are at least 5 feet deeper than pile installation locations on the west side of Lake Washington (14 feet versus 5 feet). Moreover, due to its location it has greater exposure to wind-driven waves and greater potential for surface currents. Also, the sediment at the east approach is harder than at the test pile sites. For all of these reasons, and in the absence of quantitative test pile data for the area, it is reasonable to assume that noise levels from both attenuated and unattenuated pile-driving at the east approach will be substantially larger than for other piles driven for the project. Therefore, WSDOT used the results from other pile-driving studies, as summarized in the WSDOT Advanced BA Training Manual previous studies (WSDOT 2010), to predict initial sound levels. Based on this information, it is assumed that the impact driving of 30-inch-diameter piles in the east approach area will result in peak sound levels of approximately 212 dB, a typical single-strike SEL of about 195 dB, and a root mean square sound level of 186 dB_{RMS} (all measured at a 10-meter distance) (see Exhibit D-2). The assumed effectiveness of sound attenuation devices in this location is -10 dB.

The noise analysis used data based on the SR 520 Test Pile Project, which measured sound levels at 10, 200, and 500 meters, respectively. To ensure the model's suitability to site-specific conditions, the observed attenuation rates reported in this study were compared with the results predicted by the practical spreading model that was used for the analysis. The comparison indicated that the sound attenuation rates by distance as predicted by the practical spreading model were consistent with the attenuation distances observed and reported for the SR 520 Test Pile Project.

The following model assumptions were included in the noise analysis:

- The 199 dB_{peak} level (at 10 meters from source) assumed for unattenuated pile-driving of 30-inch-diameter steel piles represents a conservative estimate of the expected site-specific in-water noise levels. Average levels ranged from 178 to 198 $dB_{peak.}$.
- The analysis assumed a conservative average of 500 piles strikes per pile to account for differences in local substrate and limnological conditions. However, the test pile data indicated that in some locations, including Portage Bay and Union Bay, piles were driven to depth with substantially fewer blows (275 to 450 blows).
- The zone of injury from cumulative blows extends only 2 meters on each side of a pile. Many fish within the project site are actively moving within the lake. For a fish to be

exposed to 8,000 pile strikes, it would need to be located within a 4-meter circular area for an entire day. In many cases, fish will be moving through the affected area, and thus be exposed to substantially fewer pile-driving strikes.

The analysis assumed a conservative installation average, which would only occur if the maximum number of pile-driving crews were all driving a maximum number of piles. Therefore, the total number of cumulative strikes driven prior to a 12-hour rest period would likely occur only during limited portions of the in-water work windows (when multiple pile-driving rigs are operating concurrently). At other times, the number of consecutive piles installed during a single day, and thus the cumulative sound energy generated, would be substantially less.

The unattenuated sound levels and noise attenuation numbers for Portage Bay, Union Bay, and the west approach in Exhibit D-2 are based on the data from the SR 520 Test Pile Project (Illingworth and Rodkin, Inc. 2010). The attenuated noise levels are based on the use of either a confined or unconfined bubble curtain during pile-driving activities. The results of the SR 520 Test Pile Project indicated that either type of noise attenuation device is equally effective in reducing sound levels at the project pile-driving locations. A DNAP was also tested during the SR 520 Test Pile Project; however, this device was found to be substantially less effective in reducing the noise level from pile-driving (reductions of only 4 to 8 dB), and implementation of the device proved to be difficult and time-consuming. Therefore, WSDOT contract specifications will require the project contractor to use either a confined or unconfined bubble curtain, or another device demonstrated to have comparable noise attenuation capabilities.

As mentioned above, no test pile data are available for the east approach area. Therefore, a conservative estimate of the noise attenuation that can be achieved by use of a bubble curtain was applied. Because the east approach has deeper water depths, higher current velocity, and harder substrate, it is assumed that any noise attenuation device applied will not be as effective in reducing in-water noise, as compared to the Test Pile Project results. Based on these factors and results from past WSDOT projects, it is assumed that a bubble curtain applied to driven piles in the east approach area will result in a 10 dB reduction in noise levels (see Exhibit D-2).

Based on these parameters, the practical spreading loss model indicates that noise related to attenuated pile-driving at locations within Portage Bay, Union Bay, and the western portion of the west approach (location B) will attenuate to below the 150 dB_{RMS} sound level at a distance of 22 meters for 30-inch-diameter piles (Exhibit D-3). In the eastern portion of the west approach (location A), noise will attenuate below the 150 dB_{RMS} sound level at a distance of 136 meters, while pile-driving at similar locations at the east approach would result in fish disturbance out to 2,154 meters (see Exhibit D-3).

EXHIBIT D-3.
Predicted distances of underwater sound relative to thresholds for pile-driving locations

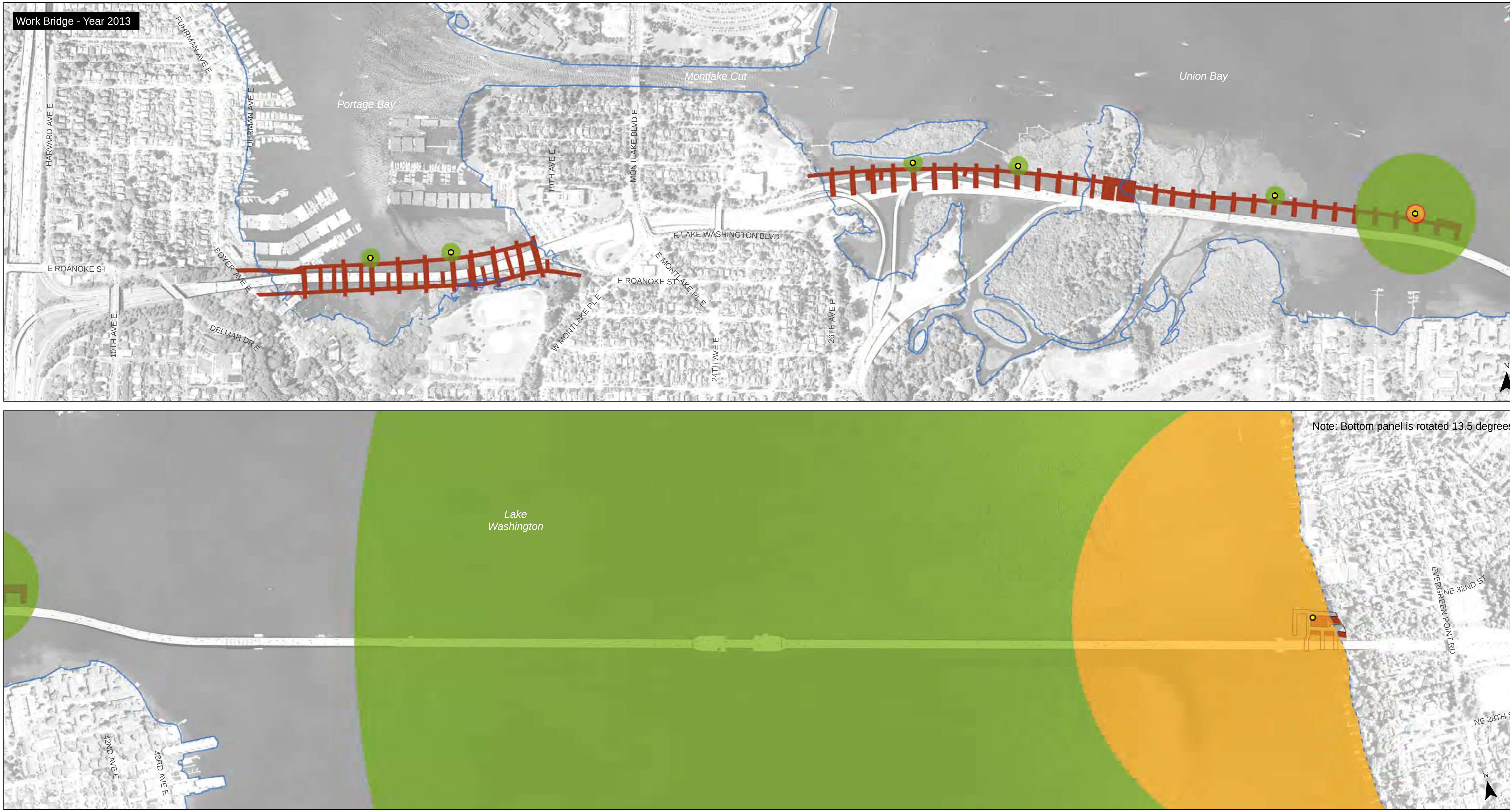
Area	Maximum Strikes	Injury Threshold			Disturbance Threshold
		Distance to Exceed 206 dB_{peak} for Injury (m)	Distance to Exceed SEL dB for Cumulative Injury		150 dB_{RMS} (m)
			Fish ≥ 2 g (m)	Fish < 2 g (m)	
Portage Bay (Location C)	16,000	0	2	2	22
Union Bay/ West Approach (Location B)	8,000	0	2	2	22
West Approach (Location A)	4,000	0	19	22	136
East Approach	8,000	5	541	541	2,154

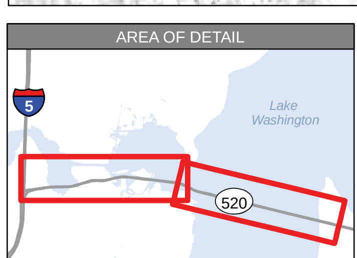
In Portage Bay, Union Bay, and all of the west approach, injury to fish from peak noise levels (above 206 dB_{peak}) will only result immediately adjacent to the 24- or 30-inch-diameter hollow steel piles pile(s) being driven, within a distance of less than 1 meter (see Exhibit D-3). This distance will be contained within the area of the noise attenuation system and therefore will not be accessible to fish. However, based on a lesser degree of certainty on the noise attenuation levels that may be achieved with bubble curtain use for piles at the east approach, the single strike injury zone in that area will be slightly greater, at about 5 meters from each pile (see Exhibit D-3).

In Portage Bay, Union Bay, and the west approach, the range at which the cumulative SEL would remain above the injury threshold for juvenile and sub-adult/adult fish (183 dB and 187 dB, respectively) increases logarithmically with increasing numbers of pile strikes, up to about 5,000 pile strikes in a day, and remains at that range for any additional strikes per day. In Portage Bay, Union Bay, and the western portion of the west approach (location B), for both sizes of fish (greater or less than 2 grams), the maximum expected range that the SEL would exceed the threshold for the expected number of pile strikes in these three areas is about 2 meters for a 30-inch-diameter pile (see Exhibit D-3). In the eastern portion of the west approach (location A), the maximum expected range that the SEL would exceed the threshold for the expected number of pile strikes in this area is about 19 meters for fish greater or equal to 2 grams and 22 meters for fish less than 2 grams.

In the east approach area, the range at which the cumulative SEL would remain above the injury threshold for juvenile and sub-adult/adult fish is larger. A maximum average of 8,000 pile strikes per day is expected in the east approach area, which would indicate a cumulative injury zone of 541 meters (see Exhibit D-3). This zone also increases logarithmically with increasing numbers of pile strikes, up to about 5,000 pile strikes in a day, and remains at that range for any additional strikes per day.

Exhibit D-4 shows the spatial extent of pile-driving noise propagation (single pile) by area in construction year 2013.





- Noise Driving Point
- Ordinary High Water Mark
- Ordinary High Water Mark (Not Surveyed)
- Work Bridge
- Work Bridge and Falsework Construction in Progress

Potential Fish Behavior/Injury Thresholds

- 150 dB RMS
- 183 dB SEL
- 187/183 dB SEL
- 206 dB Peak

0 500 1,000 2,000 Feet

Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit D-4. **Overview of Annual Pile-Driving Noise in Year 2013**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

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Terrestrial Noise Analysis

Potential terrestrial sound level effects of the SR 520, I-5 to Medina project are primarily related to the pile-driving activities. For projects adjacent to transportation corridors, traffic noise typically determines the baseline noise level in the project vicinity. The SR 520, I-5 to Medina project will occur along the existing Evergreen Point Bridge, which receives heavy traffic volumes throughout most of the day. Baseline daytime environmental noise levels at the site were measured as a part of the SR 520 Test Pile Program (Illingworth and Rodkin, Inc. 2010). Based on a review of these data, ambient noise in Portage Bay, Union Bay, and the west approach was conservatively estimated at 73 dBA (at 50 feet from the source) (Exhibit D-5). Traffic noise levels were established by using a table provided in the WSDOT Advanced BA Training Manual (WSDOT 2010) to predict line-source traffic noise levels, which uses both average hourly traffic volume at the site as well as the posted speed limit of the roadway. Within the action area, SR 520 has more than 6,000 vehicles per hour and a posted speed limit of 55 miles per hour (mph), indicating that traffic noise is approximately 77 dBA (see Exhibit D-5).

EXHIBIT D-5.
TERRESTRIAL SOUND ATTENUATION FOR EVERGREEN POINT BRIDGE IMPACT PILE-DRIVING ACTIVITIES

Distance from Source (feet)	Sound Levels from Construction Noise (dBA)[a]	Sound Levels from Highway Traffic (dBA)[b]	Daytime Baseline Noise (dBA) in Project Vicinity[c]
50	111	77	73
100	105	74	73
200	99	71	73
400	93	68	73
800	87	65	73
1,600	81	62	73
3,200	75	59	73
6,400	69	56	73
12,800	63	53	73
25,600	57	50	73

[a] Assumes impact pile-driving point sound level of 108 dB at 50 feet, and additional 3dB addition from other equipment noise, and a 6 dB reduction per doubling of distance for a hard site.

[b] Assumes traffic sound level of 77 dBA at 50 feet and a 3 dB reduction per doubling of distance for a hard site.

[c] Daytime baseline noise level is based on ambient noise measured during SR 520 Test Pile Project.

For the terrestrial impact zone, the primary disturbance to any listed wildlife species will be from impact pile-driving and from the visual disturbance and noise generated from other onsite construction equipment. Other sources of noise during construction will include the use of compressors, pumps, tug boats, and smaller construction skiffs. WSDOT (2010) has assembled noise level information from various construction activities at various sites (Exhibit D-6).

Based on the proposed project activities and the construction equipment required, the worst case scenario for noise transmission is expected to be from impact pile-driving. Because the construction activities will occur in open-water areas, hard surface conditions were used to estimate the noise attenuation of construction activities (see Exhibit D-5).

EXHIBIT D-6.
NOISE RANGES AT 50 FEET FROM COMMON CONSTRUCTION EQUIPMENT (WSDOT 2010)

Equipment Type	Noise Level (dB)
Impact Pile Driver [a]	108
Compressor	73–88
Crane	74–89
Generator	71–82
Pumps	68–80

[a] In air noise levels from impact pile-driving at 50 feet as measured during SR 520 Test Pile Project.

The results of the attenuation table were graphed to linearly display the attenuation rates for noise from pile-driving and to calculate the respective regression equations (Exhibit D-7). The point where the two lines cross represents the distance where construction noise is indistinguishable from traffic noise. The pile-driving is considered a point source, while the traffic is considered a line source, and noise from the two sources attenuates at different rates (6 dB and 3 dB per doubling of distance, respectively). Therefore, the range at which the attenuation lines cross (become indistinguishable) is well beyond the range at which sound levels from pile-driving attenuate to below the estimated urban background noise levels (about 73 dBA) (WSDOT 2010). Based on the terrestrial noise analysis, the point where airborne construction noise attenuates to background (ambient) levels is about 4,000 feet or about 0.75 mile from the location of impact pile-driving activities.

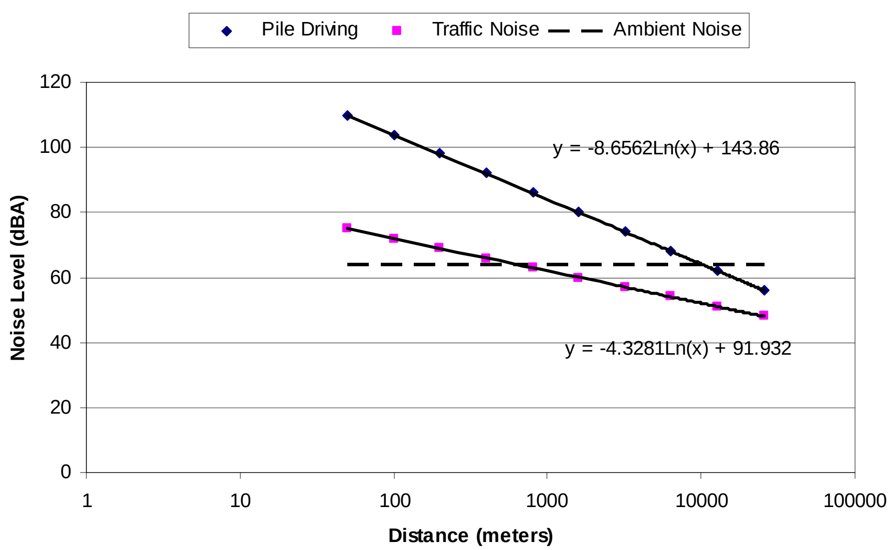

EXHIBIT D-7.
TERRESTRIAL NOISE ATTENUATION GRAPH

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APPENDIX E: FISH USE AND TIMING IN THE ACTION AREA

SR 520 DRAFT In Water Work Discussion Matrix

Nominal Presence
Low Presence
High Presence

Species	Life History Stage	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Notes
Chinook	-Adult													
	-Residual													
	-Juvenile													
Steelhead	-Adult													
	-Residual													
	-Juvenile													
Sockeye	-Adult													
	-Juvenile Rearing													
	-Juvenile Outmigrating													
Coho	-Adult													
	-Juvenile													
Bull Trout	-Sub Adult													

SR 520 DRAFT In-Water Construction Discussion Matrix
ZONE 1: Lake Union to the downstream end of the Locks

Legend	
Yellow	Nominal Presence
Light blue	Low Presence
Dark blue	High Presence
Green	In-Water Construction Window
Red	Avoid In-Water Construction

Species	Life History Stage	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Notes
Chinook	-Adult						Low	High	High	High	Low			
	-Residual	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	
	-Juvenile				Low	High	High	High	Low					
Steelhead	-Adult	Low	Low	Low	Low	Low	Nominal						Nominal	-low presence yet sensitive population
	-Residual	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	-low presence yet sensitive population
	-Juvenile		Nominal	Nominal	Nominal	Low	Low	Low	Nominal					-low presence yet sensitive population
Sockeye	-Adult					Low	High	High	High	Low				
	-Juvenile Rearing					Nominal	Nominal	Nominal	Nominal					
	-Juvenile Out migrating			Nominal	High	High	High	High						
Coho	-Adult								Low	High	High	High	High	
	-Juvenile			Nominal	High	High	High	Low						
Bull Trout	-Sub Adult	Nominal	Nominal	Nominal	Low	Low	Low	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	-low presence yet sensitive population

Construction Activity	Steps/Components	Functional Impacts	Threshold of Concern	BMPs	Proposed Work Window: Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Notes
2) Pontoon Towing	Barge/Tug operations	-vessel activity	-vessel activity not regulated in deep water		Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	
	Lock operations	-water quantity	-operation of locks is separately regulated and approved		Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	
17) Material Transport	Barge/Tug operations	-vessel activity	-vessel activity not regulated in deep water/navigation channels		Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	
	Lock operations	-water quantity	-operation of locks is separately regulated and approved		Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	

		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
Published Work Window	**Bull Trout and Juvenile Chinook**	Window	Window	Window	Window/Avoid	Avoid	Avoid	Avoid	Avoid	Avoid	Window	Window	Window	

SR 520 DRAFT In-Water Construction Discussion Matrix
ZONE 2: Portage Bay

Legend	
Yellow	Nominal Presence
Light blue	Low Presence
Dark blue	High Presence
Green	In-Water Construction Window
Red	Avoid In-Water Construction
Hatched	Work Window - Pending Further Discussion/Review

Species	Life History Stage	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Notes
Chinook	-Adult						Low	Low	Low	Low	Low			
	-Residual	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	
	-Juvenile				Low	Low	Low	Low	Low					
Steelhead	-Adult	Low	Low	Low	Low	Low	Nominal						Nominal	-low presence yet sensitive population
	-Residual	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	-low presence yet sensitive population
	-Juvenile		Nominal	Nominal	Nominal	Low	Low	Low	Nominal					-low presence yet sensitive population
Sockeye	-Adult					Low	Low	Low	Low	Low				
	-Juvenile Rearing					Nominal	Nominal	Nominal	Nominal					
	-Juvenile Out migrating			Nominal	Low	Low	Low	Low						
Coho	-Adult								High	High	High	High	High	-limited data
	-Juvenile			Nominal	High	High	High	High						-limited data
Bull Trout	-Sub Adult	Nominal	Nominal	Nominal	Low	Low	Low	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	-low presence yet sensitive population

Construction Activity	Steps/Components	Functional Impacts	Threshold of Concern	BMPs	Proposed Work Window: Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Notes
5) Workbridge Construction	Shoreline access	-turbidity -habitat disturbance	-State water quality standard 5 NTU over background	-silt curtain, TESC plan	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	
	Pile driving	-underwater noise -turbidity	-NMFS underwater noise standards	-vibratory installation when possible -sound attenuation device (bubble curtain, gunderboom)	Window	Window	Window	Pending	Avoid	Avoid	Avoid	Avoid	Window	Window	Window	Window	-work may be allowed through April depending on presence of juvenile Chinook -include period of no pile driving for fish passage
	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	
6) Cofferdam Installation	Sheet pile vibratory installation	-underwater noise -turbidity	-NMFS underwater noise standards	-sound attenuation if thresholds exceeded	Window	Window	Window	Window	Avoid	Avoid	Avoid	Avoid/Window	Window	Window	Window	Window	-higher water temps are a concern
	Seal course pouring	-turbidity -ph	-State water quality standard 5 NTU over background -no uncured concrete in water	-Spill Prevention, Control and Countermeasures Plan (SPCC)	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	
	Dewatering	-turbidity	-State water quality standard 5 NTU over background	-no release of turbid water (e.g., settlement, baker tanks)	Pending	Pending	Pending	Pending	Pending	Pending	Pending	Pending	Pending	Pending	Pending	Pending	-work may be allowed year round conditional to an approved dewatering plan -performance standards should address location, turbidity, and temperature
7) Drilled Shaft	Shaft vibratory installation	-underwater noise -turbidity	-NMFS underwater noise standards	-sound attenuation if thresholds exceeded	Window	Window	Window	Window	Avoid	Avoid	Avoid	Avoid/Window	Window	Window	Window	Window	
	Shaft dewatering/excavation	-turbidity	-State water quality standard 5 NTU over background	-no release of turbid water (e.g., settlement, baker tanks)	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	
	Concrete pour w/in shaft	-turbidity -ph	-State water quality standard 5 NTU over background -no uncured concrete in water	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	

In-Water Construction TWG - April 2010
Zone 2

SR 520 DRAFT In-Water Construction Discussion Matrix
ZONE 2: Portage Bay

Construction Activity	Steps/Components	Functional Impacts	Threshold of Concern	BMPs	Proposed Work Window												Notes
					Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
18) Mudline Footing	Concrete pour into template	-turbidity -ph	-State water quality standard 5 NTU over background -no uncured concrete in water	-completed within cofferdam -Spill Prevention, Control and Countermeasures Plan (SPCC)													
	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
8) Waterline Footing	Form placement	-none															
	Concrete pour into form	-turbidity -ph	-State water quality standard 5 NTU over background -no uncured concrete in water	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
11) Pier on Waterline Footings	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
	Concrete pier construction	-turbidity -ph	-State water quality standard 5 NTU over background -no uncured concrete in water	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
13) Segmental	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
	Concrete box girder construction	-turbidity -ph	-State water quality standard 5 NTU over background -no uncured concrete in water	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
14) Exist Bridge Removal	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
	Piling removal	-underwater noise -turbidity	-NMFS underwater noise standards	-vibratory removal where possible -sound attenuation if thresholds exceeded													
15) Work Bridge Removal	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
	Piling removal	-underwater noise -turbidity	-NMFS underwater noise standards	-sound attenuation if thresholds exceeded													

		Jan	Feb	Mar	Apr	May	June	July	AugAug	Sept	Oct	Nov	Dec	
Published Work Window	**Bull Trout and Juvenile Chinook**													

SR 520 DRAFT In-Water Construction Discussion Matrix
ZONE 3: Montlake Cut

Legend:
- Nominal Presence (yellow)
- Low Presence (light blue)
- High Presence (dark blue)
- In-Water Construction Window (green)
- Avoid In-Water Construction (red)

Species	Life History Stage	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Notes
Chinook	-Adult						Low	High	High	High	Low			
	-Residual	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	
	-Juvenile				Low	High	High	High	Low					
Steelhead	-Adult	Low	Low	Low	Low	Low	Nominal						Nominal	-low presence yet sensitive population
	-Residual	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	-low presence yet sensitive population
	-Juvenile		Nominal	Nominal	Nominal	Low	Low	Low	Nominal					-low presence yet sensitive population
Sockeye	-Adult					Low	High	High	High	Low				
	-Juvenile Rearing					Nominal	Nominal	Nominal	Nominal					
	-Juvenile Out migrating			Nominal	High	High	High	High						
Coho	-Adult								Low	High	High	High	High	
	-Juvenile			Nominal	High	High	High	Low						
Bull Trout	-Sub Adult	Nominal	Nominal	Nominal	Low	Low	Low	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	-low presence yet sensitive population

Construction Activity	Steps/Components	Functional Impacts	Threshold of Concern	BMPs	Proposed Work Window: Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Notes
2) Pontoon Towing	Barge/Tug operations	-vessel activity	-vessel activity not regulated in deep water		Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	
	Lock operations	-water quantity	-operation of locks is separately regulated and approved		Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	
17) Material Transport	Barge/Tug operations	-vessel activity	-vessel activity not regulated in deep water/navigation channels		Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	
	Lock operations	-water quantity	-operation of locks is separately regulated and approved		Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	
19) Tunneling	Underground/underwater work	-turbidity (if failure)	-State water quality standard 5 NTU over background -no uncured concrete in water		Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	
	Upland excavation	-turbidity -habitat disturbance	-State water quality standard 5 NTU over background	-silt curtain, TESC plan	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	
20) Bascule Bridge Construction	Shoreline work	-turbidity -habitat disturbance	-State water quality standard 5 NTU over background	-silt curtain, TESC plan	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	
	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	

		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
Published Work Window	**Bull Trout and Juvenile Chinook**	Window	Window	Window/Avoid	Avoid	Avoid	Avoid	Avoid	Avoid	Avoid	Window	Window	Window	

In-Water Construction TWG - April 2010
Zone 3

SR 520 DRAFT In-Water Construction Discussion Matrix
ZONE 4: Arboretum and Foster Island

Legend	
(yellow)	Nominal Presence
(light blue)	Low Presence
(dark blue)	High Presence
(green)	In-Water Construction Window
(red)	Avoid In-Water Construction
(hatched)	Work Window - Pending Further Discussion/Review

Species	Life History Stage	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Notes
Chinook	-Adult						Low	Low	Low	Low	Low			
	-Residual	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	
	-Juvenile			Low	Low	Low	Low	Low	Low					
Steelhead	-Adult	Low	Low	Low	Low	Low	Nominal						Nominal	-low presence yet sensitive population
	-Residual	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	-low presence yet sensitive population
	-Juvenile		Nominal	Nominal	Nominal	Low	Low	Low	Nominal					-low presence yet sensitive population\
Sockeye	-Adult					Low	Low	Low	Low	Low				
	-Juvenile Rearing					Nominal	Nominal	Nominal	Nominal					
	-Juvenile Out migrating			Nominal	Low	Low	Low	Low						
Coho	-Adult								Low	Low	Low	Low	Low	
	-Juvenile			Low	Low	Low	Low	Low						
Bull Trout	-Sub Adult	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	-low presence yet sensitive population

Construction Activity	Steps/Components	Functional Impacts	Threshold of Concern	BMPs	Proposed Work Window												Notes
					Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
5) Workbridge Construction	Shoreline access	-turbidity -habitat disturbance	-State water quality standard 5 NTU over background	-silt curtain, TESC plan	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	
	Pile driving	-underwater noise -turbidity	-NMFS underwater noise standards	-vibratory installation when possible -sound attenuation device (bubble curtain, gunderboom)	Window	Window	Window	Pending	Avoid	Avoid	Avoid	Avoid	Window	Window	Window	Window	-work may be allowed through April depending on presence of juvenile Chinook
	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	
7) Drilled Shaft	Template pile installation	-underwater noise -turbidity	'-NMFS underwater noise standards	-vibratory installation when possible -sound attenuation device (bubble curtain, gunderboom)	Window	Window	Window	Pending	Avoid	Avoid	Avoid	Avoid	Window	Window	Window	Window	-work may be allowed through April depending on presence of juvenile Chinook
	Shaft vibratory installation	-underwater noise -turbidity	-NMFS underwater noise standards	-sound attenuation if thresholds exceeded	Window	Window	Window	Pending	Pending	Pending	Pending	Pending/Window	Window	Window	Window	Window	-review with Eric Warner, MIT
	Shaft dewatering/excavation	-turbidity	-State water quality standard 5 NTU over background	-no release of turbid water (e.g., settlement, baker tanks)	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	
	Concrete pour w/in shaft	-turbidity -ph	-State water quality standard 5 NTU over background -no uncured concrete in water	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	

SR 520 DRAFT In-Water Construction Discussion Matrix
ZONE 4: Arboretum and Foster Island

Construction Activity	Steps/Components	Functional Impacts	Threshold of Concern	BMPs	Proposed Work Window												Notes
					Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
8) Waterline Footing	Form placement	-none															
	Concrete pour into form	-turbidity -ph	-State water quality standard 5 NTU over background -no uncured concrete in water	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
11) Pier on Waterline Footings	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
	Concrete pier construction	-turbidity -ph	-State water quality standard 5 NTU over background -no uncured concrete in water	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
13) Segmental	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
	Concrete box girder construction	-turbidity -ph	-State water quality standard 5 NTU over background -no uncured concrete in water	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
14) Exist Bridge Removal	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
	Piling removal	-underwater noise -turbidity	-NMFS underwater noise standards	-sound attenuation if thresholds exceeded													
15) Work Bridge Removal	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
	Piling removal	-underwater noise -turbidity	-NMFS underwater noise standards	-sound attenuation if thresholds exceeded													-review with Eric Warner, MIT

		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
Published Work Windows	**North of SR 520: Bull Trout and Juvenile Chinook**													
	South of SR 520: Bull Trout and Juvenile Chinook													

SR 520 DRAFT In-Water Construction Discussion Matrix
ZONE 5: Union Bay

Legend:
- Yellow: Nominal Presence
- Light blue: Low Presence
- Dark blue: High Presence
- Green: In-Water Construction Window
- Red: Avoid In-Water Construction

Species	Life History Stage	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Notes
Chinook	-Adult						Low	High	High	High	Low			
	-Residual	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	
	-Juvenile			Low	Low	High	High	High	Low					
Steelhead	-Adult	Low	Low	Low	Low	Low	Nominal						Nominal	-low presence yet sensitive population
	-Residual	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	-low presence yet sensitive population
	-Juvenile		Nominal	Nominal	Nominal	Low	Low	Low	Nominal					-low presence yet sensitive population
Sockeye	-Adult	Nominal				Low	High	High	High	Low			Nominal	
	-Juvenile Rearing	High	High	High	High	High	High	High	High	High	High	High	High	
	-Juvenile Out migrating			Low	High	High	High	High						
Coho	-Adult								Low	High	High	High	Low	
	-Juvenile			Low	High	High	High	Low						
Bull Trout	-Sub Adult	Nominal	Nominal	Nominal	Low	Low	Low	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	-low presence yet sensitive population

Construction Activity	Steps/Components	Functional Impacts	Threshold of Concern	BMPs	Proposed Work Window												Notes
					Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
2) Pontoon Towing	Barge/Tug operations	-vessel activity	-vessel activity not regulated in deep water		Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	
	Lock operations	-water quantity	-operation of locks is separately regulated and approved		Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	
17) Material Transport	Barge/Tug operations	-vessel activity	-vessel activity not regulated in deep water/navigation channels		Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	

		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
Published Work Window	**Bull Trout and Juvenile Chinook**	Window	Window	Window / Avoid	Avoid	Avoid	Avoid	Avoid / Window	Window	Window	Window	Window	Window	

SR 520 DRAFT In-Water Construction Discussion Matrix
ZONE 6: West Approach

Legend:
- Nominal Presence
- Low Presence
- High Presence
- In-Water Construction Window
- Avoid In-Water Construction
- Work Window - Pending Further Discussion/Review

Species	Life History Stage	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Notes
Chinook	-Adult						Low Presence	High Presence	High Presence	High Presence	Low Presence			
	-Residual	Nominal Presence	Nominal Presence	Nominal Presence	Nominal Presence	Nominal Presence	Nominal Presence	Nominal Presence	Nominal Presence	Nominal Presence	Nominal Presence	Nominal Presence	Nominal Presence	
	-Juvenile			Low Presence	Low Presence	High Presence	High Presence	High Presence	Low Presence					
Steelhead	-Adult	Low Presence	Low Presence	Low Presence	Low Presence	Low Presence	Nominal Presence						Nominal Presence	-low presence yet sensitive population
	-Residual	Nominal Presence	Nominal Presence	Nominal Presence	Nominal Presence	Nominal Presence	Nominal Presence	Nominal Presence	Nominal Presence	Nominal Presence	Nominal Presence	Nominal Presence	Nominal Presence	-low presence yet sensitive population
	-Juvenile		Nominal Presence	Nominal Presence	Nominal Presence	Low Presence	Low Presence	Low Presence	Nominal Presence					-low presence yet sensitive population
Sockeye	-Adult	Nominal Presence				Low Presence	High Presence	High Presence	High Presence	Low Presence			Nominal Presence	
	-Juvenile Rearing	High Presence	High Presence	High Presence	High Presence	High Presence	High Presence	High Presence	High Presence	High Presence	High Presence	High Presence	High Presence	
	-Juvenile Out migrating			Low Presence	High Presence	High Presence	High Presence	High Presence						
Coho	-Adult								Low Presence	High Presence	High Presence	High Presence	Low Presence	
	-Juvenile			Low Presence	High Presence	High Presence	High Presence	Low Presence						
Bull Trout	-Sub Adult	Nominal Presence	Nominal Presence	Nominal Presence	Low Presence	Low Presence	Low Presence	Nominal Presence	Nominal Presence	Nominal Presence	Nominal Presence	Nominal Presence	Nominal Presence	-low presence yet sensitive population

Construction Activity	Steps/Components	Functional Impacts	Threshold of Concern	BMPs	Proposed Work Window												Notes
					Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
5) Workbridge Construction	Shoreline access	-turbidity -habitat disturbance	-State water quality standard 5 NTU over background	-silt curtain, TESC plan	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	
	Pile driving	-underwater noise -turbidity	-NMFS underwater noise standards	-vibratory installation when possible -sound attenuation device (bubble curtain, gunderboom)	Window	Window	Window	Window / Avoid	Avoid	Avoid	Avoid	Avoid	Avoid	Window	Window	Window	-include period of no pile driving to allow fish to pass through -potential effect to adult Coho and Steelhead
	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	
7) Drilled Shaft	Template pile installation	-underwater noise -turbidity	-NMFS underwater noise standards	-vibratory installation when possible -sound attenuation device (bubble curtain, gunderboom)	Window	Window	Window	Avoid	Avoid	Avoid	Avoid	Window	Window	Window	Window	Window	
	Shaft vibratory installation	-underwater noise -turbidity	-NMFS underwater noise standards	-sound attenuation if thresholds exceeded	Window	Window	Window	Avoid	Avoid	Avoid	Avoid	Window	Window	Window	Window	Window	-research dissolved oxygen (DO) level in this zone
	Shaft dewatering/excavation	-turbidity	-State water quality standard 5 NTU over background	-no release of turbid water (e.g., settlement, baker tanks)	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	
	Concrete pour w/in shaft	-turbidity -ph	-State water quality standard 5 NTU over background -no uncured concrete in water	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	

SR 520 DRAFT In-Water Construction Discussion Matrix
ZONE 6: West Approach

Construction Activity	Steps/Components	Functional Impacts	Threshold of Concern	BMPs	Proposed Work Window												Notes
					Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
8) Waterline Footing	Form placement	-none															
	Concrete pour into form	-turbidity -ph	-State water quality standard 5 NTU over background -no uncured concrete in water	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
11) Pier on Waterline Footings	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
	Concrete pier construction	-turbidity -ph	-State water quality standard 5 NTU over background -no uncured concrete in water	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
13) Segmental	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
	Concrete box girder construction	-turbidity -ph	-State water quality standard 5 NTU over background -no uncured concrete in water	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
14) Exist Bridge Removal	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
	Piling removal	-underwater noise -turbidity	-NMFS underwater noise standards	-sound attenuation if thresholds exceeded													
15) Work Bridge Removal	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
	Piling removal	-underwater noise -turbidity	-NMFS underwater noise standards	-sound attenuation if thresholds exceeded													-work may be restricted through August and September, depending on DO level

		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
Published Work Windows	**North of SR 520: Bull Trout and Juvenile Chinook**													
	South of SR 520: Bull Trout and Juvenile Chinook													

SR 520 DRAFT In-Water Construction Discussion Matrix
ZONE 7: Floating Bridge

Nominal Presence
Low Presence
High Presence

In-Water Construction Window
Avoid In-Water Construction

Species	Life History Stage	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Notes
Chinook	-Adult													
	-Residual													
	-Juvenile													
Steelhead	-Adult													-low presence yet sensitive population
	-Residual													-low presence yet sensitive population
	-Juvenile													-low presence yet sensitive population
Sockeye	-Adult													
	-Juvenile Rearing													
	-Juvenile Out migrating													
Coho	-Adult													
	-Juvenile													
Bull Trout	-Sub Adult													-low presence yet sensitive population

Construction Activity	Steps/Components	Functional Impacts	Threshold of Concern	BMPs	Proposed Work Window												Notes
					Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
1) Anchor System Installation	Barge/Tug operations	-vessel activity	-vessel activity not regulated in deep water														
	Anchor lowering and securing	-turbidity	-State water quality standard 5 NTU over background	-turbidity and habitat disturbance are limited and would occur at depths greater than used by species of concern													
	Cable attachment																
2) Pontoon Towing	Barge/Tug operations	-vessel activity	-operation of locks is separately regulated and approved														
	Lock operations	-water quantity															
3) Pontoon Assembly	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
	Seal placement	-water quality pH	-no uncured concrete in water	-Spill Prevention, Control and Countermeasures Plan (SPCC)													
4) Superstructure Outfitting	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
	Concrete pour	-turbidity -pH	-State water quality standard 5 NTU over background -no uncured concrete in water	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													

SR 520 DRAFT In-Water Construction Discussion Matrix
ZONE 7: Floating Bridge

Construction Activity	Steps/Components	Functional Impacts	Threshold of Concern	BMPs	Proposed Work Window: Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Notes
14) Exist Bridge Removal 16) Pontoon Disassembly	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
	Seal removal	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													

		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
Published Work Windows	**North of SR 520: Bull Trout and Juvenile Chinook**													
	South of SR 520: Bull Trout and Juvenile Chinook													

SR 520 DRAFT In-Water Construction Discussion Matrix
ZONE 8: East Approach

Legend	
Yellow	Nominal Presence
Light blue	Low Presence
Dark blue	High Presence
Green	In-Water Construction Window
Red	Avoid In-Water Construction

Species	Life History Stage	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Notes
Chinook	-Adult						Low	High	High	High	Low			
	-Residual	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	
	-Juvenile			Low	Low	High	High	High	Low					
Steelhead	-Adult	Low	Low	Low	Low	Low	Nominal						Nominal	-low presence yet sensitive population
	-Residual	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	-low presence yet sensitive population
	-Juvenile		Nominal	Nominal	Nominal	Low	Low	Low	Nominal					-low presence yet sensitive population
Sockeye	-Adult	Nominal				Low	High	High	High	Low		Nominal	Nominal	-Nov, Dec, Jan are peak Sockeye spawning months
	-Juvenile Rearing	High	High	High	High	High	High	High	High	High	High	High	High	
	-Juvenile Out migrating			Low	High	High	High	High						
Coho	-Adult								Low	High	High	High	Low	
	-Juvenile			Low	High	High	High	Low						
Bull Trout	-Sub Adult	Nominal	Nominal	Nominal	Low	Low	Low	Nominal	Nominal	Nominal	Nominal	Nominal	Nominal	-low presence yet sensitive population

Construction Activity	Steps/Components	Functional Impacts	Threshold of Concern	BMPs	Proposed Work Window: Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Notes
5) Workbridge Construction	Shoreline access	-turbidity -habitat disturbance	-State water quality standard 5 NTU over background	-silt curtain, TESC plan	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	-allowed year round with BMPs
	Pile driving	-underwater noise -turbidity	-NMFS underwater noise standards	-vibratory installation when possible -sound attenuation device (bubble curtain, gunderboom)	Window	Window	Window/Avoid	Avoid	Avoid	Avoid	Avoid	Avoid/Window	Window	Window	Window	Window	-avoid close-to-shore work in spring when fry may be present -impacts to Chinook and Steelhead juveniles are a concern in fall -potential for direct effect to adult beach spawning Sockeye, mitigation may be needed -if possible, schedule pile driving activities with a 1 year gap in between (for above water work)
	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	-avoid lights on water surface from May 1 through August 30, especially when smolts are present
7) Drilled Shaft	Template pile installation	-underwater noise -turbidity	-NMFS underwater noise standards	-vibratory installation when possible -sound attenuation device (bubble curtain, gunderboom)	Window	Window	Window/Avoid	Avoid	Avoid	Avoid	Avoid	Avoid/Window	Window	Window	Window	Window	-avoid close-to-shore work in spring when fry may be present -impacts to Chinook and Steelhead juveniles are a concern in fall -potential for direct effect to adult beach spawning Sockeye, mitigation may be needed -if possible, schedule pile driving activities with a 1 year gap in between (for above water work)
	Shaft vibratory installation	-underwater noise -turbidity	-NMFS underwater noise standards	-sound attenuation if thresholds exceeded	Window	Window	Window	Window	Window/Avoid	Avoid	Avoid	Avoid	Window	Window	Window	Window	-avoid close-to-shore work in spring when fry may be present
	Shaft dewatering/excavation	-turbidity	-State water quality standard 5 NTU over background	-no release of turbid water (e.g., settlement, baker tanks)	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	
	Concrete pour w/in shaft	-turbidity -ph	-State water quality standard 5 NTU over background -no uncured concrete in water	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	Window	

SR 520 DRAFT In-Water Construction Discussion Matrix
ZONE 8: East Approach

Construction Activity	Steps/Components	Functional Impacts	Threshold of Concern	BMPs	Proposed Work Window												Notes
					Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
10) Pier on Drilled Shaft	Template placement	-none															
	Concrete pour into template	-turbidity -ph	-State water quality standard 5 NTU over background -no uncured concrete in water	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
12) Box Girder	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
	Falsework piling installation	-underwater noise -turbidity	-NMFS underwater noise standards	-vibratory installation when possible -sound attenuation device (bubble curtain, gunderboom)													-avoid close-to-shore work in spring when fry may be present
	Concrete pour	-turbidity -ph	-State water quality standard 5 NTU over background No uncured concrete in water	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
	Falsework piling removal	-underwater noise -turbidity	-NMFS underwater noise standards	-vibratory removal where possible -sound attenuation if thresholds exceeded													-avoid close-to-shore work in spring when fry may be present
14) Exist Bridge Removal	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
	Piling removal	-underwater noise -turbidity	-NMFS underwater noise standards	-vibratory removal where possible -Sound attenuation if thresholds exceeded													
15) Work Bridge Removal	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)													
	Piling removal	-underwater noise -turbidity	-NMFS underwater noise standards	-vibratory removal where possible -sound attenuation if thresholds exceeded													-avoid close-to-shore work in spring when fry may be present

		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
Published Work Windows	**North of SR 520: Bull Trout and Juvenile Chinook**													
	South of SR 520: Bull Trout and Juvenile Chinook													
	Sockeye Spawning Area													

In-Water Construction TWG - Construction Activities

No.	Construction Activity	Description	Steps/Components	Functional Impact	Thresholds of Concern	BMPs	Notes
1	**Anchor System** Installation	Large anchors are used to hold the pontoons in place. Two main types would be used for the new bridge: Gravity anchors would be used in the dense, harder lakebed materials of Lake Washington (near the shores). These anchors would consist of large concrete blocks or boxes stacked on top of one another. Fluke anchors would be used in the soft bottom sediments of the lake. These anchors would be installed using a combination of their own weight and water or air-jetting to set them below the mud line. The fluke anchors would be 32 to 35 feet across in width. Both types of anchors would be connected to the floating pontoons with steel cables. The anchors would extend approximately 690 to 700 feet out from the bridge. Approximately 27 anchors would be installed along each of the north and south sides of the new bridge structure, for a total of 54 anchors.	Barge/Tug operations	-vessel activity	-vessel activity not regulated in deep water		
			Anchor lowering and securing	-turbidity	-State water quality standard 5 NTU over background	-turbidity and habitat disturbance are limited and would occur at depths greater than used by species of concern	
			Cable attachment				
2	**Pontoon Towing**	Pontoons will be built in Gray's Harbor or Puget Sound and towed to Lake Washington through the locks. No towing between Nov 1st and Jan 31st due to weather.	Barge/Tug operations	-vessel activity	-vessel activity not regulated in deep water		
			Lock operations	-water quantity			
3	**Pontoon Assembly**	A single row of 21 - 75-foot-wide x 360-foot-long longitudinal pontoons are connected together using a watertight seal and a bolted connection. 52 - 50-foot wide x 96-foot long flanker pontoons are then connected to the longitudinal pontoons to increase stability and floatation. No assembly between Nov 1st to Jan 31st due to weather.	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)	
			Seal placement	-water quality pH	-no uncured concrete in water		
4	**Floating Bridge Superstructure Outfitting**	Bridge columns, cap beams, girder and deck are casts/placed on the end pontoons on the lake. The center pontoons will come preassembled with most of the superstructure already in place. At each pontoon joint, a single span of superstructure will be placed on the lake. No assembly between Nov 1st to Jan 31st due to weather.	Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)	
			Concrete pour	-turbidity -pH	-State water quality standard 5 NTU over background -no uncured concrete in water	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)	
5	**Workbridge** Construction and Removal	Temporary bridge built with steel piles spaced at 40' that is used to construct a permanent bridge from. Typically used in shallow water where access from barge or land is restricted.	Shoreline access	-turbidity -habitat disturbance	-State water quality standard 5 NTU over background	-silt curtain, TESC plan	
			Pile driving	-underwater noise -turbidity	-NMFS underwater noise standards	-vibratory installation when possible -sound attenuation device (bubble curtain, gunderboom)	
			Above water work	-debris/spills	-any fuel spill	-debris containment -Spill Prevention, Control and Countermeasures Plan (SPCC)	
6	**Cofferdam** Construction and Removal from Workbridge	Cofferdams are used to construct footings in the water. A cofferdam is a steel sheet piling that surrounds the perimeter of the footing. A waler frame is located on the inside of the sheets. A concrete tremie seal is placed at the bottom of excavation to resist buoyancy when the cofferdam is dewatered. Cofferdams will be usually about 4- to 6-feet wider than the footing that they contain.	Sheet pile vibratory installation	-underwater noise -turbidity	-NMFS underwater noise standards	-sound attenuation if thresholds exceeded	
			Seal course pouring	-turbidity -ph	-State water quality standard 5 NTU over background -no uncured concrete in water		
			Dewatering	-turbidity	-State water quality standard 5 NTU over background		
7	**Drilled Shaft** Construction	Drilled shafts are foundation elements used to resist structure loading at deep bearing strata. Typical drilled shafts are 8- to 10-foot diameter reinforced concrete, drilled inside steel cased holes with a drill auger. Build from work bridges or barges.	Template pile installation	-underwater noise -turbidity	-NMFS underwater noise standards		
			Shaft vibratory installation	-underwater noise -turbidity	-NMFS underwater noise standards	-sound attenuation if thresholds exceeded	
			Shaft dewatering/excavation	-turbidity	-State water quality standard 5 NTU over background		
			Concrete pour w/in shaft	-turbidity -ph	-State water quality standard 5 NTU over background -no uncured concrete in water		

In-Water Construction TWG - Construction Activities

No.	Construction Activity	Description	Steps/Components	Functional Impact	Thresholds of Concern	BMPs	Notes
8	**Waterline Footing** Construction from Barge	Waterline footings are typically used in deep water to connect a group of drilled shafts together. Built from barges.	Form placement	-none			
			-operation of locks is separately regulated and approved	-turbidity -ph	-State water quality standard 5 NTU over background -no uncured concrete in water		
			Above water work	-debris/spills	-any fuel spill		
9	**Pier** Construction **in Cofferdam** from Workbridge	Pier construction will include pouring a cofferdam tremie seal, a footing, and column.	Above water work	-debris/spills	-any fuel spill		
			Concrete pier construction	-turbidity -ph	-State water quality standard 5 NTU over background No uncured concrete in water		
10	**Pier** Construction **on Drilled Shafts** from Workbridge	Pier construction will include constructing a single column directly above a single drilled shaft.	Template placement	-none			
			Concrete pour into template	-turbidity -ph	-State water quality standard 5 NTU over background -no uncured concrete in water		
			Above water work	-debris/spills	-any fuel spill		
11	**Pier** Construction **on Waterline Footings** from Barge.	Pier construction will include constructing columns directly above a waterline footing.	Above water work	-debris/spills	-any fuel spill		
			Concrete pier construction	-turbidity -ph	-State water quality standard 5 NTU over background -no uncured concrete in water		
12	Cast-In-Place Concrete **Box Girder** Superstructure	CIP Box Girders are used where the span lengths are moderate and use of falsework is feasible. Span lengths are 150-feet to 260-feet for constant depth superstructures. Built from work bridges or barges.	Above water work	-debris/spills	-any fuel spill		
			Falsework piling installation	-underwater noise -turbidity	-NMFS underwater noise standards		
			Concrete pour	-turbidity -ph	-State water quality standard 5 NTU over background -no uncured concrete in water		
			Falsework piling removal	-underwater noise -turbidity	-NMFS underwater noise standards		
13	**Segmental** Concrete Balanced Cantilever Superstructure	Segmental concrete balanced cantilever construction is used where the span lengths are moderate and use of falsework is unfeasible, such as over water. Span lengths are 200-feet to 320-feet for constant depth superstructures, and 300-feet to 600-feet for variable depth haunched superstructures. Concrete box girders may be either precast or cast-in-place. Precast concrete is utilized whenever there is sufficient repetition in spans and segments to warrant. Built from work bridges or barges.	Above water work	-debris/spills	-any fuel spill		
			Concrete box girder construction	-turbidity -ph	-State water quality standard 5 NTU over background -no uncured concrete in water		

In-Water Construction TWG - Construction Activities

No.	Construction Activity	Description	Steps/Components	Functional Impact	Thresholds of Concern	BMPs	Notes
14	**Existing Bridge Removal**	Demolition of existing bridge will include all the superstructure and substructure down to the mudline. Bridges over water will require special precaution not to drop debris in the water. Nets, tarps, and platforms will be used. The crane will lift sections of the bridge off and swing them to a dump truck or barge standing by. The existing floating bridge will be de-stressed and disassembled. Anchors will remain, anchor cables will be removed. Demo from barge or work bridges.	Above water work	-debris/spills	-any fuel spill		
			Piling removal	-underwater noise -turbidity	-205 dB Injury -187 dB Behavioral		
15	**Work Bridge Removal**	Demolition of existing work bridge will include all the superstructure and substructure down to the mudline. The crane will lift sections of the bridge off and swing them to a dump truck or barge standing by. Demo from barge or existing work bridges.	Above water work	-debris/spills	-any fuel spill		
			Piling removal	-underwater noise -turbidity	-NMFS underwater noise standards -205 dB Injury -187 dB Behavioral		
16	**Pontoon Disassembly**	Disassembly of the existing pontoons will include demolition of the elevated superstructure on the ends of the pontoons, de-tensioning of the external post-tensioning, and using a wire saw to cut through the bolted joints. The existing anchors will be detached from the anchor cables and the anchor cables cables removed. The existing anchors will be left in place on the lake bottom.	Above water work	-debris/spills	-any fuel spill		
			Seal removal	-debris/spills	-any fuel spill		
17	**Materials Transport**	Transport of materials to and from the site will be both by land and by water. Barges and tugs will transport a large portion of the material. Dry bulk barges will pass through the Montlake Cut and the Hiram Chittenden locks to and from supply and disposal sites with access by water. Barges may also travel to temporary transfer facilities at the north and south ends of Lake Washington for material transfer from barge to truck. Dump trucks, haul trucks, and delivery trucks will travel over designated haul routes, using city streets and state and county highways to arrive at the site. Because of the large amount of material and the multimodal methods of transport, multiple access routes will be required.	Barge/Tug operations	-vessel activity	-vessel activity not regulated in deep water/navigation channels		
			Lock operations	-water quantity	-operation of locks is separately regulated and approved		
18	**Mudline Footing**	Mudline footings will be constructed by fist creating a cofferdam. The cofferdam will be created by vibrating and or driving template piles and beams to guide the sheet pile installation. The sheet piles will be vibrated into place and the interior strengthened by walers, frames, and struts. Drilled shafts would be constructed inside the cofferdam. A concrete seal would be placed underwater inside the cofferdam and then the cofferdam would be dewatered. Construction of the footing would commence inside the dewatered cofferdam.	Concrete pour into template	-turbidity -ph	-State water quality standard 5 NTU over background -no uncured concrete in water		
			Above water work	-debris/spills	-any fuel spill		
19	**Tunneling**		Underground/underwater work	-turbidity (if failure)	-State water quality standard 5 NTU over background -no uncured concrete in water		
			Upland excavation	-turbidity -habitat disturbance	-State water quality standard 5 NTU over background		
20	**Bascule Bridge Construction**		Shoreline work	-turbidity -habitat disturbance	-State water quality standard 5 NTU over background		
			Above water work	-debris/spills	-any fuel spill		

In-Water Construction TWG - Construction Activities

No.	Construction Activity	Overall Description	Steps/Components	Description of Steps/Components
1	**Anchor System** Installation	Large anchors are used to hold the pontoons in place. Two main types would be used for the new bridge: Gravity anchors would be used in the dense, harder lakebed materials of Lake Washington (near the shores). These anchors would consist of large concrete blocks or boxes stacked on top of one another. Fluke anchors would be used in the soft bottom sediments of the lake. These anchors would be installed using a combination of their own weight and water or air-jetting to set them below the mud line. The fluke anchors would be 32 to 35 feet across in width. Both types of anchors would be connected to the floating pontoons with steel cables. The anchors would extend approximately 690 to 700 feet out from the bridge. Approximately 27 anchors would be installed along each of the north and south sides of the new bridge structure, for a total of 54 anchors.	Barge/Tug operations	
			Anchor lowering and securing	
			Cable attachment	
2	**Pontoon Towing**	Pontoons will be built in Gray's Harbor or Puget Sound and towed to Lake Washington through the locks. No towing between Nov 1st and Jan 31st due to weather.	Barge/Tug operations	
			Lock operations	
3	**Pontoon Assembly**	A single row of 21 - 75-foot-wide x 360-foot-long longitudinal pontoons are connected together using a watertight seal and a bolted connection. 52 - 50-foot wide x 96-foot long flanker pontoons are then connected to the longitudinal pontoons to increase stability and floatation. No assembly between Nov 1st to Jan 31st due to weather.	Above water work	
			Seal placement	
4	**Floating Bridge Superstructure Outfitting**	Bridge columns, cap beams, girder and deck are casts/placed on the end pontoons on the lake. The center pontoons will come preassembled with most of the superstructure already in place. At each pontoon joint, a single span of superstructure will be placed on the lake. No assembly between Nov 1st to Jan 31st due to weather.	Above water work	
			Concrete pour	
5	**Workbridge** Construction and Removal	Temporary bridge built with steel piles spaced at 40' that is used to construct a permanent bridge from. Typically used in shallow water where access from barge or land is restricted.	Shoreline access	
			Pile driving	
			Above water work	
6	**Cofferdam** Construction and Removal from Workbridge	Cofferdams are used to construct footings in the water. A cofferdam is a steel sheet piling that surrounds the perimeter of the footing. A waler frame is located on the inside of the sheets. A concrete tremie seal is placed at the bottom of excavation to resist buoyancy when the cofferdam is dewatered. Cofferdams will be usually about 4- to 6-feet wider than the footing that they contain.	Sheet pile vibratory installation	
			Seal course pouring	
			Dewatering	
7	**Drilled Shaft** Construction	Drilled shafts are foundation elements used to resist structure loading at deep bearing strata. Typical drilled shafts are 8- to 10-foot diameter reinforced concrete, drilled inside steel cased holes with a drill auger. Build from work bridges or barges.	Template pile installation	
			Shaft vibratory installation	
			Shaft dewatering/excavation	
			Concrete pour w/in shaft	

In-Water Construction TWG - Construction Activities

No.	Construction Activity	Overall Description	Steps/Components	Description of Steps/Components
8	**Waterline Footing** Construction from Barge	Waterline footings are typically used in deep water to connect a group of drilled shafts together. Built from barges.	Form placement	
			-operation of locks is separately regulated and approved	
			Above water work	
9	**Pier** Construction **in Cofferdam** from Workbridge	Pier construction will include pouring a cofferdam tremie seal, a footing, and column.	Above water work	
			Concrete pier construction	
10	**Pier** Construction **on Drilled Shafts** from Workbridge	Pier construction will include constructing a single column directly above a single drilled shaft.	Template placement	
			Concrete pour into template	
			Above water work	
11	**Pier** Construction **on Waterline Footings** from Barge.	Pier construction will include constructing columns directly above a waterline footing.	Above water work	
			Concrete pier construction	
12	Cast-In-Place Concrete **Box Girder** Superstructure	CIP Box Girders are used where the span lengths are moderate and use of falsework is feasible. Span lengths are 150-feet to 260-feet for constant depth superstructures. Built from work bridges or barges.	Above water work	
			Falsework piling installation	
			Concrete pour	
			Falsework piling removal	
13	**Segmental** Concrete Balanced Cantilever Superstructure	Segmental concrete balanced cantilever construction is used where the span lengths are moderate and use of falsework is unfeasible, such as over water. Span lengths are 200-feet to 320-feet for constant depth superstructures, and 300-feet to 600-feet for variable depth haunched superstructures. Concrete box girders may be either precast or cast-in-place. Precast concrete is utilized whenever there is sufficient repetition in spans and segments to warrant. Built from work bridges or barges.	Above water work	
			Concrete box girder construction	

In-Water Construction TWG - Construction Activities

No.	Construction Activity	Overall Description	Steps/Components	Description of Steps/Components
14	**Existing Bridge Removal**	Demolition of existing bridge will include all the superstructure and substructure down to the mudline. Bridges over water will require special precaution not to drop debris in the water. Nets, tarps, and platforms will be used. The crane will lift sections of the bridge off and swing them to a dump truck or barge standing by. The existing floating bridge will be de-stressed and disassembled. Anchors will remain, anchor cables will be removed. Demo from barge or work bridges.	Above water work	
			Piling removal	
15	**Work Bridge Removal**	Demolition of existing work bridge will include all the superstructure and substructure down to the mudline. The crane will lift sections of the bridge off and swing them to a dump truck or barge standing by. Demo from barge or existing work bridges.	Above water work	
			Piling removal	
16	**Pontoon Disassembly**	Disassembly of the existing pontoons will include demolition of the elevated superstructure on the ends of the pontoons, de-tensioning of the external post-tensioning, and using a wire saw to cut through the bolted joints. The existing anchors will be detached from the anchor cables and the anchor cables cables removed. The existing anchors will be left in place on the lake bottom.	Above water work	
			Seal removal	
17	**Materials Transport**	Transport of materials to and from the site will be both by land and by water. Barges and tugs will transport a large portion of the material. Dry bulk barges will pass through the Montlake Cut and the Hiram Chittenden locks to and from supply and disposal sites with access by water. Barges may also travel to temporary transfer facilities at the north and south ends of Lake Washington for material transfer from barge to truck. Dump trucks, haul trucks, and delivery trucks will travel over designated haul routes, using city streets and state and county highways to arrive at the site. Because of the large amount of material and the multimodal methods of transport, multiple access routes will be required.	Barge/Tug operations	
			Lock operations	
18	**Mudline Footing**	Mudline footings will be constructed by fist creating a cofferdam. The cofferdam will be created by vibrating and or driving template piles and beams to guide the sheet pile installation. The sheet piles will be vibrated into place and the interior strengthened by walers, frames, and struts. Drilled shafts would be constructed inside the cofferdam. A concrete seal would be placed underwater inside the cofferdam and then the cofferdam would be dewatered. Construction of the footing would commence inside the dewatered cofferdam.	Concrete pour into template	
			Above water work	
19	**Tunneling**		Underground/underwater work	
			Upland excavation	
20	**Bascule Bridge Construction**		Shoreline work	
			Above water work	

APPENDIX F: SALMONID MIGRATION AND REARING IN THE LAKE WASHINGTON WATERSHED

SALMONID MIGRATION AND REARING IN THE LAKE WASHINGTON WATERSHED

Chinook Salmon

The Puget Sound Chinook salmon evolutionarily significant unit (ESU) includes the Lake Washington subpopulation. Puget Sound Chinook salmon characteristically return to their natal streams (the streams where they hatched) and spawn at 3 or 4 years of age. Chinook salmon reproducing in the Lake Washington watershed are summer- or fall-run fish that have an ocean-type life cycle. Ocean-type fish commonly migrate from spawning areas to the ocean during the first 2 to 6 months following their emergence from the spawning gravel. Chinook runs passing through Lake Washington include those produced in the Cedar and Sammamish River watersheds, as well as runs to several small streams. Chinook have been reported to spawn in McAleer, Lyon, Swamp, North, Little Bear, Mercer Slough (Kelsey Creek), and May creeks (Williams et al. 1975). All of these adult fish pass through the Lake Washington Ship Canal (Ship Canal) and Union Bay into Lake Washington before reaching their spawning streams. Adults from each of these runs migrate through the Ship Canal and into Lake Washington before reaching their spawning areas.

Adult Migration

Adult Lake Washington Chinook return at essentially the same time as other fall Chinook salmon stocks in south Puget Sound (Warner and Fresh 1999; Tabor et al. 2002). The adults begin arriving at the Hiram M. Chittenden Locks (Ballard Locks) in mid-June, with peak numbers passing in mid-to-late August, and all generally pass the locks by early October. Fresh et al. (2000) reported that the mean residence time of adult Chinook salmon at the Ballard Locks was 19.1 days in 1998 and 18.2 days in 1999, and ranged between 0.2 days and 47 days for individual fish. There was also considerable variation in both horizontal and vertical movements of individual fish. In 1998 none of the tagged fish migrated from the Ballard Locks toward Lake Washington until 19 days after tagging began. In 1999, some tagged fish had already entered Lake Washington within 2 days (based upon detection at the east end of the Ship Canal) after tagging began on July 19. This suggests that the Ballard Locks has been delaying the entry of some fish into Lake Washington, potentially based on elevated water temperatures (> 21°C). In addition, many fish dropped back downstream from the Ballard Locks at least once. Adult Chinook used the Ship Canal primarily as a migratory corridor, typically spending less than 1 day in the canal with a range of 4 hours to 7.7 days (Fresh et al. 1999, 2000).

Most adult Chinook returning to the Lake Washington drainage are hatchery produced, and most migrate to the Issaquah Creek hatchery or to the smaller facility at the University of Washington. However, there has not been a means to visually discriminate between hatchery- and wild-produced fish as they pass through the counting process at the Ballard Locks during most years of record. Currently, the Issaquah Hatchery releases about 2 million marked juvenile Chinook each year resulting in returns of 4,000 adults or more (WDFW 2010).

The number of hatchery-produced fish that stray and naturally spawn is not known. However, the recent trends in naturally spawning Chinook salmon exhibit a slightly declining or flat trend in the North Lake Washington and Issaquah Creek populations and a slightly increasing trend for the Cedar River population (Exhibit F-1). While these data are only derived from index areas, they suggest that a majority of the Lake Washington Chinook salmon pass under the Evergreen Point Bridge as they migrate between the Cedar River and Puget Sound. In addition, all of the Lake Washington Chinook salmon pass through the action area as they migrate through Union Bay, the Montlake Cut, and the Ship Canal.

EXHIBIT F-1.
ESCAPEMENT OF NATURALLY SPAWNING CHINOOK SALMON INTO THE LAKE WASHINGTON BASIN

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

Juvenile Migration

Chinook salmon produced in the Lake Washington basin are ocean-type salmon that typically rear in rivers for several months prior to migrating to an estuary. The substantially altered migratory corridor has the lake inserted between the Cedar River and Puget Sound, while the historical route for Cedar River migrants was through the Black and Duwamish rivers. Opening of the Ship Canal and Ballard Locks in 1917 resulted in a drop in lake elevation of about 9 feet. The juvenile Chinook were subsequently forced to rear from fry (~30 millimeters) to a smolt size (~50 millimeters or larger) either in the Cedar River or in Lake Washington rather than in the Duwamish River estuary. Later modification of the river and lake shoreline habitat, which included the removal of natural vegetation, construction of overwater structures, and introduction of predator and competitor species, has substantially altered the migratory corridor habitat conditions.

Ocean-type Chinook generally migrate to marine environments during their first year of life. However, a substantial number may rear within Lake Washington for 1 or more years. Previously, Haw and Buckley (1962) determined that 24 percent reared for 2 years in Lake Washington, 1 percent for 3 years, and less than 1 percent reared for 4 or 5 years in Lake Washington before migrating to Puget Sound. These larger fish are more likely to undergo a rapid spring migration when they move through Puget Sound and are also less likely to be shoreline oriented (Tabor and Pisakowski 2002; Celedonia et al. 2008b).

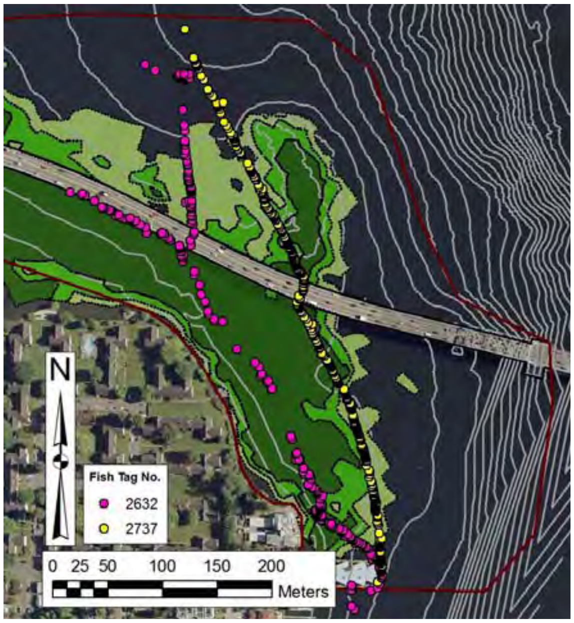
A variety of investigations have provided information on the migrations of juvenile Chinook salmon in Lake Washington, including the SR 520, I-5 to Medina: Bridge Replacement and HOV Project (SR 520, I-5 to Medina project) area. Information on the migrations of young Chinook in and through Lake Washington has been derived primarily from investigation of Chinook produced in the Cedar River. Cedar River Chinook fry emerge from the gravel in late winter to early spring and begin migrating downstream by at least mid-January, with some migrating into Lake Washington as late as early July (Warner and Fresh 1999). Many of the fry migrate from the Cedar River to Lake Washington shortly following emergence (Celedonia et al. 2008b, p. 2). Those fry that rear within the river for several months migrate into Lake Washington as larger juveniles in late May and June and appear to migrate relatively quickly through the lake.

Young Chinook salmon migrate from Lake Washington through Union Bay, the Ship Canal, and Lake Union along the shorelines in both shallow water and open water (Tabor and Pisakowski 2002; Celedonia et al. 2008b). Some young Chinook salmon may enter the Ship Canal early in the spring to rear along the shorelines as they do in Lake Washington. However, available information indicates most do not enter the Ship Canal until late in the migration period and spend days to weeks between Lake Washington and the Ballard Locks (Tabor and Pisakowski 2002; Celedonia et al. 2008b).

After entering the lake, the Chinook fry (30 to 40 millimeters) follow a rearing movement pattern, moving slowly along the shorelines in very shallow water, (< 3 feet) rearing in sandy-gravel beach portions of the shoreline (Tabor and Pisakowski 2002; Tabor et al. 2003, Celedonia et al. 2008b, p. 2). Information available from other locations supports these observations of young Chinook in lentic (still water) environments such as lakes or reservoirs. In Lake Sammamish, aggregations of juvenile hatchery Chinook (and coho) salmon have been observed in surface waters extending from the shoreline to nearshore areas overlying relatively deep water (Pflug 2000 personal communication). Celedonia et al. (2008a, p. 104) observed juvenile Chinook to also use the upper surface of aquatic vegetation as an artificial bottom, placing them farther from the physical shoreline.

Recently, the migratory behavior of juvenile Chinook in the vicinity of the Evergreen Point Bridge has been reported by Celedonia et al. (2008a, 2008b). Tagged young Chinook released in the vicinity of the bridge were observed to have both migratory and holding behavior patterns near the bridge, with substantially variable behaviors within each general pattern. Exhibit F-2 demonstrates examples of two tagged Chinook actively migrating past the existing Evergreen Point Bridge at the edge of Union Bay and a single Chinook exhibiting a holding pattern near the bridge (Celedonia et al. 2008a). Exhibit F-3 shows the general area commonly used by tagged juvenile Chinook as they migrate from Lake Washington to Union Bay in the Evergreen Point Bridge vicinity. The young Chinook tend to select water column depths of about 13 to 20 feet (4 to 6 meters) as they migrate in the vicinity of the bridge.

Detailed tracking of young Chinook indicated they use the Lake Washington shoreline south of the Evergreen Point Bridge as a migratory corridor where they remained close to shore in shallow water (3 to 16 feet; 1 to 5 meters) during the day and far offshore in limnetic areas at night (Celedonia et al. 2008b, p. 1). They used Portage Bay along the Ship Canal as both a migratory corridor and as short-term (< 24 hour) holding habitat. The juvenile Chinook subsequently used Lake Union as moderate-term (1 to 7 days) holding habitat during their migration to the Ballard Locks. In the Ship Canal area, the young Chinook were broadly distributed across deep-water areas (26 to 33 feet; 8 to 10 meters) at all times. Celedonia et al. (2008b, p. 101) reported that the apparent change in behavior in the Ship Canal could be due to generally lower water clarity conditions in the Ship Canal compared to the Lake Washington shoreline. They observed that the decreased clarity may have allowed the tracked fish to utilize open-water areas during the day and take advantage of presumably better foraging opportunities as well as lower, more favorable water temperatures.



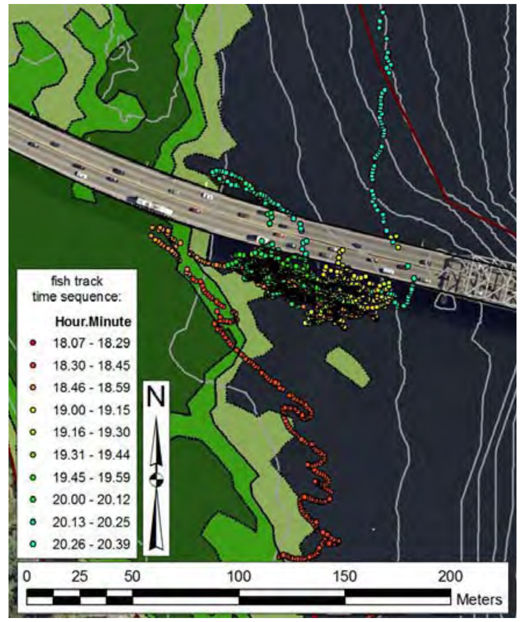


EXHIBIT F-2.
EXAMPLE OF TWO TAGGED CHINOOK PASSING DIRECTLY UNDER THE EVERGREEN POINT BRIDGE (LEFT) AND CHINOOK EXHIBITING COMPLEX BEHAVIOR PASSING MULTIPLE TIMES UNDER THE BRIDGE (RIGHT)

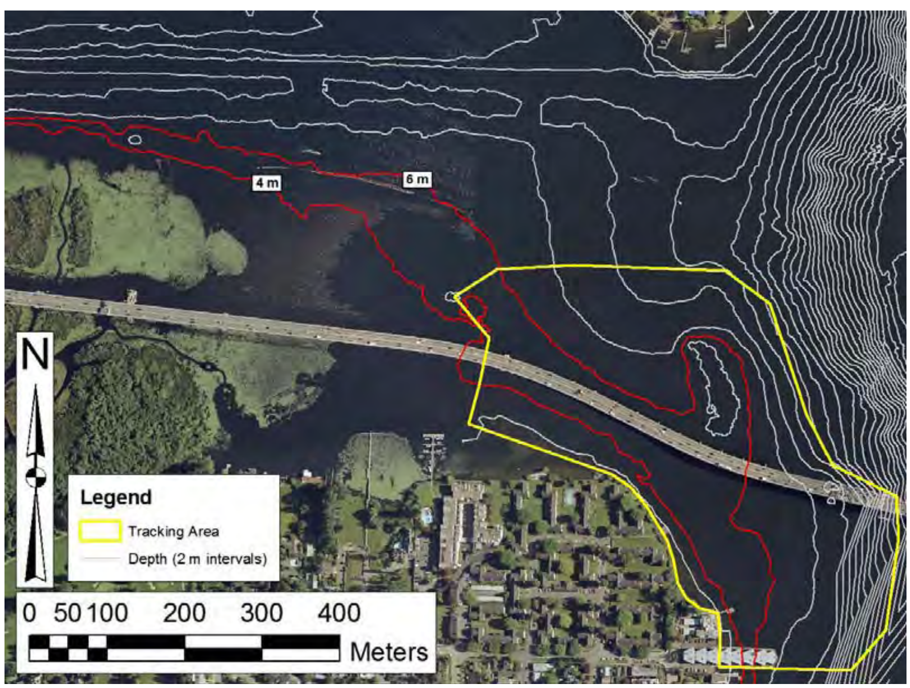


EXHIBIT F-3.
GENERAL MIGRATORY CORRIDOR (RED LINE) SELECTED BY JUVENILE CHINOOK MIGRATING PAST THE EVERGREEN POINT BRIDGE

Celedonia et al. (2008b) tracked tagged fish in a 17.2-hectare area along a 560-meter stretch of the Evergreen Point Bridge from late May through early August. Tagged hatchery smolts were released 800 meters south of the bridge in three groups from early to late June. Chinook released in early June rapidly migrated through the study site and into the Ship Canal. Most of these fish spent less than 2 hours at the study site and reached the University Bridge at the west end of the SR 520, I-5 to Medina project area less than 5 hours after release. However, Chinook released in mid- and late June remained near the study site, but their behavior did not appear to be a direct consequence of the bridge. These fish generally spent less than 30 hours near the study site, and took more than 65 hours to reach the University Bridge. Celedonia et al. (2008b) concluded differences in timing of migrational cues (e.g., moon apogee), physiological smolt status, water temperature, water clarity, and prey availability may have contributed to the differences in migrational behavior.

Juvenile Chinook in the vicinity of the Evergreen Point Bridge commonly demonstrated either holding or actively migrating behavior patterns. About two-thirds of the actively migrating juvenile Chinook were observed to hold briefly before migrating through the area, with about half of these fish holding for only a few minutes (Celedonia et al. 2008a, p. 102). Similar behavior was also observed in 2008 (Celedonia et al. 2009). The non-actively migrant fish were observed to often cross beneath the bridge to the north and later return to holding immediately adjacent to the bridge's southern edge (< 65 feet from the bridge edge). These fish may have been using the bridge as cover (i.e., shadow and/or structure). However, Celedonia et al. (2008a, p. iii) reported that "The bridge did not appear to be a factor in delaying migration of holding fish."

Juvenile Chinook passed under the bridge throughout much of the project action area shown in Exhibit F-3, with no distinct preference other than a slight shift towards deeper water passage points later in the migration period. Nonetheless, the closeness with which fish moved along the edge of the bridge strongly suggests that the bridge played an important role in directing some migrating Chinook salmon. They also reported that the most favorable location to pass beneath the bridge was likely related to some combination of macrophyte density beneath and beyond the bridge, water column depth, light levels beneath the bridge, and perhaps also presence of predators (Celedonia et al. 2008a, p. 103). Similar behavior patterns were observed in a subsequent evaluation in 2008 (Celedonia et al. 2009).

In contrast to the behavior of actively migrating Chinook salmon smolts, the bridge appeared to influence habitat use of holding (i.e., not actively migrating) smolts (Celedonia et al. 2008a, p. iii). Juveniles exhibiting holding behavior statistically selected areas near the bridge (15 to 60 feet from bridge edge), as well as areas of dense macrophytes away from the bridge. The spatial distribution, habitat selection, and depth selection were largely similar to patterns observed in 2008 (Celedonia et al. 2009). In 2008, the most common and consistently selected habitat was near the bridge but not directly underneath the bridge. Habitat least often selected included offshore open-water areas, sparse vegetation, the offshore edge of vegetation, and unvegetated nearshore areas.

These data suggest that underwater structure is an important habitat characteristic for holding/rearing juvenile Chinook salmon. Similarly, Celedonia et al. (2008a, p. 103) observed that the tagged Chinook salmon smolts shifted to deeper water when near the bridge, and they suggested that this may have been due to the bridge serving as a source of cover that allowed smolts to access deeper, cooler water and/or presumably better foraging opportunities. Similar depth distributions were observed in 2008, particularly during the day (Celedonia et al. 2009). While areas near the bridge were also selected at night, the observed distributions indicate that light cast on the water surface from overhead lights on the bridge appear to attract juvenile Chinook. The frequency of nighttime detections tended to be higher in areas immediately adjacent to light standards on the bridge than other areas near the bridge. Although not as obvious, slightly higher detection rates were also observed on the opposite side of the bridge from the light standards.

Similar tagging studies in 2008 showed some of the same movement patterns observed in 2007, but also some distinct differences (Celedonia et al. 2009). In 2007 the actively migrating fish tended to move in more or less a unidirectional pattern, which suggested that the brief holding behavior observed of some of these actively migrating fish (or the non-migratory movement behavior patterns of other fish) was related to the presence of overwater and in-water bridge structures. However, a significant subset of the 2008 salmonids did not move in a unidirectional pattern, but actually moved from location to location and sometimes returned to previous locations.

The 2008 tagging studies also showed that the non-actively migrating (holding) fish appeared to spend a significant amount of time near the bridge. However, while the 2007 fish tended to hold on the south edge of the bridge, the 2008 fish used both sides of the bridge, as well as near the center of spans (away from columns) under the bridge (Celedonia et al. 2009). Therefore, despite these extensive tagging studies, there are no obvious or consistent behavior patterns that suggest that the Evergreen Point Bridge is a substantial impediment to juvenile Chinook migrations.

The timing of juvenile Chinook migration through Union Bay and the Ship Canal has not been closely monitored, although they likely migrate quickly through this vicinity. Exhibit F-4 shows recorded migration rates for young Chinook migrating from Bear Creek to the Ballard Locks. However, juvenile Chinook are rarely observed at the Ballard Locks in early May, and generally small numbers are present in late May. As indicated in Exhibit F-4, nearly all juvenile salmon (including Chinook salmon) pass through the Ballard Locks flume system by late June. The majority of young Chinook pass through the Ballard Locks in June or early July, and the wild-produced fish tend to be earlier in this period than the hatchery-produced fish (City of Seattle 2003, p. 47).

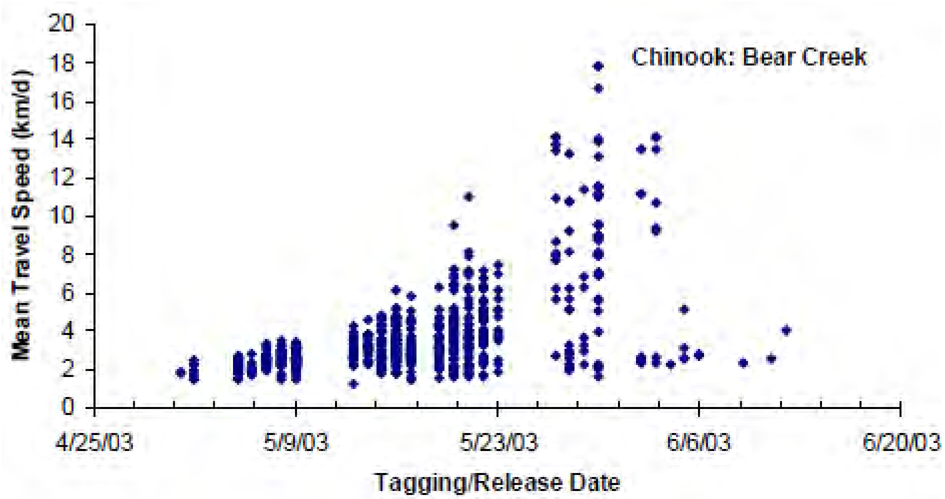


EXHIBIT F-4.
AVERAGE TRAVEL SPEED JUVENILE CHINOOK FROM BEAR CREEK TO BALLARD LOCKS

Celedonia et al. (2008b, p. 86) report that Lake Washington Chinook salmon appear to migrate primarily during the day. While some migration movement was observed during dawn hours, active migration occurred predominantly during the day but never at night. This is consistent with the results of the SR 520 tracking study (Celedonia et al. 2008a, p. 6), which observed movement of Chinook salmon smolts through the study site and into the Ship Canal almost exclusively during the day. Passage at the Ballard Locks also occurs predominantly during daylight hours (DeVries et al. 2005).

Steelhead

The National Marine Fisheries Service listed the Puget Sound steelhead distinct population segment (DPS) as a threatened species under the Endangered Species Act (ESA) in May 2007 (Federal Register Vol. 7). However, critical habitat has not been designated yet. Steelhead is the anadromous form of rainbow trout, which typically spend 2 to 3 years in freshwater before migrating to marine waters. Typically, steelhead migrate as relatively large juveniles that rapidly move through lower rivers and the Puget Sound to the ocean, where they reside for several years before returning to their natal streams. Adult steelhead generally return to their natal rivers either in the summer or winter months and are referred to as summer- or winter-run populations. Puget Sound steelhead are primarily winter-run populations with adults returning relatively late in the year. In the Lake Washington basin there are two steelhead populations: one spawning naturally in the Cedar River, and the introduced north Lake Washington population. Both populations have decreased considerably in recent years.

Adult Migration

The Washington Department of Fish and Wildlife (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 (WDF et al. 1993). 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.

Steelhead are iteroparous, that is many adults survive spawning to return to marine waters and subsequently return to their natal streams to spawn a second time (Wydoski and Whitney 2003). Steelhead spawning takes place at various places in the Lake Washington basin including the lower Cedar River, the Sammamish River and its tributaries, and several smaller Lake Washington tributaries (WDFW 2006). In the Cedar River steelhead spawn primarily in the mainstem from March through early June. Both wild and hatchery steelhead occur in the Cedar River and likely in other steelhead spawning areas. Cedar River and the Lake Washington watershed studies (Marshall et al. 2004) indicate that resident rainbow trout produce out-migrating smolts in the Lake Washington basin, which likely leads to interbreeding between the two life history forms (i.e., anadromous and resident).

Beauchamp (1995) determined wild steelhead smolts are a primary riverine predator of sockeye salmon fry migrating from the Cedar River into Lake Washington. Hatchery-reared steelhead smolts were released during the latter half of the fry migration but showed no evidence of preying on fry. Predation by steelhead on young Chinook and sockeye in Lake Washington and the Ship Canal has not been evaluated but likely occurs to some degree.

No recorded information is available on the migration timing of juvenile steelhead through the project vicinity. The majority of Cedar River steelhead appear to migrate downstream to Lake Washington as smolts after 2 years of freshwater residence. Most likely, juvenile steelhead migrate though the project vicinity during May to early June. Because of their large size, steelhead smolts likely move rapidly during their migration to marine waters and likely occur in deeper offshore areas.

The Lake Washington steelhead is believed to be a native stock maintained by natural production. However, the stock has declined substantially in recent years. WDFW rated it as critical in 2002, and the return numbers have remained at these critical levels (Exhibit F-5). The relative abundance of steelhead produced in the Cedar River, south of the SR 520, I-5 to Medina project, is not indicated by available data. Therefore, the proportion of steelhead that would need to pass under the bridge is uncertain.

EXHIBIT F-5.
ESCAPEMENT INDICES OF NATURALLY SPAWNING STEELHEAD IN THE LAKE WASHINGTON BASIN

Year	Cedar River, Bear and Issaquah Creeks
1992	599
1993	184
1994	70
1995	126
1996	234
1997	620
1998	584
1999	220
2000	48
2001	42
2002	38
2003	20
2004	44
2005	22
2006	32
2007	8
2008	4
Average	170

Juvenile Migration

In recent years small numbers of juvenile steelhead have been caught in Cedar River migrant traps in late April and May. Because steelhead commonly undergo active migrations to marine waters, it is likely the Cedar River steelhead pass the project site within a month of their movement out of the lower Cedar River.

Winter-run steelhead are native to the larger tributaries of the Sammamish River and Lake Sammamish, notably Issaquah Creek, but have been greatly reduced in abundance in recent years. Beginning in the late 1990s, winter-run steelhead have been reared at the Issaquah Salmon Hatchery and released in Bear Creek. Migrating steelhead smolts have been collected in Bear Creek traps also in late April and May at an average size of 177 millimeters (Volkhardt et al. 2006, p. 33). 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 (Cooksey et al. 2008, p. 46).

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.

Bull Trout

The U.S. Fish and Wildlife Service listed bull trout in the Coastal-Puget Sound DPS as threatened on November 1, 1999 (USFWS 1999), including the population occurring in the Lake Washington basin. The Lake Washington basin bull trout include the adfluvial population in Chester Morse Reservoir and potentially small numbers of amphidromous bull trout that migrate into Lake Washington from other Puget Sound populations. The Chester Morse population also likely produces a few individuals that pass downstream from the dam to then become isolated from the reproducing population. These isolated fish would be expected to migrate downstream to Lake Washington. Bull trout are an ESA-listed species that at least occasionally occurs in Lake Washington and thus in the vicinity of the Evergreen Point Bridge. However, there is no information that Lake Washington has supported a reproducing population of amphidromous bull trout in recent times.

Little is known about the historical distribution and abundance of bull trout in the Lake Washington system. A 1-year survey of the closely connected Lake Sammamish in 1982 through 1983 reported no char (WDFW 1998). No char have been recently reported in Lake Sammamish (WDFW 1998). There have also been few reports of native char in the Lake Washington basin downstream from Chester Morse Reservoir (USFWS 1998). Small numbers (one to several) of native char have been observed in Issaquah Creek (Fuerstenburg 1998 personal communication), the Ballard Locks, or Lake Washington (Bradbury and Pfeifer 1992; USFWS 1998) in the past 20 years. Several large native char (approximately 410 millimeters long) have been observed passing through the viewing chamber at the Ballard Locks, but only one bull trout was identified in a 2-year creel survey of Lake Washington (Bradbury and Pfeifer 1992; USFWS 1998). These fish likely originated in other basins and were foraging within the Lake Washington system or are isolated individuals that have moved downstream from the Chester Morse population.

Although bull trout may occasionally occur at or near the project site, there is no known regular occurrence of bull trout in this area. Within the Lake Washington basin, spawning populations of bull trout (native char) occur only in Chester Morse Reservoir and its tributaries, and no bull trout reproduction has been reported in the Lake Washington basin downstream from Chester Morse Reservoir (WDFW 1998). Bull trout are also unlikely to occur in the surface waters of Lake Washington during the summer when water temperatures typically exceed 59°F (15°C) for several months. To the extent that they may occur in the Lake Washington basin, these piscivorous char can be considered potential predators of smaller salmonids.

The migration and distribution of bull trout in Lake Washington is uncertain, apparently because very small numbers are present. In addition, there are no known amphidromous stocks of bull trout in the Lake Washington basin (Jones & Stokes 2001). The migration patterns of bull trout that do occur in Lake Washington cannot be described based on the limited observations reported for this area other than Chester Morse Reservoir in the Cedar River basin. A population of more than 3,000 bull trout was estimated in Chester Morse Reservoir (City of Seattle 2003, p.111).

No other viable bull trout population is known in the Cedar/Lake Washington basin, although the U.S. Fish and Wildlife Service has classified the Ship Canal, Lake Washington, and the Lower Cedar River as bull trout migration and overwintering habitat. It is suspected that the bull trout observed in Lake Washington and the Ballard Locks are foraging fish from other river systems in Puget Sound, although no genetic information is available to verify their origin (Jones & Stokes 2001, p. 11-22; King County 2000, p. 22). A small number (34) of bull trout or char have been captured near the Ballard Locks since 1949. These are also believed to have originated in other watersheds (Port of Seattle 2005, p. 12). Bull trout have been observed downstream of the Ballard Locks in May to July preying on juvenile outmigrants, but there is little information regarding their likely presence in the action area (Jones & Stokes 2001, p. 11-22).

Coho Salmon

Adult Lake Washington coho salmon enter freshwater from mid-September to mid-November to spawn from late October through late February (Williams et al. 1975; WDF et al. 1993). The migration of adult coho tends to overlap that of adult Chinook salmon. Coho salmon in Lake Washington originate from both natural production and hatchery production. The Issaquah Hatchery annually releases about a half million yearling coho salmon.

There are two general coho populations in the basin—the North Lake Washington and Lake Sammamish tributary spawning stock, and the Cedar River stock. Although escapement estimates appear relatively stable in recent years, there has been more than an order of magnitude variation in both stocks since 1994 (Exhibit F-6). Although these data are estimates from index areas, they suggest that more coho return to tributaries north of the SR 520, I-5 to Medina project area. Under this assumption, fewer coho are likely to encounter the Evergreen Point Bridge, although they do migrate through the project action area.

EXHIBIT F-6.
RECENT RELATIVE ESTIMATES OF ABUNDANCE FOR NATURALLY SPAWNING COHO SALMON IN THE LAKE WASHINGTON BASIN

Year	Lakes Washington and Sammamish Tributaries	Cedar River	Total
1994	339	128	467
1995	7,225	2,333	9,558
1996	4,832	1,355	6,187
1997	2,375	1,612	3,987
1998	630	132	762
1999	1,414	291	1,705
2000	3,852	672	4,524
2001	1,804	1,035	2,839
2002	862	1,001	1,863
2003	1,763	1,286	3,049
2004	644	653	1,297
2005	503	1,030	1,533
2006	523	115	638
2007	541	504	1,045
2008	641	349	990
Average	1,863	833	2,696

There is little site-specific information available on the migration of juvenile coho in and from Lake Washington to Puget Sound. Young coho salmon tend to remain for more than a year in their natal streams prior to migrating rapidly to Puget Sound during their third year of life. Coho smolts from the Cedar River enter Lake Washington in May and June (Volkardt et al. 2006). As seen in Exhibit F-7, the majority of coho likely migrate through the Ship Canal between late May and late June.

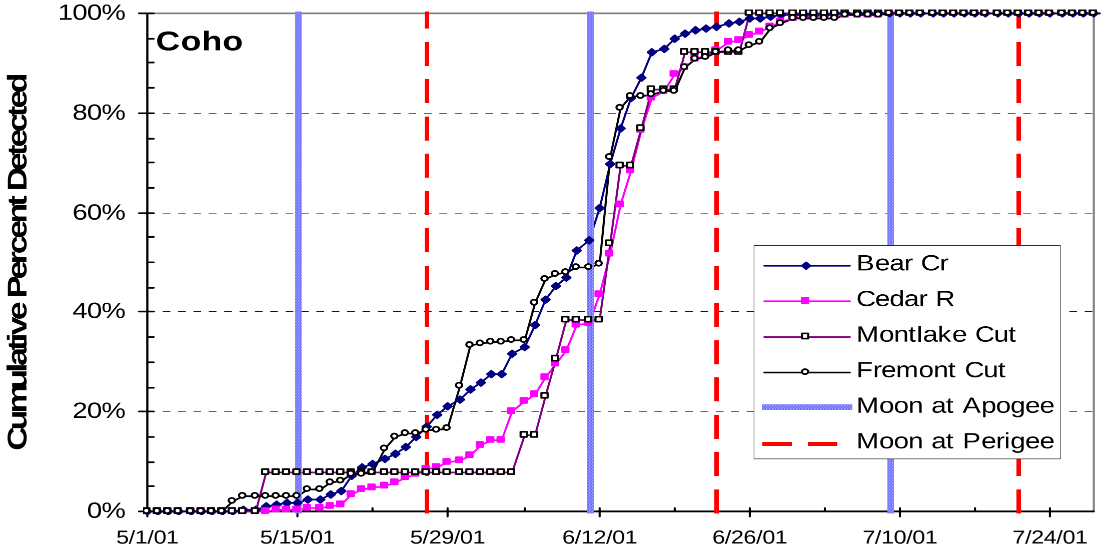


EXHIBIT F-7.
MIGRATION TIMING OF JUVENILE COHO SALMON THROUGH LAKE WASHINGTON

Most likely, the young coho migrate rapidly through Lake Washington and past the Evergreen Point Bridge as they do in other freshwater corridors. Migrating juvenile coho are likely about 4 inches long (10 centimeters) (Salo and Bayliff 1988). This larger size is expected to allow these fish to utilize a wide range of habitats as they migrate through the project area.

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APPENDIX G: PREDATOR-PREY INTERACTIONS IN LAKE WASHINGTON

PREDATOR-PREY INTERACTIONS IN LAKE WASHINGTON

Both adult and juvenile salmonids are subject to predation throughout their life cycle. However, the Evergreen Point Bridge only potentially affects predator populations and salmonid susceptibility to predation during that portion of their life cycle when they are passing through or rearing in the Union Bay and Portage Bay areas or near the bridge in Lake Washington. Because of their much larger size and mobility and the absence of large predators, adult salmonids are less susceptible to predation in Lake Washington. In the context of the SR 520, I-5 to Medina: Bridge Replacement and HOV Project (SR 520, I-5 to Medina project), discussion of predation will focus primarily on juvenile salmonids.

Mammals

Adult salmonids are seldom subject to substantial predation in habitats such as Lake Washington other than by man. However, predation on adult salmonids returning to Lake Washington has been identified to occur downstream from the Hiram M. Chittenden Locks (Ballard Locks) where sea lions (California sea lion [*Zalophus californianus*], Steller sea lion [*Eumetopias jubatus*]) have been substantial predators in the past. Sea lions have been present primarily at times when steelhead are the salmonid species migrating upstream at the locks. Control efforts have essentially eliminated sea lion predation on adult salmonids downstream from the locks in recent years. The proposed SR 520, I-5 to Medina project would not change predation conditions at the locks.

Small mammals such as otters and mink are known to occur in the project area and are expected to prey on juvenile salmonids and perhaps sexually precocious adults. However, they are also likely to prey on other resident fish occurring in the area throughout the year. Some of these other prey fish are also likely to be predators of juvenile salmonids, somewhat offsetting the potential direct predation rate. In addition, the potential predation of juvenile salmonids by these predator species is likely to be small relative to the large populations of predator fish expected to occur in the action area.

Birds

Birds present that are likely to provide substantial predation of juvenile salmonids in the SR 520, I-5 to Medina project area are double-crested cormorants (*Phalacrocorax auritas*). Cormorants have been shown to be a substantial predator of juvenile salmonids in the lower Columbia River (Collis et al. 2002; Ryan et al. 2003). Cormorants are present in substantial numbers resting on floating boom sticks and other structures in Union Bay adjacent to the Evergreen Point Bridge during the spring months. However, no investigations of cormorant predation in Lake Washington or the Lake Washington Ship Canal (Ship Canal) have been identified.

Because young salmon are commonly shoreline oriented and generally are near the water surface, they are also vulnerable to predation by a number of other bird species. Avian species likely to prey on young salmon in the vicinity of the project include common merganser (*Mergus merganser*), western grebes (*Aechmophorus occidentalis*) common loons (*Gava immer*), pigeon guillemots (*Cepphus columba*), great blue heron (*Ardea herodias*), kingfisher (*Ceryle alcyon*), glaucous-winged gulls (*Larus glaucescens*), and Caspian terns (*Sterna caspia*). Many of these birds consume approximately 0.5 kilogram of food per day, most of which is fish. Thus, they are potentially substantial predators, although there are no records of substantial numbers of any of these bird species being present in the project vicinity during the juvenile migration periods. While these species are not likely to be major predators, there are no available data documenting avian predation rates for this area.

Great blue herons are common along the salmonid migration route through Union and Portage bays. However, little information is available on their consumption of young salmonids. Hodgens et al. (2004) found that stocked rainbow trout in a river provided 13 percent of the fish these large birds consumed. Most of the trout consumed were in the size range of 105 to 280 millimeters, about the size range of salmonid smolts. Herons prey on young salmon from the shoreline or from floating perches. The SR 520, I-5 to Medina project reconstruction will not increase the available perches.

Fish

Fish are assumed to be the primary predators of young salmonids as they migrate from Lake Washington through the Ship Canal. These predators include both native species that naturally occur in the Lake and nonnative species that have been introduced to Lake Washington. The primary nonnative fish predators of Puget Sound Chinook in Lake Washington include smallmouth bass (*Micropterus dolomieui*) and largemouth bass (*Micropterus salmoides*). However, the native northern pikeminnow (*Ptychocheilus oregonensis*) appears to be an important predator, but little data are available on their abundance (Bartoo 1972; Eggers et al. 1978; Beauchamp 1987). Although the northern pikeminnow is considered the primary native fish predator, cutthroat trout (*Oncorhynchus clarki clarki*) and rainbow trout (*Oncorhynchus mykiss*) are also native fish that are known to prey on young salmonids (Beauchamp 1995; Tabor et al. 2004). Cutthroat trout were historically one of the most abundant fish species in Lake Washington (Evermann and Meek 1897), and they likely represented one of the primary predators of juvenile salmonids prior to the introduction of nonnative bass. Rainbow trout are also native but have also been planted in Lake Washington in the past. Beauchamp (1987) estimated between 2 and 5 percent of the sockeye smolt production in 1984 to 1985 was lost to rainbow trout predation.

Tabor et al. (2004) examined the stomach contents of 1,875 fish in the southern end of Lake Washington, near the Cedar River, over a 3-year period and found a total of only 15 Chinook salmon. The only predators observed to prey on Chinook salmon were cutthroat trout, prickly sculpin (*C. asper*), smallmouth bass, and largemouth bass. They estimated a total of about 1,400 Chinook salmon fry were consumed by littoral predators from February to mid-May, with most of the predation loss attributed to prickly sculpin due to their substantially larger population size than the other predators.

Fayram (1996) also identified smallmouth and largemouth bass as substantial predators of young salmonids in Lake Washington. Young salmon were estimated to constitute 28 percent of the diet of smallmouth bass larger than 150 millimeters in the lake and 38 percent in the Ship Canal (Fayram and Sibley 2000). They estimated that, as a worst case scenario, the bass were consuming nearly 200,000 young salmon in a year. Tabor et al. (2004) concluded juvenile Chinook salmon may be particularly vulnerable to predatory fishes, although predatory fishes probably consumed less than 10 percent of the fry that entered the lake from the Cedar River.

In the Ship Canal, young salmonids are vulnerable to several species of predatory fishes including northern pikeminnow, smallmouth bass, and largemouth bass. There are an estimated 3,400 smallmouth and 2,500 largemouth bass in the Ship Canal (Tabor et al. 2000). They also estimated that approximately 60 percent of the bass population in the Ship Canal is present in the Portage Bay area. Smallmouth bass consumed almost twice as many Chinook smolts per fish compared to largemouth bass (500 smolts versus 280 smolts, respectively). Chinook smolt consumption occurred primarily from mid-May to the end of July during their primary out-migration period. Salmonid smolts are about 50 to 70 percent of the diet of smallmouth bass during this time (Tabor et al. 2000). Tabor et al. (2006) estimated consumption of juvenile salmon in the Ship Canal was 36,000 fish based on a bioenergetics model and 45,500 fish based on a meal-turnover consumption model, or about 1 percent of the juvenile Chinook outmigrants.

Smallmouth bass of all size categories have been found to consume young salmonids in Lake Washington (Tabor et al. 2004). The smallest smallmouth bass they observed to have consumed a salmonid was 138 millimeters (fork length), although predation was typically observed in fish 148 to 249 millimeters. Predation appeared to be highest in June when salmonids made up approximately 50 percent of their diet. However, consumption rates of salmonids by largemouth bass were generally low (Tabor et al. 2006).

Northern pikeminnow and cutthroat trout are the principal fish predators of steelhead with bass also consuming some. Olney (1975) found northern pikeminnow tend to concentrate in deep water in winter and move inshore in the spring and summer. In the deeper lake areas they fed on young sockeye and longfin smelt. In the Ship Canal, Tabor et al. (2004) found approximately 45 percent of the diet of northern pikeminnow consisted of salmonids. The salmonid prey consisted of 47 percent Chinook, 32 percent coho, and 21 percent sockeye. The consumed salmonids also appeared to be mostly subyearling fish.

The incidence of freshwater predation by fish in the Ship Canal may be increasing due to increasing water temperatures. There has been a long-term trend of increasing water temperatures in the Ship Canal, which may result in increased energy demands and higher predation rates from native and nonnative predators, particularly on later-migrating Chinook smolts (Schindler 2000).

Cottids (*Cottus* spp.) have also been identified as predators of juvenile salmonids as they migrate downstream to the lake (Tabor et al. 2004). They observed cottids consumed about 5 percent of the available sockeye fry during complete darkness and 45 percent of fry available with bright light in artificial streams. Along shorelines of the Cedar River, they observed predation of up to 7.6 fry per cottid at a lighted area. However, these cottids are not known to occur in substantial numbers in the Union and Portage bay areas.

Prickly sculpin are a substantial predator of juvenile salmonids that may be present throughout Lake Washington. Although juvenile salmon are not a major prey item for prickly sculpin (less than 0.03 percent of the diet overall), predation losses to prickly sculpin could be potentially large (4.9 to 26.3 percent of juvenile Chinook population and 10.8 to 59.1 percent of juvenile sockeye population) due to the large prickly sculpin population throughout the lake (Moss 2001). Those juvenile salmon that are closely associated with the bottom along the shoreline or along deeper slopes have a high risk of being eaten by cottids.

Cutthroat trout are a native species (Evermann and Meek 1897) that was dominant prior to human modifications to the Lake Washington basin. Cutthroat trout are a top native piscivore in Lake Washington that may affect the dynamics of other fish species (Nowak et al. 2004). Cartwright et al. (1988) determined cutthroat trout predation on juvenile sockeye salmon can be sufficient to substantially affect population size. In Lake Washington the cutthroat trout become increasingly piscivorous as they grow larger (Nowak et al. 2004), preying heavily on sockeye. The cutthroat tended to occupy the limnetic zone, where the young Chinook are also likely to be, after they reach about 250 millimeters (fork length).

Larger rainbow trout are also a substantial predator of young salmonids in Lake Washington (Beauchamp 1987), with 2 percent and 7 percent of the sockeye production consumed in 2 years of investigation.

Juvenile coho are also potential predators of the young salmon (Pearsons and Fritts 1999). Juvenile coho salmon are released from hatcheries in large numbers and tend to migrate rapidly through downstream areas at the same time numerous young Chinook, chum and sockeye salmon are present. However, the threat from juvenile coho is limited by the size of salmon they can consume. Coho can consume salmon up to half of their body length, but rarely do so (Ruggerone and Rogers 1992; Orr et al. 2004). Predation by larger coho smolts (100 to 180 millimeters) would be limited to smaller individuals (30 to 70 millimeters), which likely includes most of the wild Chinook and the smaller sockeye salmon.

Predator-Prey Interaction

Only recently has information has been obtained on the behavior of both prey and predators within the SR 520, I-5 to Medina project area and adjacent vicinity. During the last few years, Celedonia et al. (2008a, 2008b) have used a fine-scale acoustic tracking system to follow the movements of tagged Chinook smolts and predators. Fish were tracked in Lake Washington in the vicinity of the Evergreen Point Bridge and in the Ship Canal. Young Chinook were found to either actively migrate, moving quickly from one destination to the next, or hold for periods. The Chinook behaved differently at each site, although there was considerable individual variability. At the Seattle Tennis Club the Chinook were actively migrating. In Portage Bay they were also actively migrating with some short-term (< 24 hours) holding. In 2004, most fish spent several hours to several days at the Portage Bay site, whereas in 2005 most fish actively migrated through in less than 1 hour. Celedonia et al. (2008a) opined that environmental cues and habitat conditions may be more important than physical site characteristics in determining Chinook smolt movement patterns. They also observed distinct diel patterns in habitat use. In Lake Washington the Chinook were close to shore in shallow water (1 to 5 meters) during the day, and far offshore in limnetic areas at night. Whereas, in the Ship Canal, they were broadly distributed across deep-water areas (> 8 to 10 meters) at all times.

The current overwater structures of the Evergreen Point Bridge and macrophyte beds appeared to influence movement patterns and depth selection of Chinook salmon smolts. Chinook salmon smolts generally avoided areas directly beneath overwater structures, although some fish held in areas along the edges of structures (within 2 meters) for up to 2 hours. Actively migrating fish appeared to change course, moving into deeper water to travel beneath or around structures, with the degree of avoidance affected by structure width and water depth. Chinook appeared less hesitant to pass beneath narrow structures. Along those shorelines where macrophytes were present, Chinook appeared to use deeper water column depths than where macrophytes were absent. The juveniles tend to move above the macrophyte canopy along its outer edge, apparently using the macrophytes as a false bottom.

Behavioral responses of Chinook to the bridge are at least partially dependent upon their overall migratory behavior (active migration or holding) (Celedonia et al. 2009, p. ii). About two-thirds (65 percent) of actively migrating smolts appeared to delay briefly (minutes) at the bridge with the remainder negligibly affected by the bridge. Delayed fish varied widely in time of delay and distance traveled along the bridge corridor. Nearly half (45 percent) of the delayed Chinook took less than 3 minutes to pass beneath the bridge travelling less than 33 meters along the edge of the bridge during this time. Holding smolts tended to selectively reside in areas near the bridge for prolonged periods, often crossing beneath the bridge to the north and were later detected returning to and holding in areas immediately adjacent (within 20 meters) to the bridge's southern edge. This behavior may have been associated with these fish using the bridge as potential cover (shadow and/or structure). In addition, holding Chinook also selected areas of dense macrophytes away from the bridge. When near the bridge, smolts shifted to deeper water

6 to 8 meters in depth as compared to the 4- to 6-meter water-column depth when not near the bridge.

In the lake, juvenile Chinook salmon are likely to be in proximity to smallmouth bass as they move along the shoreline and encounter docks, which appear to be a selected habitat feature for smallmouth bass (Celedonia et al. 2008b). However, in the Ship Canal, there is less potential for overlap because Chinook salmon typically are found farther offshore and in deeper water.

Additional observations of tagged Chinook in 2008 found more random and wandering movements and somewhat less unidirectional migration than previous observations (Celedonia et al. 2009). Chinook were observed to use areas on the south side of the bridge, under the bridge, and on the north side of the bridge.

Tracking studies (Celedonia et al. 2008a; Celedonia et al. 2009) found that in both years, smallmouth bass were primarily concentrated in 4- to 8-meter-depth interval during all diel periods. At dawn they often moved into sparse vegetation and the offshore edge of vegetation. Smallmouth bass associated with overwater structures were generally in shallower water than those that were not associated with an overwater structure. Smallmouth were closely associated with either an overwater structure, a steep sloping shoreline (riprap or bulkhead), or the offshore edge of aquatic macrophytes. Overlap in habitat between smallmouth bass and juvenile Chinook salmon occurs at each of these three habitat types. Small bass (< 185 millimeters) overwhelmingly selected nearshore overwater structures (i.e., boat docks) and made no notable use of the area around the bridge. Larger bass selected both nearshore overwater structures and the bridge with some closely associated with bridge columns. Smallmouth bass in the Ship Canal showed similar behavior patterns.

Northern pikeminnow tagged near the Evergreen Point Bridge tended to leave the area soon after tagging Celedonia et al. (2008b). Those that remained in the bridge vicinity did not differentially select areas near or away from the bridge. Northern pikeminnow selected moderately dense to dense vegetation during all times of day and night, and they strongly selected overwater structures other than the bridge during the day only. They selected 4- to 6-meter water-column depths during all diel periods. Gillnet sampling in 2008 indicated salmon are a significant portion of pikeminnow diets, but no higher at the bridge than at other areas evaluated (Celedonia et al. 2009). Some of the tagged pikeminnow and bass appeared to preferentially use the habitat under the bridge in 2008, particularly areas near the bridge columns. However, the data do not indicate that their abundances are elevated over other nearby areas sampled. The bridge structure likely does not represent ideal habitat conditions because the structure is not very complex, the substrate consists mostly of fine sediments, and the bottom has a gentle slope.

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APPENDIX H: INDIRECT EFFECTS

INDIRECT EFFECTS

This appendix assesses indirect effects to listed species and designated or proposed critical habitat from land-use changes that could result from the SR 520, I-5 to Medina: Bridge Replacement and HOV Project (SR 520, I-5 to Medina project). The analysis follows guidance in *ESA, Transportation and Development – Assessing Indirect Effects* (WSDOT 2009a), which provides a stepwise approach by posing a series of questions about the proposed project.

1. Will the project create a new facility (e.g., new road, new interchange, etc.)?

The project will not create a new facility; however, it will increase the capacity of the existing transportation system through proposed improvements. The project will increase the capacity of the existing system through the addition of two new high-occupancy vehicle (HOV) lanes, the replacement of three vulnerable structures, and the reconfiguration of several interchanges and associated ramps in the action area.

The addition of two new HOV lanes will improve traffic flow and reduce congestion in the general-purpose lanes. This improvement, coupled with the restripe and reconfiguration between Evergreen Point Road and 92nd Avenue Northeast to complete the HOV system, will improve the flow of carpools and transit. Carpools and transit will be able to travel in the HOV lane for the length of the SR 520 corridor; they will no longer have to move from the general-purpose lane to the HOV lane east of Evergreen Point Road. The reconfiguration of interchanges and associated ramps will improve access to and traffic flow on SR 520, but it will not result in new access points or provide access to previously inaccessible and/or undeveloped lands.

The project will also result in the implementation of tolling on the SR 520 corridor. Although the project will not generate additional regional traffic, traffic circulation patterns will change to and from SR 520 and in the vicinity of the project.

2. Will the project improve a level of service of an existing facility as established in local Growth Management Act (GMA) plans?

The project will improve the level of service of an existing facility: SR 520. The Transportation Discipline Report (WSDOT 2009b) prepared for the project NEPA process concludes that as a result of the project, interchanges and local streets along the SR 520 corridor, and the SR 520 corridor as a whole, will operate at improved levels of service.

3. Identify if the transportation project has a causal relationship to a land-use change.

First, this step identifies development that is tied to the project by a permit condition or building moratorium. Comprehensive plans for jurisdictions in the action area were reviewed to identify any development contingent on the project. These plans did not identify any development tied to the project by a permit condition or building moratorium contingent on the project. These findings were reinforced by information provided by local jurisdiction planners in the action area, who indicated that jurisdictions throughout the action area, including communities on the west and east sides of Lake Washington, are fully developed or very close to full development. Based on information from the relevant jurisdictions, the development of any currently undeveloped land within these communities is not contingent or dependent on the project.

Second, this step identifies the extent to which the project would influence changes in land use, in rates of land-use change, or in growth patterns and/or rates. Existing land uses in the action area are established and consistent with current zoning and comprehensive plan land-use designations and policies. Comprehensive plans for jurisdictions in the action area do not identify any planned changes in existing land uses or land-use patterns in response to the project.

The project will require the acquisition of land for right-of-way, converting existing land uses to transportation land use. The Land Use, Economics, and Relocations Discipline Report (WSDOT 2009c) concludes that conversion of these lands to transportation right-of-way will not result in subsequent changes in land use or in the rate of land-use change. The conversion of lands to transportation right-of-way will not result in changes to land-use patterns, such as creating access to previously inaccessible or less accessible areas, providing new or additional access to and from SR 520 or local streets, or altering existing access to or within surrounding communities. For these reasons, growth patterns or rates would not change as a result of the project.

4. Determine the size and location of the action area.

The action area for a project is defined as “all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action” (50 CFR § 402.02).

The project extends along the SR 520 corridor from I-5 in Seattle to 92nd Avenue Northeast in Yarrow Point; however, the action area includes areas outside of and farther from the action area that would be immediately affected by the project. Specifically, the action area includes the SR 520 corridor from I-5 in Seattle east to SR 202 in Redmond. Jurisdictions in the action area are Seattle, Medina, Hunts Point, Clyde Hill, Yarrow Point, Kirkland, Bellevue, and Redmond. The zone of influence for changes in traffic includes the SR 520 corridor, properties adjacent to or near SR 520, and roadways that intersect with SR 520 within the action area.

5. Determine the presence of proposed or listed species or designated critical habitat in the action area.

Three species listed under the Endangered Species Act are present in the action area, as shown in Exhibit H-1.

EXHIBIT H-1.
LISTED SPECIES PRESENT IN THE ACTION AREA

Species (ESU or DPS)	Status	Federal Jurisdiction	Critical Habitat Designation
Chinook Salmon (*Oncorhynchus tshawytscha*) (Puget Sound ESU)	Threatened	NMFS	Designated
Steelhead Trout (*Oncorhynchus mykiss*) (Puget Sound ESU)	Threatened	NMFS	None designated
Bull Trout (*Salvelinus confluentus*) (Coastal-Puget Sound DPS)	Threatened	USFWS	Designated

ESU – Evolutionarily Significant Unit, DPS – Distinct Population Segment
NMFS – National Marine Fisheries Service, USFWS – U.S. Fish and Wildlife Service

Designated critical habitat for Puget Sound Chinook salmon and Coastal-Puget Sound bull trout is present in the action area. Lake Washington is designated critical habitat for both species. The National Marine Fisheries Service (NMFS) has not proposed or designated critical habitat for Puget Sound steelhead.

6. Identify the potential for impacts to the species and habitat from the development.

As stated in step 3, no development is contingent or dependent on the project. Additionally, there are no expected changes in land use or the rate of land-use changes, land-use patterns, or growth patterns or rates that would be caused by or dependent on the project. For these reasons, no effects on listed species or designated critical habitat will occur from such development.

7. Identify the rules or measures in place to help minimize the potential effects.

As stated in step 6, no development is contingent on or dependent on the project. Consequently, no effects on listed species or designated critical habitat are expected to result from such development. However, Critical Areas Ordinances (CAOs) in the action area provide protection for listed species and designated critical habitat. CAOs identify other rules and measures in place to avoid and/or minimize effects on natural resources, including sensitive species and habitats, at the federal, state, county, and local levels.

8. Describe how the development would affect the environmental baseline conditions.

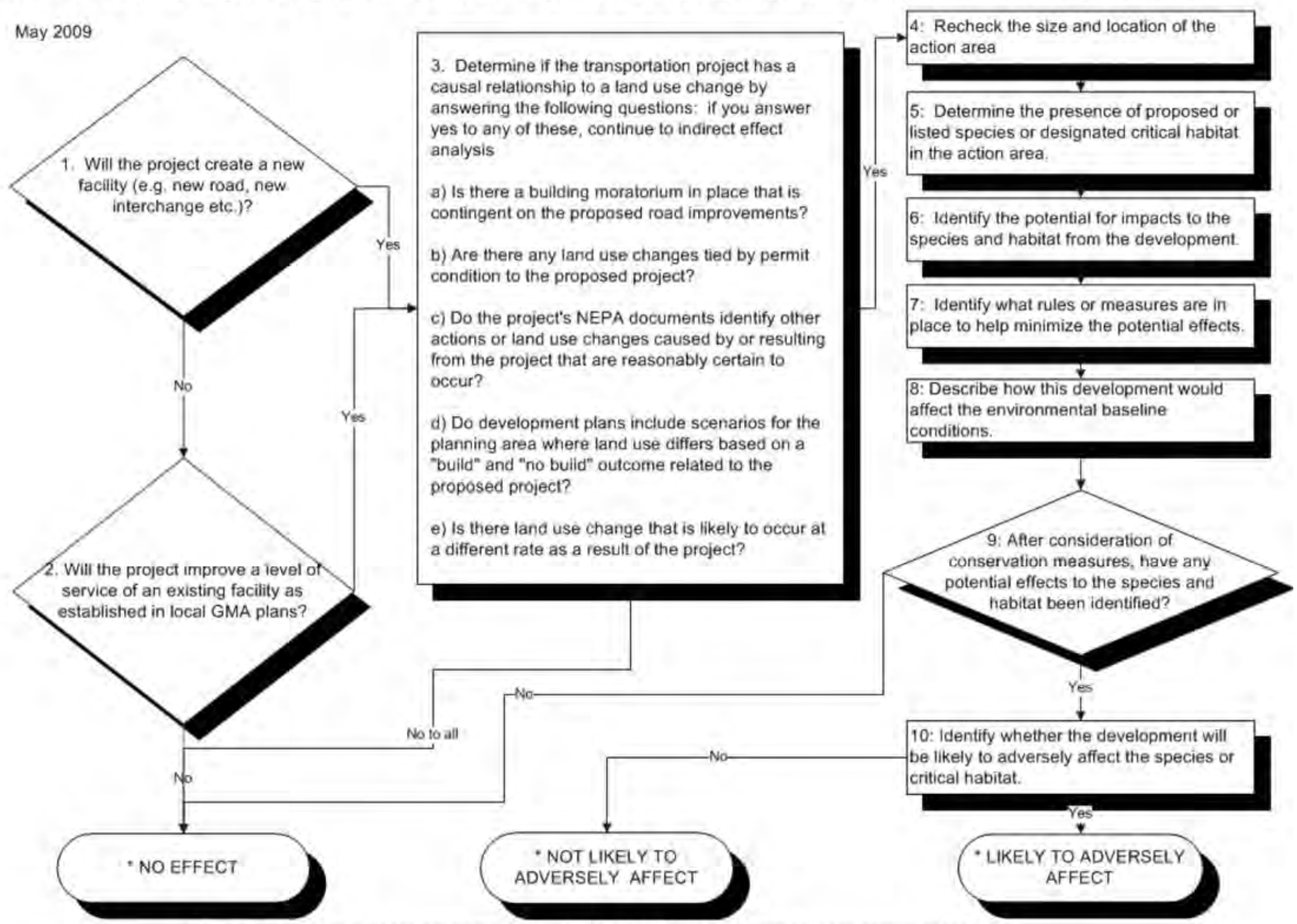
Because no development is contingent or dependent on the project, there will be no effects on the environmental baseline conditions as a result of such development.

9. After the consideration of conservation measures above, identify any of the remaining potential effects to the species and habitat from the associated land-use development.

As stated in steps 6 and 8, no effects on listed species, designated critical habitat, or environmental baseline conditions will result from development contingent or dependent on the project. Therefore, no conservation measures are identified to minimize such effects beyond the rules and measures referenced in step 7. As such, there are no remaining potential effects on listed species or designated critical habitat.

10. Identify whether the development will be likely to adversely affect the species or critical habitat.

Based on the information presented in steps 1 through 9, the project will have **no effect** on Puget Sound Chinook salmon, Puget Sound steelhead, or Coastal-Puget Sound bull trout or designated critical habitat for Chinook salmon or bull trout (Exhibit H-2).



*Note: This process is for the assessment of land use-related Indirect Effects only and presumes the project is analyzed for Direct Effects and any other indirect effects before a final effect determination is made.

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APPENDIX I: ENVIRONMENTAL BASELINE PER USFWS AND NMFS MATRICES OF PATHWAYS AND INDICATORS

ENVIRONMENTAL BASELINE PER USFWS AND NMFS MATRICES OF PATHWAYS AND INDICATORS

The *Checklists for Documenting Environmental Baseline and Effects of Proposed Actions(s) on Relevant Indicators* (NMFS 1996; USFWS 1998) was used to assess the environmental baseline conditions. Several indicators are not applicable to the lentic environment; therefore, they are not included in Exhibit I-1. As shown in Exhibit I-1, the applicable indicators are at risk or not properly functioning. Details on each pathway and its indicators are provided in this appendix.

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

Pathways Indicators	Environmental Baseline			Effects of the Action(s)		
	Properly Functioning	At Risk	Not Properly Functioning	Restore	Maintain	Degrade
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	
Watershed Conditions						
Disturbance History			X		X	
Riparian Reserves			X		X	
Bull Trout Subpopulation Characteristics						
Subpopulation Size			X		X	
Growth and Survival			X		X	
Life History Diversity and Isolation			X		X	
Persistence and Genetic Integrity			X		X	

Watershed Name: Lake Washington

Location: Section 24,* Township 25 North, Range 5 East, Sections 20,21,22, Township 25 North, Range 4 East,

EXHIBIT I-1A.
CHECKLIST FOR DOCUMENTING ENVIRONMENTAL BASELINE AND EFFECTS OF PROPOSED ACTION(S) ON RELEVANT INDICATORS

Pathways Indicators	Environmental Baseline	Effects of the Action(s)
Water Quality		
Temperature	AR	
Sediment/Turbidity	NPF	
Chemical Contamination/Nutrients	AR	
Habitat Access		
Physical Barriers	PF	
Habitat Elements		
Substrate (Substrate Embeddedness[a])	NPF	
Refugia	AR	
Channel Conditions and Dynamics		
Floodplain Connectivity	NPF	
Watershed Conditions		
Road Density and Location	NPF	
Disturbance History (Regime[a])	NPF	
Riparian Reserves (Conservation Areas[a])	NPF	

PF – Properly Functioning FA – Functioning Appropriately
AR – At Risk FAR – Functioning at Risk
NPF – Not Properly Functioning FUR – Functioning at Unacceptable Risk

Notes:

1 The categories of function are defined for each indicator in the Matrix of Pathways and Indicators (NMFS 1996, USFWS 1998).

2. For the purposes of this checklist, the categories of effect are defined as the following:

Restore means to change the function of an *At Risk* indicator to *Properly Functioning*, or to change the function of a *Not Properly Functioning* indicator to *At Risk* or *Properly Functioning* an *At Risk* indicator to *Properly Functioning* (NMFS 1996)*; Restore* means to change the function of a *Functioning at Risk* indicator to *Functioning Appropriately*, or to change the function of a *Functioning at Unacceptable Risk* indicator to *Functioning at Risk* or *Functioning Appropriately* (USFWS 1998).
Maintain means that the function of an indicator does not change (i.e., it applies to all indicators regardless of function al level).
Degrade means to change the function of an indicator for the worse (this applies to all indicators regardless of functional level). In some cases, a *Not Properly Functioning* or *Functioning at Unacceptable Risk* may be further worsened, and this should be noted.

[a] Language specific to bull trout

As indicated in Exhibit I-2, the biological requirements of the listed salmonid species are generally not being met within the action area. The factors for decline of the species continue to be present in the action area and throughout the Lake Washington watershed. Lake Washington and the Lake Washington Ship Canal (Ship Canal) generally lack the necessary shoreline habitat, which under natural conditions provides food (insects), detritus for the ecosystem, refuge from predators, and adequate water quality throughout much of the summer and early fall. While much of the shoreline habitat in Union Bay and Portage Bay contains natural vegetation providing both food and detritus sources, the dense aquatic vegetation and accumulation of fine-grained sediments restricts the usefulness of the habitat to salmonid species.

EXHIBIT I-2.
OVERVIEW OF ENVIRONMENTAL BASELINE CONDITIONS AND EFFECTS OF PROPOSED ACTION(S) ON INDICATORS SPECIFIC TO BULL TROUT

Pathways Indicators	Environmental Baseline	Effects of the Action(s)
Subpopulation Characteristics within Subpopulation Watersheds		
Subpopulation Size	There are no distinct bull trout subpopulations in the action area.	Maintain
Growth and Survival	There are no distinct bull trout subpopulations in the action area.	Maintain
Life History Diversity and Isolation	There are no distinct bull trout subpopulations in the action area.	Maintain
Persistence &Genetic Integrity	There are no distinct bull trout subpopulations in the action area.	Maintain
Integration of Species and Habitat Conditions	There are no distinct bull trout subpopulations in the action area.	Maintain

Water Quality

The water quality pathway includes three indicators applicable to the action area: temperature, sediment/turbidity, and chemical contamination/nutrients.

Temperature

Little information is available for water temperature in the action area. However, temperatures in Lake Washington frequently exceed the state water quality standard of 64°F (18°C) during the summer months (Ecology 2008). Monthly water quality sampling indicated exceedances in mid-July and mid-August from 2003 through 2005. These high temperatures may impair salmonid migration and rearing activities in the vicinity of the Evergreen Point Bridge and the Ship Canal, which is a migratory corridor to Puget Sound.

Using the matrix of pathways and indicators criteria, the baseline condition for temperature is **at risk**. The project is not expected to alter water temperature in the action area. Therefore, the project would **maintain** the baseline conditions for temperature.

Sediment/Turbidity

In the action area, the shoreline is highly altered and includes extensive aquatic vegetation. As a result, the sediment in the action area consists primarily of silt and mud with isolated patches of sand and gravel.

Based on the matrix of pathways and indicators criteria, the baseline condition is **not properly functioning**. Although temporary alteration in turbidity will occur associated with project activities, no persistant changes to this indicator are indentified. Therefore, the project is expected to **maintain** baseline conditions.

Chemical Contamination/Nutrients

While the sediments in the action area are not listed as contaminated (Ecology 2008), the highly developed surrounding area and numerous potential pollutant sources are likely to have produced some elevated contaminant levels in the sediments.

Based on the matrix of pathways and indicators criteria, baseline conditions for chemical contamination and nutrients are **at risk**. Appropriate spill control best management practices (BMPs) will be employed and only limited disturbance of the sediments is expected from the proposed project. Therefore, the project is expected to **maintain** baseline conditions.

Habitat Access

Physical Barriers

There are no physical barriers in Lake Washington or Portage Bay; however, the occurrence of dense aquatic vegetation in the area could block access to nearshore rearing habitat for juvenile fish.

Based on the matrix of pathways and indicators criteria, the baseline conditions are **properly functioning**. No alteration to this indicator would result from this project. Therefore, the project is expected to **maintain** baseline conditions.

Habitat Elements

The Habitat Elements pathway includes six indicators. These indicators are primarily related to stream or riverine habitats, not the lentic habitat present in the action area. Therefore, the pool frequency and quality, large pools, off-channel habitat, and large woody debris indicators are not addressed. Although the indicators of substrate/substrate embeddedness and refugia are also intended for stream or river habitat conditions, they are applicable to lentic areas in the action area that would support juvenile rearing.

Substrate/Substrate Embeddedness

The substrate/substrate embeddedness indicator is predominantly focused on stream and river habitats rather than lentic habitats. However, Lake Washington is used as rearing habitat for the listed salmonid species. The lake's bottom substrate is composed primarily of soft sediments and organic detritus. Therefore, substrate in the action area is considered **not properly functioning**. Project activities are not expected to alter existing conditions. Therefore, the project will **maintain** baseline conditions.

Refugia

Lake Washington does not provide tributary refuge habitat capable of supporting and maintaining all life stages of salmonids. The existing shallow shoreline habitat has extensive invasive aquatic vegetation, which is thought to limit access and utilization by salmonids. Based on the matrix of pathways and indicators criteria, the baseline conditions are **at risk**. The project will likely temporarily reduce invasive aquatic vegetation; however, no long-term improvement is expected. Therefore, the project will **maintain** baseline conditions.

Channel Conditions and Dynamics

The Channel Conditions and Dynamics pathway includes three indicators: width/depth ratio, stream bank condition, and floodplain connectivity. These indicators are primarily related to stream or riverine habitats, not the lentic habitat present in the action area. Therefore, the width/depth ratio and stream bank condition indicators are not addressed. However, floodplain connectivity is applicable to lentic areas in the action area that would support juvenile rearing.

Floodplain Connectivity

The lowering of Lake Washington, the completion of the Montlake Cut, and the control of the lake level at the Hiram M. Chittenden Locks (Ballard Locks) have eliminated all connections between the lake and its natural floodplain. In addition, extensive shoreline modification and development has modified large areas of the historical floodplain around the lake. Based on the matrix of pathways and indicators criteria, the baseline conditions are **not properly functioning**. The project will **maintain** baseline conditions.

Flow/Hydrology

The Flow/Hydrology pathway includes two indicators: change in peak and base flows and drainage network increases. These indicators are intended for stream or river habitats and are not applicable to the lentic habitats in the action area; therefore, these indicators are not addressed.

Watershed Conditions

The Watershed Conditions pathway includes three indicators: road density and location, disturbance history (regime), and riparian reserves (conservation areas).

Road Density and Location

The drainage areas within the action area and watershed are all highly developed. High road densities (> 5 miles of road per square mile of land) exist throughout much of the Lake Washington watershed. Based on the matrix of pathways and indicators criteria, the baseline conditions are **at risk**. Because the action area is generally fully developed, the project will not alter this indicator. Therefore, the project will **maintain** baseline conditions.

Disturbance History (Regime)

Substantial disturbance of all habitats in the action area has occurred due to extensive residential, commercial, and industrial development along Lake Washington and the Ship Canal. Extensive development of the shoreline has contributed to the disturbance history. In addition, the lowering of the lake resulted in substantial disturbance of the natural shoreline conditions in the area.

Based on the matrix of pathways and indicators criteria, the existing baseline conditions are **at risk**. The project will **maintain** baseline conditions.

Riparian Reserves (Conservation Areas)

Although the riparian habitats in the action area are highly disturbed compared to historical conditions, much of the lake shoreline is vegetated. However, most of the vegetation is nonnative. Based on the matrix of pathways and indicators criteria, the baseline condition for riparian reserves (conservation areas) is **at risk**. The project and associated mitigation will provide improvements to riparian areas. Therefore, the project will **maintain** baseline conditions.

Pathways and Indicators Specific to Bull Trout Only

Subpopulation Characteristics within Subpopulation Watersheds

Subpopulation Size

No distinct bull trout subpopulations are associated with the Cedar River-Lake Washington or Sammamish watersheds, although the action area falls within the Lake Washington foraging, migration, and overwintering (FMO) habitat (USFWS 2004). The Lake Washington FMO habitat consists of the lower Cedar River below Cedar Falls; the Sammamish River; Lakes Washington, Sammamish and Union; the Ship Canal; and all accessible tributaries. Population status information, extent of use, and complete recovery value of this area is currently unknown. Adult- and subadult-size individuals have been observed infrequently in Lake Washington. 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 above Chester Morse Lake.

The potential for spawning in the Lake Washington watershed is believed to be very low because a majority of accessible habitat is low elevation, below 152 meters (500 feet), and thus not expected to have the proper thermal regime to sustain successful spawning. There are some coldwater springs and tributaries that may come close to suitable spawning temperatures and that may provide thermal refuge for rearing or foraging during warm summer periods (USFWS

2004). However, streams in the action area are not considered to provide suitable spawning habitat for bull trout.

Aside from spawning, the Lake Washington watershed has both potential benefits and challenges to adult and subadult bull trout. Two large lakes with high forage fish availability are dominant parts of the lower watershed and provide significant foraging habitat. A number of observations of subadult- and adult-size bull trout have been made in Lake Washington. The connection with the Chester Morse Lake core area (population located in the upper Cedar River) is one-way only; currently, the level of connectivity with other core areas is unknown. Observations of bull trout in the Ballard Locks suggest migration from other watersheds is likely occurring (USFWS 2004).

Growth and Survival

No distinct bull trout subpopulations are associated with the Cedar River-Lake Washington or Sammamish watersheds.

Life History Diversity and Isolation

No distinct bull trout subpopulations are associated with the Cedar River-Lake Washington or Sammamish watersheds.

Persistence and Genetic Integrity

No distinct bull trout subpopulations are associated with the Cedar River-Lake Washington or Sammamish watersheds.

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APPENDIX J: STORMWATER ANALYSIS AND HI-RUN SUMMARY

Introduction

This appendix summarizes the available information on potential stormwater changes resulting from the SR 520 to Medina: Bridge Replacement and HOV Project (SR 520, I-5 to Medina project). It also describes how these changes could affect Endangered Species Act (ESA) listed species and critical habitat within Lake Washington, Union Bay, Portage Bay, Lake Union, Lake Washington Ship Canal (Ship Canal), and Puget Sound. The stormwater quality review presented in this appendix evaluates the existing and proposed conditions for Option A Prime of the SR 520, I-5 to Medina project. Option A Prime is a combination of the original Option A combined with a constant 0.3 percent grade from the shoreline at Montlake to the west approach transition, as proposed in Option L. This appendix provides detailed information on water quality and quantity within the project action area under both existing and post project conditions. The analysis evaluates changes in land use and impervious surfaces within individual threshold discharge areas (TDAs) within the project action area. A TDA is defined as an onsite area draining to a single natural discharge location or multiple natural discharge locations that combines within ¼ mile downstream (as determined by the shortest flow path).

Evaluating the environmental effects of constructing the SR 520, I-5 to Medina project is based on the Highway Runoff (HI-RUN) analysis tool, which uses the existing and proposed land use and stormwater treatment best management practices (BMPs) to evaluate the pollutant loads discharging into the receiving water bodies at each outfall location. A mixing zone analysis was also performed, using the modified HI-RUN model, to calculate the required distance from each stormwater outfall to where pollutant concentrations are diluted so that water quality standards are not exceeded and would not result in a taking of ESA listed species.

Existing Stormwater Collection and Conveyance System

Onsite stormwater runoff collection areas for the project have been divided into 28 TDAs. These TDAs are further subdivided into smaller stormwater subbasins depending on outfall location. There are two general types of outfall locations: 1) direct discharges to a large surface water body (such as Lake Union, Portage Bay, Lake Washington), and 2) discharges to the City of Seattle combined sewer system (CSS), which routes all water to the West Point Treatment Plant. The existing TDA delineation for the surface water discharge points are presented in Exhibit J-1 and Exhibits J-2 through J-5. The existing TDA delineation for the CSS discharge points and the combined sewer overflow (CSO) locations are provided in Exhibit J-6 and Exhibits J-7 and J-8. Under existing conditions, no stormwater generated from the project action area roadways is treated onsite. Stormwater from existing impervious surfaces is discharged to several water bodies within Lake Union, Lake Washington, and the Ship Canal, or it enters the City of Seattle CSS. The existing TDAs and outfall locations are discussed below in two sections. The first section describes all TDAs draining to a surface water outfall, and the second section describes TDAs draining to the City of Seattle CSS.

EXHIBIT J-1.
EXISTING CONDITIONS OF TDAS DISCHARGING TO SURFACE WATER OUTFALLS

PROJECT LIMIT DISCHARGE POINT (OUTFALL)	RECEIVING WATER BODY	CONTRIBUTING TDAs	TOTAL TDA AREA (acres)	EXISTING PGIS (acres)
East Garfield Street	Lake Union	TDA 1	2.52	2.45
East Allison Street	Lake Union	TDA 2	19.03	14.25
WS-C	Portage Bay (Lake Union)	TDA 5	6.43	3.34
WS-BR1	Portage Bay (Lake Union)	TDA 9	15.00	3.10
WS-D	Portage Bay (Lake Union)	TDA 10	6.31	3.37
WS-E	Union Bay (Lake Washington)	TDA 11	12.37	7.07
Union Bay	Union Bay (Lake Washington)	TDA 21	15.34	1.28
WS-BR2 (Montlake Bridge)	Montlake Cut (Lake Washington)	TDA 16 TDA 17	1.37	0.19
RWB-C	Union Bay (Lake Washington)	TDA 18	0.31	0.02
WS-BR3	Union Bay	TDA 20	26.84	4.83
WS-F	Union Bay	TDA 23	2.60	0.70
WS-BR4	Lake Washington	TDA 24	372.88	17.28
WS-G	Lake Washington	TDA 25	5.49	1.75
WS-J and RWB-G	Fairweather Bay (Lake Washington)	TDA 28	7.33	5.42
SEA-M2 and SEA-M3	Union Bay	TDA 11	1.73	0.23
RWB-F	Union Bay	TDA 22	1.08	0.38
RWB-E	Union Bay	TDA 11	5.76	1.02
RWB-H	Fairweather Bay (Lake Washington)	TDA 26	0.67	0.16
		Existing Project Totals	**497.212**	**68.168**

WS = WSDOT
RWB = Receiving Water Body (Private) outfalls

Existing TDAs and Surface Water Outfall Locations

Currently, stormwater generated within the project action area does not receive water quality or flow control treatment before being discharged to the surface water discharge locations described in this section. In these existing conditions, a single surface water discharge location may receive stormwater from one or multiple TDAs. As such, existing conditions are characterized by individual discharge points. The outfalls and their associated TDAs are discussed in more detail below. The description below characterizes discharges and existing drainage patterns.

Subsequent comparisons compare existing conditions to proposed conditions as if the drainage patterns are in the proposed condition.

East Garfield Street Outfall

This outfall discharges stormwater from TDA 1. TDA 1 is composed of the I 5 pavement area at the south end of the approach to SR 520 (Exhibit J-2), and covers a total area of 2.52 acres (Exhibit J-1). Surface water sheet flows to the south from the high point that separates TDA 1 from TDA 2. The stormwater is collected in a tightline conveyance system that consists of catch basins and stormwater pipes, and discharges into Lake Union at the East Garfield Street outfall (Exhibit J-2).

East Allison Street Outfall

This outfall discharges stormwater from TDA 2. TDA 2 includes I 5 pavement area from the high point on the southern border with TDA 1 and continues north through the off ramp to eastbound SR 520 and the southbound on ramp to I 5. TDA 2 also includes a portion of East Roanoke Street and the 10th Avenue East Bridge area south on 10th Avenue East to approximately East Miller Street within the project limits of construction. This area drains to a sag location just south of the East Roanoke Street Bridge overcrossing. The area is completely paved except for a small area of trees and brush located in the median between the northbound and southbound lanes located just north of the SR 520 interchange and south of the East Roanoke Street Bridge overcrossing. An additional grassy area with sparse trees also exists at the SR 520 interchange east of the northbound I 5 lanes. This TDA has 14.25 acres of pollution-generating impervious surface (PGIS) within a total area of 19.03 acres (see Exhibit J-1). Stormwater runoff is collected in a tightline conveyance system and discharged into Lake Union at the East Allison Street outfall (see Exhibit J-2).

WS C

This outfall discharges stormwater from TDA 5. This TDA has a combined area of 6.43 acres and PGIS of 3.34 acres (see Exhibit J-1). This TDA includes the area within the SR 520 corridor, located from just west of Portage Bay to the high point within the SR 520 vertical alignment. It also includes the pavement for the highway system and undeveloped areas of trees and brush that exist along the north and south perimeter of the corridor. Stormwater runoff from SR 520 is collected in a tightline conveyance system and discharged to Portage Bay at discharge location WS C, east of Boyer Avenue East (see Exhibit J-2).

WS BR1 (Portage Bay Bridge)

This outfall discharges stormwater from TDA 9, consisting of the Washington State Department of Transportation (WSDOT) right-of-way over the fixed Portage Bay Bridge from the western shoreline to the eastern shoreline of Portage Bay. There are 3.10 acres of PGIS within the 15-acre TDA (see Exhibit J-1). The Portage Bay Bridge has forty five 6 inch drainage downspouts, discharging directly into Portage Bay at discharge location WS BR1 (see

Exhibit J-3). Each downspout collects runoff from approximately 3,000 square feet of surface area.

WS D

Outfall WS D discharges stormwater from TDA 10 to Portage Bay (see Exhibit J-3). TDA 10 consists of the area north and south of the existing eastbound loop ramp just west of East Montlake Place. This area includes the eastbound off ramp to East Montlake Place and the westbound on ramp from SR 513 onto SR 520. The TDA includes 3.37 acres of PGIS in a total area of 6.31 acres (see Exhibit J-1).

The storm sewer system discharges through an 8 inch pipe northwesterly of West Montlake Place East, northeasterly of Montlake Park, and west of the existing eastbound loop ramp. Existing impervious surfaces are either intercepted by the existing storm sewer tightline or sheet flow into the east side of Portage Bay. The roadway improvements have inlets and a storm sewer installed to intercept and then convey the stormwater by tightline system to an existing outlet located along the eastern shoreline of Portage Bay.

WS E

Outfall location WS E discharges stormwater from TDAs 11A and 11B to Union Bay (see Exhibit J-3). These TDAs consist of the area within the SR 520 corridor from the west margin of the SR 513 corridor east to the west shoreline of Union Bay. The two TDAs have 6.94 acres of PGIS in a total area of 9.11 acres (see Exhibit J-1). The WS E outfall is under the Evergreen Point Bridge structure along the western shoreline of Union Bay just south of the outfall at the Museum of History and Industry (MOHAI) site.

SEA M2 and SEA M3

Outfall location SEA M2 and SEA M3 discharges stormwater from a portion of TDA 11 to Union Bay. TDA 11 consists of the northwest portion of McCurdy Park and has 0.23 acre of PGIS in a total area of 1.73 acres (see Exhibit J-1). Stormwater is discharged via sheet flow at the northeastern point of McCurdy Park.

RWB-E

Outfall location RWB-E discharges stormwater from TDA 11 to Union Bay (see Exhibit J-3). This TDA includes the MOHAI property in McCurdy Park, and 1.02 acres of PGIS in a total area of 5.76 acres (see Exhibit J-1). Stormwater runoff from the site discharges directly to Union Bay via sheet flow just east of the existing MOHAI parking lot.

WS BR2 (Montlake Bridge)

WS BR2 is not an end-of-pipe outfall, but rather an area where stormwater from TDAs 16 and 17 enters the Montlake Cut (see Exhibit J-3). TDA 16 consists of the Montlake Bridge—a bascule bridge that has an open grate surface that allows stormwater to fall directly through the gaps into the Montlake Cut. Runoff is not collected but is not considered effective PGIS because it does not come into contact with the road. TDA 17 includes the south and north approach to the bridge. Impervious surfaces from TDA 17 sheet flow directly into the Montlake Cut.

RWB C

Outfall location RWB C discharges stormwater from TDA 18 to Union Bay (see Exhibit J-3). TDA 18 includes the area north of the existing Montlake Bridge to the intersection with Northeast Pacific Street. Surface street runoff flows easterly toward Union Bay. The area consists of 0.02 acre of PGIS in a total TDA of 0.31 acre (see Exhibit J-1). The outfall is north of the Montlake Cut within the University of Washington property, north of the existing Canoe House.

WS BR3

Outfall location WS BR3 discharges stormwater from TDA 20 to Union Bay (see Exhibit J-3). TDA 20 consists of the area east of McCurdy Park and east of Lake Washington Boulevard. The area includes the Evergreen Point Bridge that crosses from Montlake to the landfall on Foster Island, the westbound off ramp from the SR 520 roadway to Lake Washington Boulevard, the eastbound on ramp from Lake Washington Boulevard to SR 520, and the unused portions of on ramp and off ramps within this area. The TDA consists of 4.83 acres of PGIS in a total area of 26.84 acres (see Exhibit J-1). The mainline fixed bridge is directly over the water in this TDA. The bridge has forty two 6 inch downspout drains that each collect stormwater from areas approximately 2,106 square feet and discharge directly to the water below. The on and off ramps are also placed directly over the water and contain fifty one 6 inch downspout drains, with each collecting stormwater from areas approximately 2,293 square feet. The existing pervious surfaces sheet flow to Union Bay. Only a slight variation in the TDA exists for Options A, K, and L at the southern limits of the TDA.

Union Bay

Stormwater from TDA 21 discharges to Union Bay. The TDA includes portions of the westbound off ramp from SR 520 to Lake Washington Boulevard, portions of the eastbound on ramp from Lake Washington Boulevard to SR 520, and the unused portions of on ramp and off ramps within this area. The TDA consists of 1.28 acres of PGIS in a total area of 15.34 acres (see Exhibit J-1). The fixed bridge on and off ramps has a series of 6 inch bridge drain downspouts, similar to those in TDA 20; however, these drains collect stormwater and directly drain to the land below. Stormwater on the land sheet flows directly to Union Bay; therefore, no discharge location is shown on Exhibit J-3.

RWB-F

Outfall location RWB-F discharges stormwater from TDA 22 to Union Bay (see Exhibit J-3). The TDA includes the Washington Park Arboretum sewer trestle and Lake Washington Boulevard. The TDA consists of 0.38 acre of PGIS in a total area of 1.08 acres (see Exhibit J-1). Runoff from the Arboretum parking lot and the adjacent Lake Washington Boulevard is collected in a tightline stormwater conveyance system and discharged into Union Bay from a 12 inch outfall pipe at discharge location RWB-F.

WS F

Outfall location WS F discharges stormwater from TDA 23 to Union Bay. TDA 23 includes the area of landfall on Foster Island. The TDA consists of 0.70 acre of PGIS in a total area of 2.60 acres (see Exhibit J-1). Stormwater from this section of the bridge flows to four 6 inch bridge drain downspouts located at the northwest, northeast, southwest, and southeast corners (see Exhibit J-3). Each of the four downspouts collects surface water from approximately 8,950 square feet of area. Stormwater is collected by bridge drains and discharged directly to Lake Washington within the bridge span/length.

WS BR4 (Floating Bridge)

Outfall location WS BR4 discharges stormwater from TDA 24 to Lake Washington within the bridge span/length (see Exhibits J-4 and J-5). This TDA includes the area east of Foster Island to the highrise for the existing Evergreen Point Bridge span, the floating portion of the Evergreen Point Bridge, and the east approach to the Evergreen Point Bridge. The TDA consists of 17.28 acres of PGIS in an entire TDA area of 372.88 acres (see Exhibit J-1), which includes the entire right-of-way over Lake Washington. Stormwater from the fixed bridge is collected by one hundred twenty six 6 inch bridge drains, each receiving stormwater from approximately 2,306 square feet of area and discharged directly to Lake Washington. Stormwater from the floating bridge area and bridge approaches drain 2,306 square feet of runoff to each of two hundred twelve 6 inch bridge drains that discharge directly into Lake Washington.

WS G

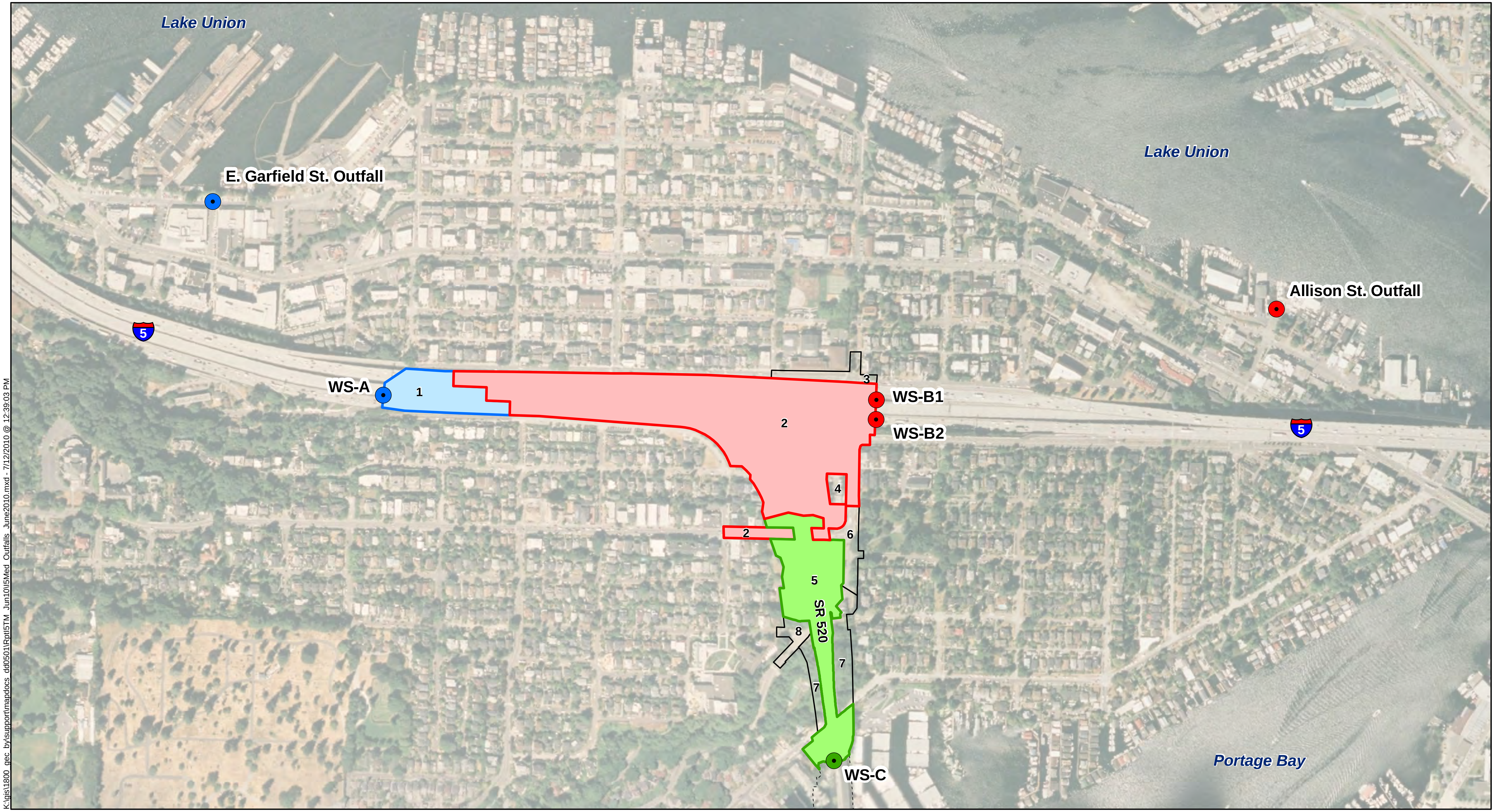
Outfall location WS G discharges stormwater from TDA 25 to Lake Washington (see Exhibit J-5). The Medina to SR 202: Eastside Transit and HOV Project (Medina to SR 202 project) will be completed before the SR 520, I-5 to Medina project, and therefore is considered the baseline condition for the SR 520, I-5 to Medina project. TDA 25 includes the Medina to SR 202 project design of both the westbound and eastbound lanes from the roadway crest near the Evergreen Point Road overpass west to the bridge abutment just east of the bridge. Baseline conditions are 1.75 acres of PGIS in a total area of 5.49 acres (see Exhibit J-1) with 0.55 acre of the PGIS treated with a bioswale. The bioswale is referred to as Facility K in the Medina to SR 202 project; however, the SR 520, I-5 to Medina project will refer only to the outfall name, WS-G.

RWB H

TDA 26 includes sections of the right-of-way of Evergreen Point Road as well as properties in a neighborhood west of Evergreen Point Road (see Exhibit J-5). The TDA consists of 0.16 acre of PGIS in a total area of 0.67 acre (see Exhibit J-1).

WS-J and RWB-G

Outfall location WS-J and RWB-G discharges stormwater from TDA 28 to Fairweather Bay (see Exhibit J-5). As discussed for outfall WS-G, the Medina to SR 202 project will be completed before the SR 520, I-5 to Medina project, and therefore is considered to be the baseline condition for the SR 520, I-5 to Medina project. The project area has 5.42 acres of PGIS in a total area of 7.33 acres. The two constructed stormwater wetland facilities provide enhanced treatment for all 5.42 acres of PGIS. Facility J receives flow from all SR 520, I-5 to Medina project TDAs and is located in TDA 28. Facility I3 receives the treated water from Facility J and other runoff from the Medina to SR 202 project and is located in TDA 28. The treated stormwater is discharged into Fairweather Bay at the WS-J outfall location. TDA 28 includes area along the east side of Evergreen Point Road, within the SR 520 right-of-way and the park and ride parking area south of the eastbound Evergreen Point transit stop.



N

0 500
Scale in Feet

Surface Water Outfall

- E. Garfield St. Outfall / WS-A (TDA 1)
- Allison St. Outfall / WS-B1 / WS-B2 (TDA 2)
- WS-C (TDA 5)

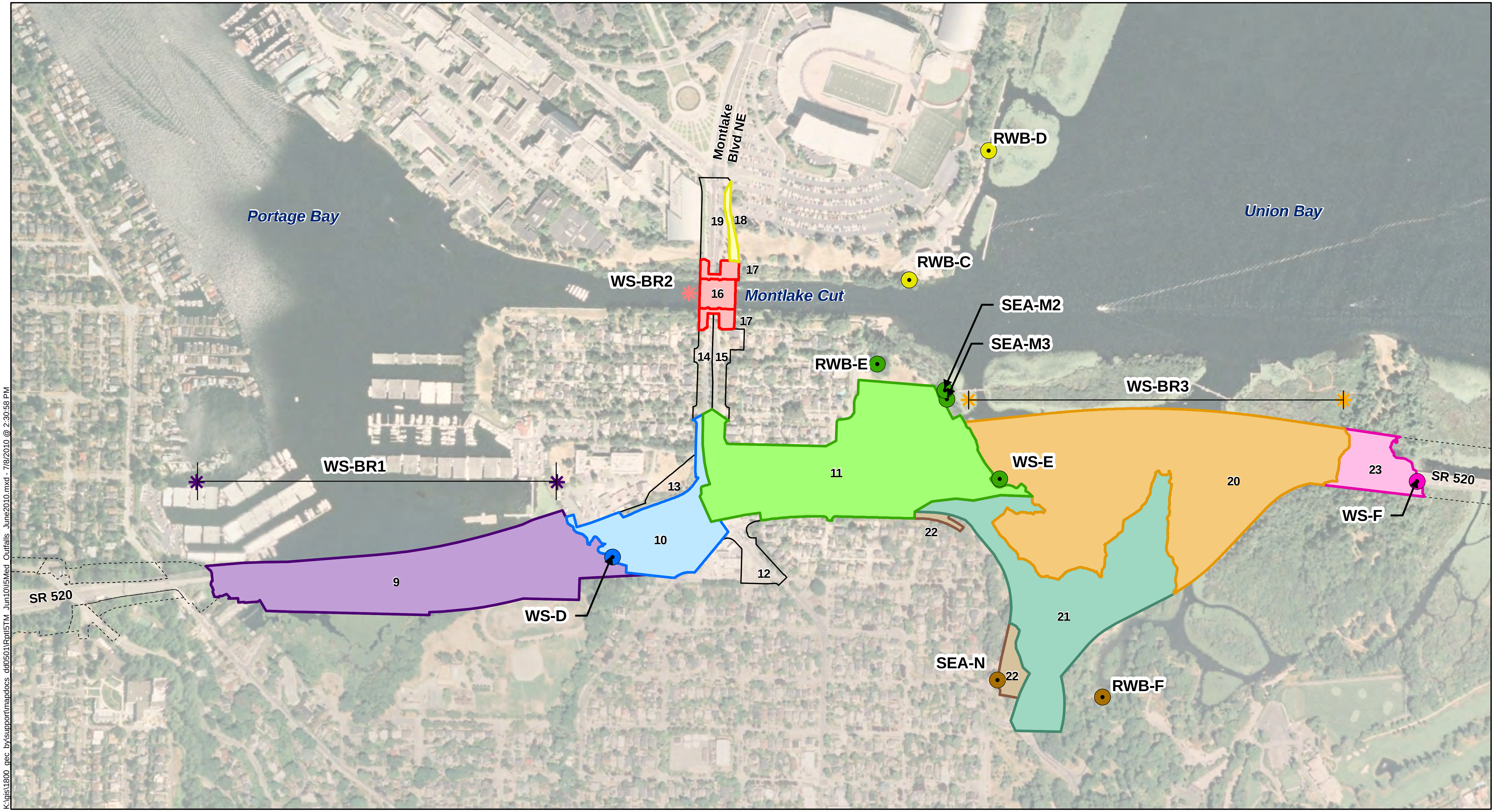
TDA boundary directed to Combined Sewer System Outfall

TDA boundary extending into adjacent sheets

NOTE: TDAs ARE DELINEATED BASED ON PROPOSED RIGHT-OF-WAY LIMITS

Exhibit J-2
Existing Condition TDA Delineation
Surface Water Outfalls

SR 520, I-5 to Medina:
Bridge Replacement and HOV Project



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0 500

Scale in Feet

Surface Water Outfall

- WS-BR1 (bridge) (TDA 9)
- WS-D (TDA 10)
- SEA-M2 / SEA-M3 / RWB-E / WS-E (TDA 11)
- WS-BR2 (bridge) (TDAs 16/17)
- RWB-C / RWB-D (TDA 18)
- WS-BR3 (bridge) (TDA 20)
- SEA-N / RWB-F (TDA 22)
- WS-F (TDA 23)
- *Union Bay* (TDA 21)

- TDA boundary directed to Combined Sewer System Outfall
- TDA boundary extending into adjacent sheets

NOTE: TDAs ARE DELINEATED BASED ON PROPOSED RIGHT-OF-WAY LIMITS

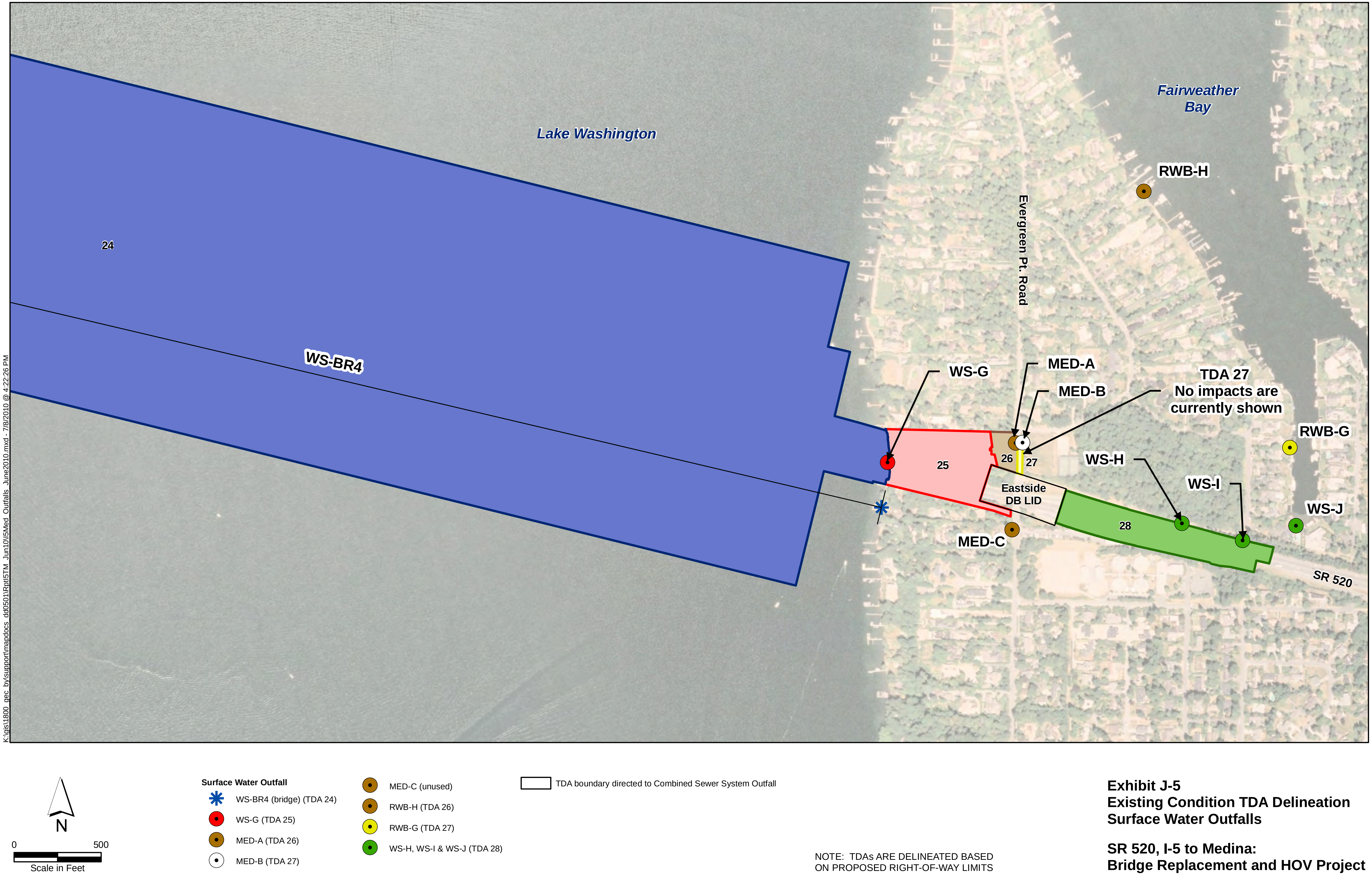
Exhibit J-3
Existing Condition TDA Delineation
Surface Water Outfalls

SR 520, I-5 to Medina:
Bridge Replacement and HOV Project

NOTE: TDAs ARE DELINEATED BASED ON PROPOSED RIGHT-OF-WAY LIMITS

Exhibit J-4
Existing Condition TDA Delineation
Surface Water Outfalls

SR 520, I-5 to Medina:
Bridge Replacement and HOV Project



Surface Water Outfall

- WS-BR4 (bridge) (TDA 24)
- WS-G (TDA 25)
- MED-A (TDA 26)
- MED-B (TDA 27)
- MED-C (unused)
- RWB-H (TDA 26)
- RWB-G (TDA 27)
- WS-H, WS-I & WS-J (TDA 28)
- TDA boundary directed to Combined Sewer System Outfall

NOTE: TDAs ARE DELINEATED BASED ON PROPOSED RIGHT-OF-WAY LIMITS

Exhibit J-5
Existing Condition TDA Delineation
Surface Water Outfalls

SR 520, I-5 to Medina:
Bridge Replacement and HOV Project

Combined Sewer System Outfall Locations

The TDAs discharging to the City of Seattle and King County combined sewers are presented separately from the surface water TDAs. Although they are located in similar areas as the surface water TDAs, they are independent of the SR 520 stormwater treatment system. Unlike newly constructed separated stormwater and sanitary sewer systems, the Seattle existing combined sewers join sewage from homes and businesses and stormwater together in a single conveyance system to the West Point Treatment Plant. Under typical operating conditions, the combined stormwater and sanitary sewage are treated and discharged to the marine waters of Puget Sound. During extreme wet weather conditions, the CSS can exceed capacity, resulting in untreated discharges at CSO outfalls. The CSO outfalls are relief points for the excess flow to prevent sewer backups, surface flooding, or operational issues at the regional wastewater treatment facilities where both stormwater and sewage are treated most of the time. King County's West Point Treatment Plant has an average inflow of approximately 110 million gallons per day (mgd) during dry weather, and a maximum instantaneous capacity of approximately 440 mgd (King County 2010). It is assumed that CSO events occur when the West Point Treatment Plant is operating at or near capacity; therefore, CSO events are likely to consist of approximately 25 percent wastewater and 75 percent stormwater.

Currently, project area stormwater runoff contributing to the CSS does not receive flow control or separate stormwater quality treatment prior to flowing into the combined system. The stormwater overflow frequency and volume for the outfalls serving the project area and operated by the City of Seattle and King County are summarized in Exhibit J-6. The TDAs contributing stormwater to the City of Seattle CSS are described in the following sections.

EXHIBIT J-6.
Combined Sewer System Overflow Locations and Events (2005 to 2009)

NPDES Number	Location	Receiving Water	Event Date	Overflow Duration (Hours)	Volume (Gallons)	Precipitation (Inches)	Storm Duration (Hours)
City of Seattle Combined Sewer System Overflow Locations and Events							
020	East Shelby Street	Union Bay	1/17/2005	8.0	605,406	1.60	20.0
			12/24/2005	3.0	31,037	3.80	150.0
			1/10/2006	4.0	13,821	1.07	26.0
			1/29/2006	15.0	77,424	1.45	100.0
			11/6/2006	6.0	239,537	0.43	197.0
			11/13/2006	3.0	43,031	0.74	356.0
			12/14/2006	14.0	1,031,852	3.80	135.0
			12/26/2006	6.0	262,906	1.40	20.0
			12/2/2007	24.0	242,376	6.09	72.0
			1/7/2009	2.5	58,507	2.55	103.2
			10/17/2009	0.7	9,693	2.31	94.3
			11/26/2009	0.2	55	1.28	12.9
132	Minor Avenue East and East Roanoke Street	Lake Union	10/1/2005	1.0	8,422	0.83	32.0
			2/4/2006	1.0	13,135	0.21	82.0
			12/14/2006	2.0	560,889	3.70	139.0
			12/3/2007	1.0	45,556	4.52	27.0
138	East Shelby Street and Furhman Avenue East	Portage Bay	1/17/2005	1.0	9,328	1.39	14.0
			12/24/2005	27.0	2,484,653	3.80	152.0
			1/5/2006	1.0	495,815	0.95	13.0
			1/10/2006	4.0	2,340,109	1.07	26.0
			1/29/2006	11.0	5,859,251	1.45	100.0
			5/27/2006	22.0	7,666,235	0.22	52.0
			11/6/2006	4.0	1,276,616	0.44	198.0
			11/13/2006	1.0	222,406	0.74	356.0
			12/14/2006	21.0	11,858,693	3.70	139.0
			12/26/2006	7.0	4,897,095	1.40	19.0
			12/2/2007	17.0	5,408,943	6.46	46.0
			11/8/2008	1.0	40,855	1.99	59.0
			1/7/2009	2.5	246,385	2.56	103.7
			11/26/2009	1.8	133,059	1.38	14.2

EXHIBIT J-6.
Combined Sewer System Overflow Locations and Events (2005 to 2009)

NPDES Number	Location	Receiving Water	Event Date	Overflow Duration (Hours)	Volume (Gallons)	Precipitation (Inches)	Storm Duration (Hours)
139	16th Avenue East and East Calhoun Street	Portage Bay	10/1/2005	2.0	11,992	1.10	49.0
			12/24/2005	1.0	1,141	3.80	152.0
			1/30/2006	1.0	649	2.35	108.0
			11/6/2006	1.0	595	0.43	196.0
			12/14/2006	5.0	43,451	3.70	139.0
			12/3/2007	15.0	4,258,050	4.52	24.0
			10/17/2009	0.2	2,884	2.28	93.5
140	East Shelby Street and West Park Drive East	Portage Bay	12/2/2007	49.0	822,007	6.63	62.0
			1/3/2008	1.0	1,715	0.99	40.0
			1/7/2009	1.1	29,916	2.56	103.5
			5/5/2009	0.1	549	0.79	11.0
			5/19/2009	0.5	4,084	1.33	25.0
			9/29/2009	0.1	1,643	0.29	20.7
			10/16/2009	14.1	21,075	2.31	94.1
			11/6/2009	0.1	109	0.81	16.5
			11/26/2009	0.1	561	1.17	12.1
King County Combined Sewer Overflow Locations and Events							
014	West of Montlake Cut Bascule Bridge	Portage Bay/Montlake Cut	8/24/2008	0.92	407,251		
			Sep-05	Unknown	>1.55 Mgal		
			Oct-05				
			2004-2005	7 Events	37.87 Mgal		
015	Portage Bay Shoreline/University Hospital Area/South of San Juan Road	Portage Bay	6/3/2008	1.07	3,959,649		
			8/24/2008	0.28	288432		
			11/4/2008	1.07	2300159		
			2007-2008	2 Events	191.6 Mgal		
			2006-2007	4 Events	62.67 Mgal		
			2005-2006	3 Events	49.28 Mgal		

SEA A

Stormwater from TDA 3 discharges to the City of Seattle CSS at discharge point SEA A (Exhibit J-7). TDA 3 includes Boylston Avenue East and a small segment of East Roanoke Street west of the intersection of the two streets. TDA 3 consists of 0.66 acre of PGIS in a total area of 0.77 acre (Exhibit J-8). If the system overflows, the CSO discharges to Lake Union through a 30 inch outfall pipe at the terminus of East Roanoke Street.

SEA B

Stormwater from TDA 4 discharges to the City of Seattle CSS at discharge point SEA B (see Exhibit J-7). TDA 4 consists of 0.12 acre of PGIS in a total area of 0.35 acre (see Exhibit J-8). TDA 4 includes the stormwater lift station that exists within this TDA just south of the East Roanoke overcrossing, and it pumps stormwater into the CSS. If the system overflows, the CSO discharges to Lake Union through the 30 inch outfall pipe at the terminus of East Roanoke Street.

SEA C

Stormwater from TDAs 6A and 6B discharge to the City of Seattle CSS at discharge point SEA C (see Exhibit J-7). TDA 6A includes the 10th Avenue East roadway south of its intersection with East Roanoke Street and has 0.08 acre of PGIS in a total area of 0.12 acre (see Exhibit J-8). TDA 6B includes East Roanoke Street between Delmar Drive East and Broadway East and it has 0.50 acre of PGIS in a total area of 0.79 acre. If the system overflows, the CSO discharges to Lake Union through the 30 inch outfall pipe at the terminus of East Roanoke Street.

SEA D

Stormwater from TDA 7A discharges to the City of Seattle CSS at two separate discharge points: SEA D (see Exhibit J-7) and SEA F (Exhibit J-9). TDA 7A consists of 0.34 acre of total area, but no PGIS stormwater is collected within the TDA (see Exhibit J-8). This TDA includes the area where East Roanoke Street turns into Delmar Drive East. If the system overflows, the CSO discharges to Portage Bay through the 15 inch outfall pipe at the west edge of the Montlake Playground.

SEA F

Stormwater from TDAs 7A through 7E discharges at discharge point SEA F. The area of these TDAs includes the neighborhood surface streets north and south of SR 520 as it approaches the Portage Bay Bridge. These TDAs have a combined area of 2.256 acres, with a 0.904 acre of PGIS (see Exhibit J-8). If the system overflows, the CSO discharges to Portage Bay through the 15 inch outfall pipe at the terminus of East Shelby Street.

SEA E

Stormwater from TDAs 8A, 8B, and 8C discharge to the City of Seattle CSS at discharge point SEA E (see Exhibit J-7). TDA 8A consists of the area south of where Delmar Drive East passes over SR 520 and includes 0.16 acre of PGIS in a total area of 0.34 acre (see Exhibit J-8).

TDA 8B consists of a small portion of 11th Avenue East just past the school parking lot. TDA 8C consists of Delmar Drive East from 11th Avenue East to East Interlaken Boulevard. If the system overflows, the CSO discharges to Lake Union through the 15 inch outfall pipe at the west edge of the Montlake Playground.

SEA G

Stormwater from TDA 13 discharges to the City of Seattle CSS at discharge point SEA G (see Exhibit J-9). TDA 13 includes an area in the WSDOT right-of-way north of the westbound on ramp to SR 520 between Portage Bay and Montlake Boulevard East, and it consists of 0.18 acre of PGIS in a total area of 1.33 acres (see Exhibit J-8). If the system overflows, the CSO discharges to Portage Bay through the 15 inch outfall pipe at the west edge of the Montlake Playground.

SEA H

Stormwater from TDAs 12A and 12B discharges to the City of Seattle CSS at discharge point SEA H (Exhibit J-9). These TDAs have a combined area of 3.271 acres, with 2.588 acres of PGIS (see Exhibit J-8). TDA 12A includes the City of Seattle and WSDOT right-of-ways along 24th Avenue East from the intersection at East McGraw Street north to the Montlake Boulevard interchange with SR 520. TDA 12B consists of the private property of the Hop In Grocery and Northwest Automotive. If the system overflows, the CSO discharges to the Montlake Cut through the 60 inch outfall pipe located just west of the Montlake Bridge.

SEA H and SEA K

Stormwater from TDA 14 discharges to the City of Seattle CSS at two discharge points: SEA H and SEA K (see Exhibit J-9). The TDA includes the City of Seattle street right-of-way for the southbound lanes of Montlake Boulevard East from East Hamlin Street to the south approach to the Montlake Bridge. Discharge point SEA H is located at East Hamlin Street and discharge point SEA K is located at East Shelby Street. If the system overflows, the CSO discharges to Portage Bay through the 18 inch outfall pipe located at the southwest shoreline of the Montlake Cut (see Exhibit J-9).

SEA I and SEA J

Stormwater from TDA 15 discharges to the City of Seattle CSS at two discharge points: SEA I and SEA J (see Exhibit J-9). The TDA includes the City of Seattle street right-of-way for the northbound lanes of Montlake Boulevard East from East Hamlin Street to the south approach to the Montlake Bridge. Discharge point SEA I is located at East Hamlin Street and discharge point SEA J is located at East Shelby Street. If the system overflows, the CSO discharges to Union Bay through the 21 inch outfall pipe located at the southeast shoreline of the Montlake Cut (see Exhibit J-9).

COS M and COS N

Stormwater from TDA 19 discharges to the City of Seattle CSS at two discharge points: COS M and COS N (see Exhibit J-3). The TDA includes the entire street right-of-way for Montlake Boulevard NE from the north approach to the Montlake Bridge to the intersection at Northeast Pacific Street. Discharge point COS M is located in the southbound lanes of Montlake Boulevard NE and discharge point COS N is located in the northbound lanes of Montlake Boulevard NE. If the system overflows, the CSO discharges to Portage Bay through the 84 inch outfall pipe located at the northwest shoreline of the Montlake Cut near the University of Washington Oceanography Storage building (see Exhibit J-9).

N

0 500
Scale in Feet

Project Limit Discharge Point
- SEA-A (TDA 3)
- SEA-B (TDA 4)
- SEA-C (TDA 6)
- SEA-D1 / SEA-D2 (TDA 7)
- SEA-E (TDA 8)

Combined Sewer System Overflow Location
- SEA-CS0#132 30" Overflow
- SEA-CS0#138 15" Overflow

- TDA boundary directed to Surface Water Outfall
- TDA boundary extending into adjacent sheets

NOTE: TDAs ARE DELINEATED BASED ON PROPOSED RIGHT-OF-WAY LIMITS

Exhibit J-7
Existing Condition TDA Delineation
Combined Sewer System Outfalls

SR520, I-5 to Medina:
Bridge Replacement and HOV Project

EXHIBIT J-8.
EXISTING CONDITION TDAS DISCHARGING TO COMBINED SEWER SYSTEMS

PROJECT LIMIT DISCHARGE POINT	COMBINED SEWER OVERFLOW RECEIVING WATER BODY	CONTRIBUTING TDAs	TOTAL TDA AREA (acres)	EXISTING PGIS (acres)
SEA-A	Lake Union	TDA 3	0.77	0.66
SEA-B	Lake Union	TDA 4	0.35	0.12
SEA-C	Lake Union	TDA 6A TDA 6B	0.91	0.58
SEA-D	Portage Bay	TDA 7	2.95	0.33
SEA-E	Portage Bay	TDA 8	0.55	0.30
SEA-G	Portage Bay	TDA 13	1.33	0.18
SEA-H	Montlake Cut	TDA 12	1.27	1.10
SEA-I and J	Union Bay	TDA 15	1.09	0.59
SEA-K and H	Portage Bay	TDA 14	0.92	0.58
COS-M and COS-N	Portage Bay	TDA 19	1.48	0.79
		Existing Project Totals	**11.62**	**5.24**

COS = City of Seattle

N

0 500

Scale in Feet

Project Limit Discharge Point

- SEA-G (TDA 12)
- SEA-F (TDA 13)
- SEA-I & SEA-J (TDA 14)
- SEA-H & SEA-K (TDA 15)
- SEA-L1 & SEA-L2 (TDA 19)

Combined Sewer System Overflow Location

- SEA-CS0#140 18" Overflow
- SEA-CS0#139 15" Overflow
- KC-CSO#014 60" Overflow
- SEA-CS0#020 21" Overflow
- KC-CS0#015 84" Overflow

- TDA boundary directed to Surface Water Outfall
- TDA boundary extending into adjacent sheets

NOTE: TDAs ARE DELINEATED BASED ON PROPOSED RIGHT-OF-WAY LIMITS

Exhibit J-9
Existing Condition TDA Delineation
Combined Sewer System Outfalls

SR 520, I-5 to Medina:
Bridge Replacement and HOV Project

Stormwater Design Criteria

Stormwater contributing to the combined stormwater and sewer discharge locations will be treated when the CSS flow reaches the West Point Treatment Plant. The following discussion focuses on only the stormwater discharge locations.

The SR 520, I-5 to Medina project will result in 45.20 acres of new PGIS and replace 29.21 acres of existing PGIS, while 16.64 acres of existing PGIS will remain onsite. Total post-project PGIS will be 91.05 acres (see Exhibits J-10 and J-11). All project stormwater will be treated by facilities that will be designed based on requirements from the WSDOT 2008 Highway Runoff Manual (HRM) and the WSDOT Hydraulics Manual. Based on these manuals, all new and replaced PGIS requires stormwater treatment. Overall, the project will provide surface water quality treatment for a total of 43.27 acres of PGIS. The bridge (20.56 acres) is a special case that will receive stormwater treatment equivalent to basic water quality as determined by the all known, available, and reasonable technology (AKART) study completed by WSDOT (WSDOT 2010). An additional 5.51 acres of PGIS will receive treatment at the West Point Treatment Plant. The remainder of PGIS within the project right-of-way (13.91 acres) consists of existing PGIS that will not be affected by the project. According to the HRM, water quality treatment is not required for existing PGIS that is not affected by the project. The local streets that are within the project limits will meet the requirements of the local jurisdiction (City of Seattle) as stated in the Memorandum of Agreement between WSDOT and the City.

The HRM has nine minimum requirements, which depending on the amount of new impervious surface to be added to the project area, may or may not be applicable to a WSDOT project. The minimum requirements are numbered according to the order in which they are to be addressed by the HRM: 1) Stormwater Planning, 2) Construction Stormwater Pollution Prevention, 3) Source Control of Pollutants, 4) Maintaining the Natural Drainage System, 5) Runoff Treatment, 6) Flow Control, 7) Wetlands Protection, 8) Incorporating Watershed/Basin Planning Into Stormwater Management, and 9) Operation and Maintenance. All nine minimum requirements apply to this project because the project will result in more than 2,000 square feet of new impervious surface. Also, the HRM states that the nine minimum requirements apply to projects where the new and replaced PGIS equals more than 50 percent of the existing surfaces within the project limits. Minimum Requirements 1 through 4 apply to the new and replaced impervious surfaces and disturbed land. Minimum Requirements 6 through 9 apply to the new impervious surfaces, converted pervious surfaces, and replaced impervious surfaces. Minimum Requirement 5 applies to the new and replaced PGIS.

WSDOT site investigations have provided data for conducting the preliminary stormwater designs for the project area. The existing stormwater design will meet HRM Minimum Requirements 1, 3, 4, 5, 6, 7, and 8 for the final developed condition. However, Minimum Requirement 2 (Construction Stormwater Pollution Prevention) and Minimum Requirement 9 (Operation and Maintenance) are not addressed by the current design plan, because these design elements will be completed by the design builder or by the WSDOT GEC team as the design progresses to 90 percent. The specific design criteria for stormwater treatment and detention facilities are discussed in greater detail below.

As noted previously, comparisons of existing conditions to future conditions will use the drainage configuration of the future conditions for calculations of existing and future PGIS and subsequent analyses of stormwater loads and concentrations. Exhibit J-10 displays the proposed PGIS for each TDA and each surface water outfall location within the project action area, while Exhibits J-12 through J-17 show the contributing areas to each outfall location. Exhibit J-11 displays the proposed PGIS for each TDA at each CSS discharge point and the corresponding CSO outfall locations and Exhibits 15 and 16 show the contributing areas to each discharge point and corresponding CSO.

EXHIBIT J-10.
EXISTING AND PROPOSED POLLUTANT-GENERATING IMPERVIOUS SURFACE BY OUTFALL

Outfall (Roadway Segment)	Receiving Water Body	Existing PGIS (acres)	Proposed Existing PGIS to Remain (acres)	Proposed New and Replaced PGIS (acres)	Total Proposed PGIS (acres)	Proposed Water Quality Treatment (acres)
East Garfield Street (I-5 Interchange)	Lake Union	2.45	2.45	0	2.45	0
East Allison Street (I-5 Interchange)	Lake Union	14.25	10.30	4.00	14.30	4.00
WS-C (SR 520, I-5 to Portage Bay Bridge)	Portage Bay (Lake Union)	3.34	0.05	5.42	2.94 (5.47) [a]	2.94
WS-D (Portage Bay Bridge)	Portage Bay (Lake Union)	6.47	0.36	8.70	9.06	8.70
WS-BR2 (Montlake Bascule Bridges)	Montlake Cut (Lake Washington)	0.19	0.14	0.13	0.27	0
RWB-C/RWB-D (Local Street – Montlake Blvd)	Union Bay (Lake Washington)	0.02	0.04	0.10	0.14	0.14
Union Bay (Local Street – Lake Washington Blvd)	Union Bay (Lake Washington)	1.28	0.09	0.04	0.13	0
RWB-F (Local Street – Lake Washington Blvd)	Union Bay (Lake Washington)	0.61	0.30	0.06	0.36	0
WS-PR (SR 520, Montlake to West Approach)	Union Bay (Lake Washington)	12.60	0.34	26.24	21.31 (26.58) [b]	21.31
WS-BR4 (Floating Bridge)	Lake Washington	17.28	0	20.56	20.56	20.56
WS-G (East Approach)	Lake Washington	1.75	0.08	1.62	1.70	1.70

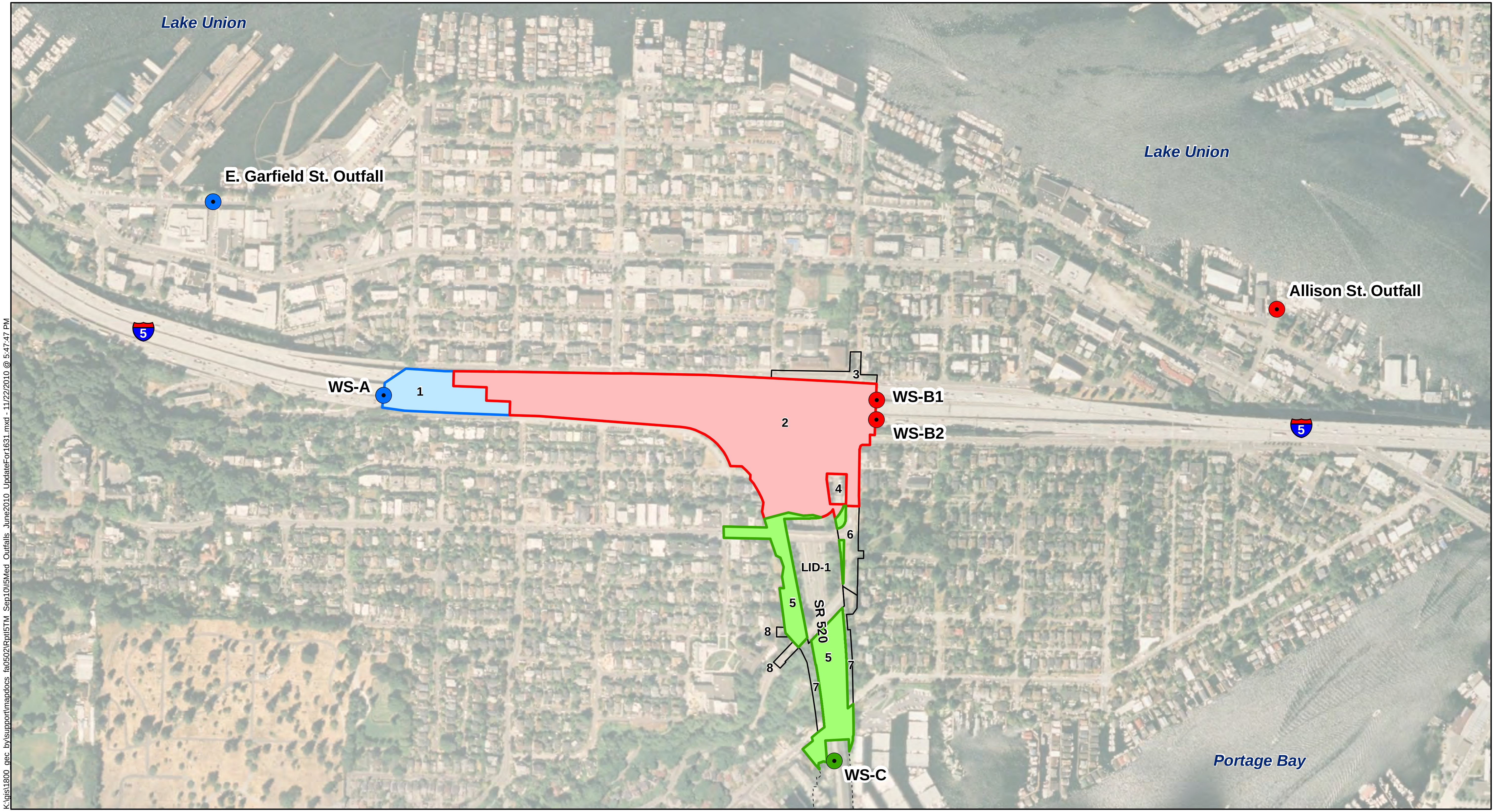
EXHIBIT J-10.
EXISTING AND PROPOSED POLLUTANT-GENERATING IMPERVIOUS SURFACE BY OUTFALL

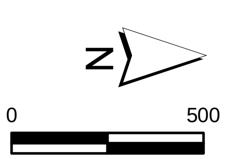
Outfall (Roadway Segment)	Receiving Water Body	Existing PGIS (acres)	Proposed Existing PGIS to Remain (acres)	Proposed New and Replaced PGIS (acres)	Total Proposed PGIS (acres)	Proposed Water Quality Treatment (acres)
WS-J (SR 520, Evergreen Point Road to 84th Avenue)	Fairweather Bay (Lake Washington)	5.42	0.01	4.47	4.48	4.48
RWB-G (Local Street – Evergreen Point Road)	Fairweather Bay (Lake Washington)	0.16	.04	0	0.04	0
Combined Sewer System (Local Streets – Montlake Boulevard and 10th Avenue East and Delmar Street vicinity)	Puget Sound	5.24	2.44	3.07	5.51	5.51
	Total	**71.06**			**83.25 (91.05)[a, b]**	**69.34**

PGIS = pollutant-generating impervious surface
RWB = receiving water basin
WS = Washington state Department of Transportation
[a] The 10th and Delmar lid reduces effective PGIS by 2.53 acres, from 5.47 to 2.94 acres total requiring water quality treatment.
[b] The Montlake lid reduces effective PGIS by 5.27 acres, from 26.58 to 21.31 acres total requiring water quality treatment.

EXHIBIT J-11.
PROPOSED CONDITIONS OF TDAS DISCHARGING TO COMBINED SEWER SYSTEMS AND THE WEST POINT TREATMENT PLANT

CSO Discharge Point	Project Limit Discharge Point	TDA	Existing Total TDA Area (acres)	Proposed Total TDA Area	Existing-PGIS (acres)	Replaced PGIS (acres)	New PGIS (acres)	Total Proposed PGIS (acres)
SEA CSO#132	SEA-A	TDA 3	0.77	0.77	0.66	0	0.00	0.66
	SEA-B	TDA 4	0.35	0.35	0.12	0.02	0.00	0.12
	SEA-C	TDA 6	0.91	0.84	0.58	0.40	0.08	0.58
SEA CSO#0138	SEA-D1 and D2	TDA 7	2.95	1.81	0.33	0.13	0.00	0.29
SEA CSO#0139	SEA-E	TDA 8	0.55	0.5	0.30	0.08	0.00	0.28
KC-CSO#014	SEA G	TDA 12	1.27	1.27	1.10	0.66	0.05	1.13
	SEA-F	TDA 13	1.33	1.33	0.18	0.02	0.06	0.23
SEA CSO0140	SEA-I and SEA-J	TDA 14	0.92	0.92	0.58	0.39	0.06	0.64
SEA CSO#020	SEAH and SEA-K	TDA 15	1.09	1.09	0.59	0.41	0.10	0.63
KC CSO#015	SEA-L1 and SEA-L2	TDA 19	1.48	1.48	0.79	0.46	0.18	0.95
		Proposed Project Totals	**11.62**	**10.36**	**5.24**	**2.57**	**0.50**	**5.51**



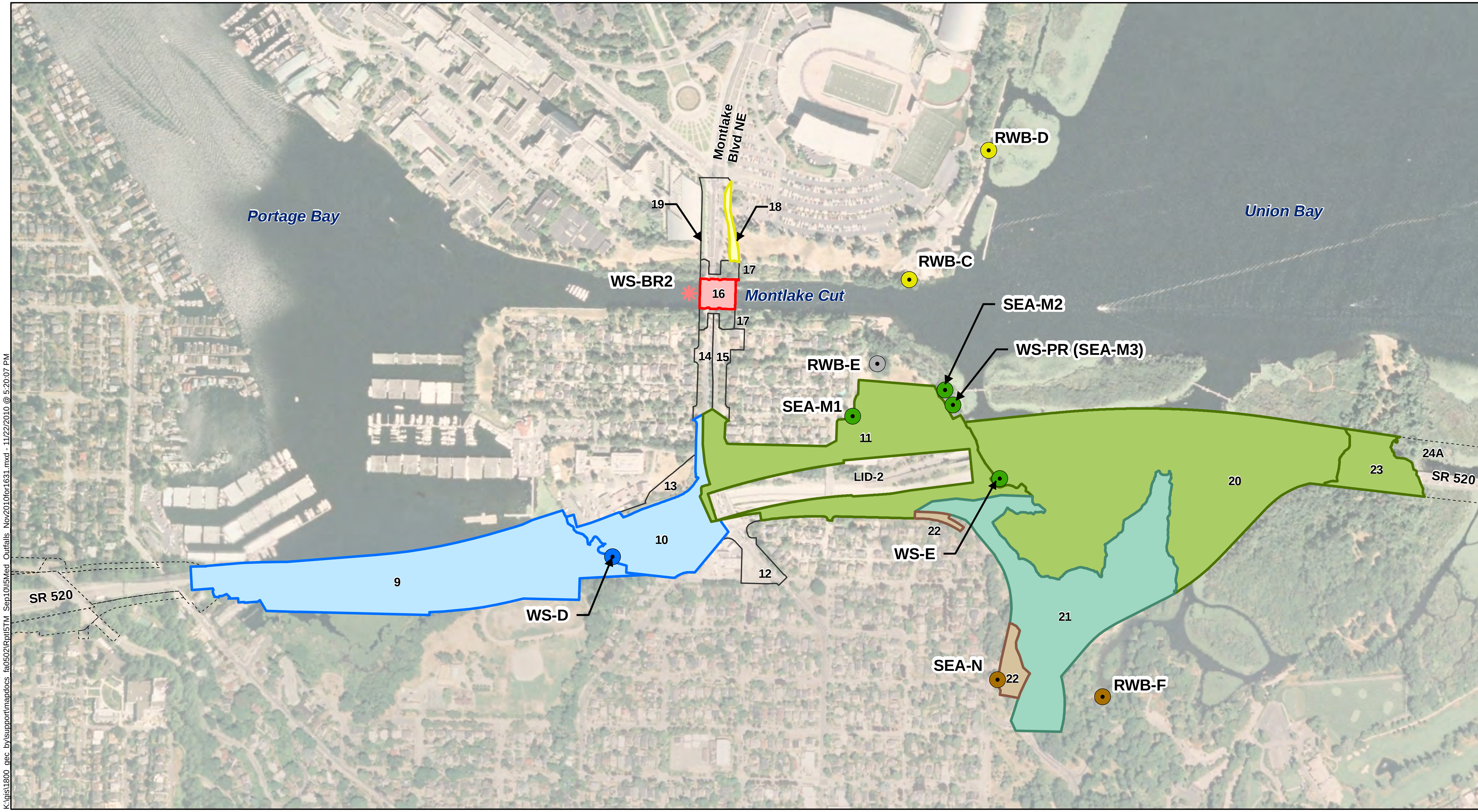


Surface Water Outfall

- E. Garfield St. Outfall / WS-A (TDA 1)
- Allison St. Outfall / WS-B1 / WS-B2 (TDA 2)
- WS-C (TDA 5)
- TDA boundary directed to Combined Sewer System Outfall
- TDA boundary extending into adjacent sheets

Exhibit J-12
Proposed Condition TDA Outfalls, Surface Water Outfalls, and Point of Connections

SR 520, I-5 to Medina:
Bridge Replacement and HOV Project



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N

0 500
Scale in Feet

Surface Water Outfall

- WS-D (TDAs 9 & 10)
- WS-PR (TDAs 11, 20, 23 & 24A)
- WS-BR2 (TDA 16)
- RWB-C / RWB-D (TDA 18)
- SEA-N / RWB-F (TDA 22)
- RWB-E (Unused)
- WS-E / SEA-M1 / SEA-M2
- TDA boundary directed to Surface Water Outfall
- TDA Boundary extending into adjacent sheets

Exhibit J-13
Proposed Condition TDA Outfalls, Surface Water Outfalls, and Point of Connections

SR 520, I-5 to Medina:
Bridge Replacement and HOV Project

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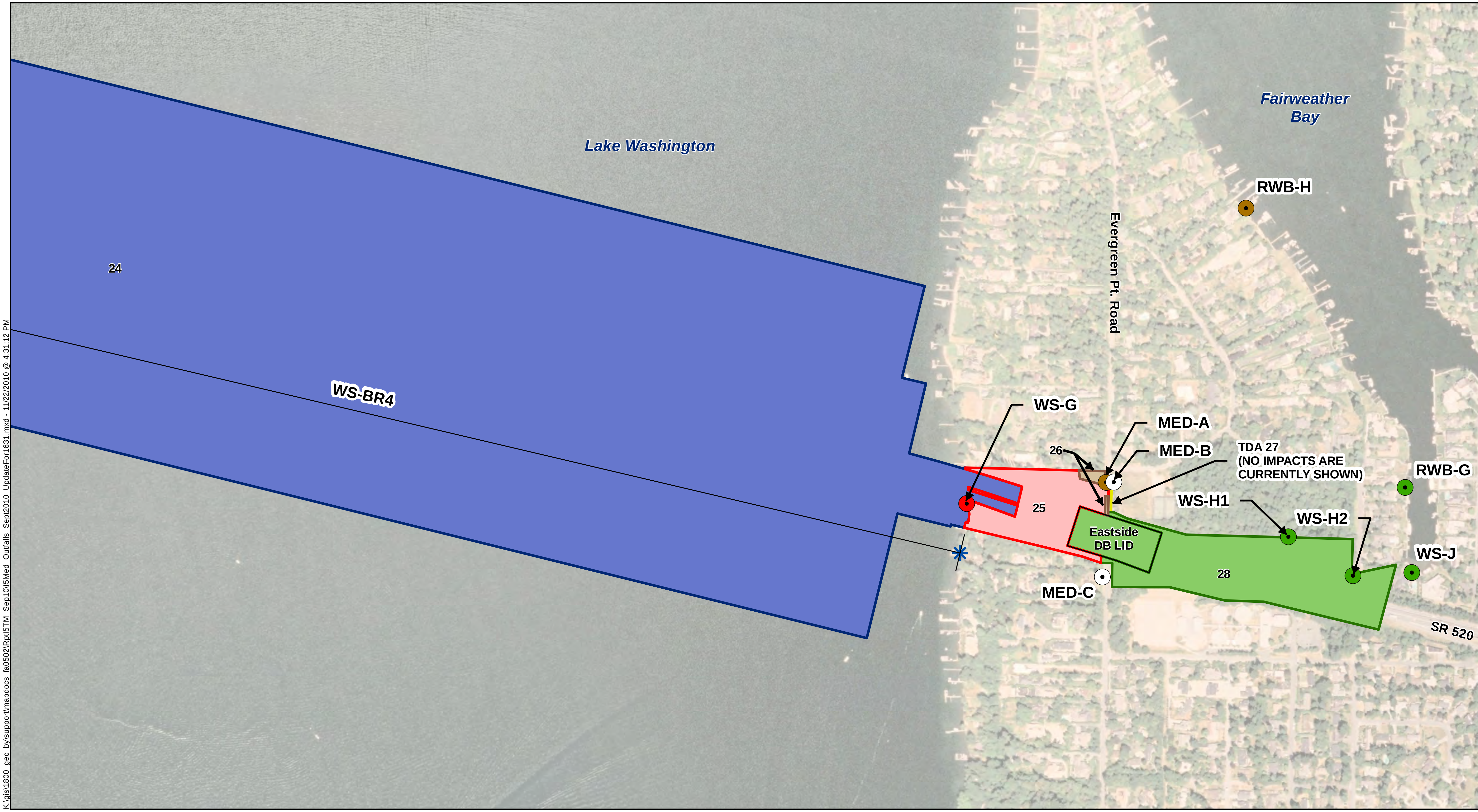
Exhibit J-14
Proposed Condition TDA Outfalls, Surface Water Outfalls, and Point of Connections

SR 520, I-5 to Medina: Bridge Replacement and HOV Project



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N

0 500

Scale in Feet

Surface Water Outfall

- WS-BR4 (bridge) (TDA 24)
- WS-G (TDA 25)
- MED-A (TDA 26)
- MED-B (TDA 26)
- MED-C (unused)
- RWB-H (TDA 26)
- RWB-G (TDA 27)
- WS-H / WS-I / WS-J (TDA 28)
- TDA boundary directed to Combined Sewer System Outfall

Exhibit J-15
Proposed Condition TDA Outfalls, Surface Water Outfalls, and Point of Connections

SR 520, I-5 to Medina:
Bridge Replacement and HOV Project

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N

0 500

Scale in Feet

Project Limit Discharge Point

- SEA-A (TDA 3)
- SEA-B (TDA 4)
- SEA-C (TDA 6)
- SEA-D1 / SEA-D2 (TDA 7)
- SEA-E (TDA 8)

Combined Sewer System Overflow Location

- SEA-CS0#132 30" Overflow (TDAs 3, 4 & 6)
- SEA-CS0#138 15" Overflow (TDA 7)

- TDA Boundary directed to Surface Water Outfall
- TDA Boundary extending into adjacent sheets

Exhibit J-16
Proposed Condition TDA Combined Sewer System Points of Connection

SR 520, I-5 to Medina:
Bridge Replacement and HOV Project

N

0 500
Scale in Feet

Project Limit Discharge Point

- SEA-G (TDA 12)
- SEA-F (TDA 13)
- SEA-I & SEA-J (TDA 14)
- SEA-H & SEA-K (TDA 15)
- SEA-L1 & SEA-L2 (TDA 19)

Combined Sewer System Overflow Location

- KC-CSO#014 60" Overflow (TDA 12 & 13)
- SEA-CS0#140 18" Overflow (TDAs 14 & 17)
- SEA-CS0#020 21" Overflow (TDAs 15 & 17)
- KC-CS0#015 84" Overflow (TDAs 17 & 19)
- SEA-CS0#139 15" Overflow

- TDA boundary directed to Surface Water Outfall
- TDA boundary extending into adjacent sheets

Exhibit J-17
Proposed Condition TDA Combined Sewer System Points of Connection

SR 520, I-5 to Medina:
Bridge Replacement and HOV Project

Stormwater Runoff Treatment Design

The project area does not include any onsite stormwater treatment for runoff contributing to the surface water outfalls or the City of Seattle CSS. According to Minimum Requirement 5, the proposed project must provide water quality treatment according to the receiving water body. All proposed PGIS (new and replaced) draining to surface water outfalls in the project area will ultimately discharge to a Basic Treatment receiving water body (as classified in both the HRM and by Washington State Department of Ecology's Stormwater Management Manual). In addition, some areas of existing PGIS located within the project area will not be altered (improved) by the project. These existing PGIS areas that will remain will not receive water quality treatment because the proposed project will not be affecting these surfaces. Lake Union, Portage Bay, Union Bay, and Lake Washington have all been classified as Basic Treatment receiving water bodies, which establishes a minimum water quality treatment for all proposed project PGIS. However, while enhanced treatment is not required, the project team has provided enhanced treatment to all areas, as practicable, in order to improve water quality and reduce impacts to ESA-listed species and other aquatic life. When insufficient space is available to provide enhanced treatment for a specific TDA, basic treatment will be included in the stormwater treatment design. For this project, stormwater wetlands are the enhanced treatment BMP of choice, and bioswales will be the BMPs used for basic treatment. Oil control will be provided for roadway intersections with an average daily traffic count greater than or equal to 15,000 vehicles, as prescribed by the HRM.

Stormwater entering the CSS will be initially untreated because it will be combined with sewage that is directed to the West Point Treatment Plant, where it will be treated and discharged to Puget Sound. During a CSO event, the combined stormwater and wastewater will discharge to Lake Union, Portage Bay, Union Bay, or Lake Washington. Under existing conditions, stormwater is anticipated to comprise approximately 75 percent of the entire flow in the CSS. Proposed flow control BMPs, discussed in the following section, should provide an environmental benefit to the receiving environments by reducing the number of uncontrolled CSO events.

Stormwater Flow Control Design

Lake Union and Lake Washington are flow control exempt water bodies; therefore, no flow control will be provided for any surface water TDAs in the project area. Runoff from surface water TDAs will not be detained and will be directly discharged to the receiving water following water quality treatment.

TDAs contributing stormwater to the CSS may require flow control depending on the capacity of the system subsections receiving project stormwater. By adding detention, it is expected that stormwater from the project area will be less likely to discharge to the CSS when the CSS pipes are at or above capacity. However, due to complexities of the CSS and the limited influence of the project area on overall CSS function, the project is not expected to measurably reduce the frequency or volume of CSO discharge events. It has not yet been determined if flow control facilities will be designed for the six remaining CSS discharge points (see Exhibit 14). It will be determined at a later date whether flow control would be necessary or feasible within the project action area. The TDAs that are now contributing to surface water systems will be treated before direct discharge to the receiving water.

Based on the water quality concerns within the CSS, any proposed flow control facilities will be constructed to accommodate flows according to the City of Seattle CSO discharge requirements (Seattle Municipal Code 22.805.080.B.4 Peak Control Standard) where the total new plus replaced impervious surface exceeds 10,000 square feet.

If flow control facilities are incorporated into the overall design, then it will be assumed that the project's predeveloped conditions will be forested till or outwash depending on the soil conditions identified from the Natural Resources Conservation Service (NRCS) soil maps for the project area.

Stormwater Conveyance

The conveyance systems have been designed in compliance with the requirements of the WSDOT Hydraulics Manual. Design storms used for the different hydraulic structures are listed in Exhibit J-18.

EXHIBIT J-18.
DESIGN STORMS FOR STORMWATER FACILITY STRUCTURES

Storm Event (years)	Hydraulic Structure
25	Standard culverts – design for HW/D ratio
25	Storm drain trunk lines
10	Storm drain laterals
50	Storm drain inlets – vertical curve sag
10	Storm inlets and gutters
10	Ditches
2	Temporary conveyance

Proposed Stormwater Treatment and Detention Facilities

Water Quality Treatment Facilities

Seven water quality treatment facilities have been proposed for the SR 520, I-5 to Medina project (Exhibit J-19). Included in the seven is the floating bridge (WS-BR4), which will receive water quality treatment as outlined in the WSDOT AKART study and described below. Six outfalls (WS-BR1, WS-E, Union Bay, RWB-C, WS-BR3, and WS-F) will not be receiving stormwater from impervious surface associated with the project (stormwater from the TDAs that contributed to these outfalls have been rerouted to other outfall locations) or from the proposed treatment facilities. Therefore, they will not require further analysis. Additionally, five outfalls (East Garfield Street, WS-BR2, COS-M, RWB-F, and RWB-G) are exempt from water quality treatment because the proposed design either does not contribute any new or replaced PGIS or does not exceed the 5,000-square-foot threshold for new and replaced PGIS.

EXHIBIT J-19.
WATER QUALITY TREATMENT FACILITIES

Discharge Point	Receiving Water	Treatment Type	Facility Type	PGIS Treated (acres)
East Allison Street Outfall	Lake Union	Basic	Bioswale	4.00
WS-C	Portage Bay	Basic	Bioswale	2.94
WS-D	Portage Bay	Enhanced	Constructed Stormwater Wetland	8.70
WS-PR	Union Bay	Enhanced	Constructed Stormwater Wetland	21.31
WS-BR4	Lake Washington	AKART	High-Efficiency Sweeping and Modified Catch Basin/Cleaning	20.56
WS-G	Lake Washington	Basic	Bioswale	1.70
WS-J	Fairweather Bay	Enhanced	Constructed Stormwater Wetland	5.51

WS = WSDOT

The stormwater facilities will provide either basic or enhanced treatment, depending on available space and feasibility for implementation within individual TDAs. The discharge points have been used in lieu of water quality BMP facilities because, although the type of treatment is known for most outfalls, the facilities have not been sized yet. See Exhibits J-12 through J-17 for the discharge locations for stormwater runoff after passing through the water quality treatment facilities. Details on the water quality treatment facilities with respect to individual discharge points are presented below.

East Garfield Street Outfall

Proposed work in TDA 1 does not include the addition of new PGIS because the only project action affecting this TDA is new lane striping. Therefore, water quality treatment is not required for this TDA.

East Allison Street Outfall

Runoff from TDAs 2A and 2B within the I 5 to SR 520 interchange will receive basic treatment in a bioswale and discharge to Lake Union at the East Allison Street outfall (see Exhibit J-12). The outfall will remain and the pipe size will not need to be increased because runoff from TDAs 2C and 2B will be collected and conveyed to the WS C outfall system. Physical constraints within the area and along the tightline conveyance system to the outfall do not provide sufficient area to implement enhanced treatment with constructed wetlands. Therefore, a bioswale will be provided to meet basic water quality treatment prior to discharge to Lake Union.

WS C

Runoff in the project corridor from the 10th Avenue East overpass to the west approach to the Portage Bay Bridge will receive basic treatment in a bioswale before discharge to Portage Bay at the WS C outfall. This outfall will receive more stormwater than the existing conditions due to widening of SR 520, requiring a larger outfall pipe. This enlarged outfall pipe will be necessary because of adding TDAs 2C and 2D from the East Allison Street outfall and TDAs 6A, 7B, 7C, 7D, and 8A from the CSS (see Exhibit J-12). Physical constraints within the TDA and along the conveyance system and outfall route do not provide sufficient area to implement enhanced treatment with constructed wetlands. Therefore, a bioswale will be provided to meet basic treatment requirements prior to discharge to Portage Bay.

WS D

Runoff within the project area from the west approach to the Portage Bay Bridge, and the interchange at Montlake Boulevard East, will receive enhanced treatment in a constructed stormwater wetland, which will discharge to Portage Bay at the WS D outfall. The area contributing to this outfall will increase to include a portion of the existing TDA 5A at the west end of the Portage Bay Bridge approach (TDA 5a), along with TDA 9 (Portage Bay Bridge), TDA 13 from the existing CSS, and the Montlake interchange (TDA 10). Although only basic treatment is required by the HRM, WSDOT will provide enhanced treatment because there is enough space to place a constructed stormwater wetland in the area west of the SR 520 eastbound loop on ramp.

WS BR2

Runoff from the north and south approaches and the spans of both the existing and the proposed Montlake bascule bridges will be collected and discharged directly into the Montlake Cut at the WS BR2 outfall (see Exhibit J-13). The contributing area from TDA 16 includes the metal grates, which serve as the travelling surface for both the existing and proposed bascule bridges. The new bascule bridge will be constructed to the east of the existing Montlake Bridge. Stormwater will fall onto the metal grates, continue through the gaps, and fall into the Montlake Cut. Runoff will not be collected and is not considered PGIS because it does not come into contact with the road. The contributing area of TDAs 17A through 17D consists mostly of the same area as the existing condition with an addition of 1,220 square feet (0.028 acre) of new PGIS. Because this amount of PGIS is below the HRM threshold of 5,000 square feet, this area does not require water quality treatment.

WS-PR

Runoff from the south approach to the Montlake Bridge all the way to the high point in the western highrise of the west approach to the floating bridge will receive enhanced treatment in a constructed stormwater wetland and discharge to Union Bay at the WS-PR outfall locations (see

Exhibit J-13). The contributing area increases greatly due to the grade of the corridor and the limited space for stormwater treatment facilities. This large contributing area will consist of TDAs 14 and 15 from the CSS on Montlake Boulevard East; TDAs 11A and 11B from the Montlake interchange to the WS E outfall at the Union Bay shoreline; TDA 11E, which is the existing MOHAI area to be demolished and relocated to accommodate the large constructed stormwater wetland; TDA 20, which is the existing bridge outfall (WS BR3) from the Union Bay west shoreline to Foster Island; TDA 23, which is the Foster Island section comprising the four outfalls of WS F; and the new TDA 24 (see Exhibit J-14), which is the highrise from Foster Island to the high point before the roadway grade decreases to the floating bridge. Stormwater will be collected in a new tightline conveyance system that will route the runoff to the existing MOHAI property. The existing MOHAI property (TDA 11E) has been purchased by WSDOT to provide space for a constructed stormwater wetland that will provide enhanced treatment for this large portion of the project area.

Union Bay

The proposed project will remove portions of the westbound off ramp from SR 520 to Lake Washington Boulevard, portions of the eastbound on ramp from Lake Washington Boulevard to SR 520, and the unused portions of on ramp and off ramps within this area. Water quality treatment will not be required because there will be no new PGIS. Stormwater in this area will directly drain to the land below the old on- and off-ramps. Stormwater on the land sheet flows directly to Union Bay; therefore, no discharge location is shown on Exhibit J-13.

RWB-F

The proposed project will remove the Lake Washington Boulevard on ramp and off ramp in this TDA, resulting in no new PGIS, and no requirement for water quality treatment. Stormwater in this area will directly drain to the land below the bridge and the Arboretum sewer trestle and will continue to flow as in existing conditions and discharge into Union Bay at discharge point RWB-F (see Exhibit J-13).

WS BR4 (Floating Bridge)

Runoff from the entire floating bridge span, from the western highrise to the east approach, will be collected by catch basins and treated by an unknown water quality treatment method before being discharged directly into Lake Washington. The contributing areas to the WS BR4 discharge location are TDA 24 (Exhibits J-13 and J-14), which has been reduced in size from the existing condition, and a portion of TDA 25 (Exhibit J-13). WSDOT has committed to developing a suitable water quality treatment BMP for the floating bridge that will achieve a minimum of basic treatment. WSDOT conducted an AKART study (WSDOT 2010) to determine or develop an effective BMP for water quality treatment and long term BMP maintenance requirements. The AKART study selected Alternative 4: High-Efficiency Sweeping and Modified Catch Basin/Cleaning as the technology preferred for the floating bridge. The technology provides high-efficiency sweeping, which consists of high-pressure air circulation and vacuuming of pollutants from the bridge road surface into a sweeping vehicle. The sweeping will prevent pollutants from entering the drainage systems and the receiving water. Stormwater from the proposed bridge will be collected by catch basins that are larger than the standard size and will therefore have an increased capability to trap sediments. Sumps will also be larger than standard to provide increased residence time for sediments to collect prior to removal. Removal will occur during scheduled cleaning of the trapped pollutants.

WS G

Runoff from SR 520 within this TDA will receive basic treatment in the same bioswale as in the existing condition and continue to discharge to Lake Washington at outfall location WS G (Exhibit J-15). The proposed bioswale will be improved from the existing conditions and will treat all 2.49 acres of PGIS contributing to the WS-G outfall. Physical constraints at the outfall do not provide sufficient area to implement enhanced treatment with constructed wetlands. The contributing areas to the WS G discharge point are TDA 25, which is smaller because some area was lost to the floating bridge outfall, and TDA 26C, which was a portion of the Evergreen Point Road right-of-way and discharge point RWB G flow that will be collected in the WS G conveyance system.

RWB F

Proposed work in TDA 27 does not include the addition of new PGIS; therefore, water quality treatment is not required for this TDA. Stormwater from TDA 27 is collected in a tightline conveyance system that discharges to Fairweather Bay at the RWB F outfall (see Exhibit J-13).

RWB G

Proposed work in TDA 26B does not include adding new PGIS and there is no work proposed in TDA 26D; therefore, water quality treatment is not required. Stormwater from these TDAs is collected in a tightline conveyance system that discharges to Fairweather Bay at the RWB G outfall (see Exhibit J-15).

WS-J

Runoff for the main line of SR 520 from Evergreen Point Road to the east end of the SR 520, I-5 to Medina project area will continue to receive enhanced treatment in the constructed stormwater wetlands. The wetland referred to as Facility J will receive an additional 1 acre of PGIS from the SR 520, I-5 to Medina project improvements and the facility will be modified to handle all the additional flow. Project stormwater will discharge at the same WS-J discharge location that was established in the existing condition. The areas contributing to the facility will add TDA 26A, from outfall RWB G in the existing conditions, to the already contributing TDAs 27A and 28A through 28I. Although minimum basic water quality treatment is required to treat the stormwater and flow control is not required because Fairweather Bay is a large receiving water body, WSDOT will apply enhanced treatment by constructing a stormwater wetland on private property (TDA 28E) that was purchased for this purpose.

Stormwater Outfalls

The proposed stormwater facilities will use existing outfall locations; however, some outfalls will need to be rebuilt to accommodate increased flow volumes. Proposed surface water outfalls and associated improvements (if needed) are described below:

- The East Garfield Street outfall is an existing 54-inch-diameter outfall that discharges below the lake surface and will not be altered.
- The East Allison Street outfall is an existing 30-inch-diameter outfall that discharges below the lake surface and will not be altered.
- The WS C outfall is an existing 18-inch-diameter outfall. It will be replaced with a new 18- to 24-inch-diameter outfall pipe that will discharge above ordinary high water (OHW) to a riprap pad 10 to 20 feet landward of OHW.
- The WS D outfall is an existing 12-inch-diameter outfall. It will be replaced with a new 24- to 30-inch-diameter outfall pipe that will discharge above OHW to a riprap pad 50 to 75 feet landward of OHW.
- The WS-PR outfall is an existing 8-inch-diameter outfall. It will be a replaced with a 24- to 36 inch-diameter outfall pipe that will discharge above OHW to a riprap pad 15 to 20 feet landward of OHW.
- RWB-C and RWB-D are existing 12-inch-diameter outfalls. These outfalls will not be altered.
- The floating bridge (WS BR4) consists of multiple downspouts, which direct stormwater discharge from the bridge to catch basin structures that are larger than standard size. Collected stormwater will be discharged to spill control lagoons built into the supplemental stability pontoons. Approximately 44 of the 54 supplemental stability pontoons will have 19-by-29-foot discharge and spill control lagoons in the center of the pontoons. Stormwater runoff from the proposed bridge will mix with water in the spill control lagoons and provide some dilution of the runoff before it flows into Lake Washington.
- Outfalls located on the east side of Lake Washington are existing outfalls (RWB-F and RWB-G) or outfalls constructed as part of the Medina to SR 202 project (WS-G and WS-J). Outfalls constructed as part of that project discharge above OHW to flow dissipation structures prior to flowing into Lake Washington.
- West Point Treatment Plant discharges to a diffuser located approximately 3,600 feet offshore at a depth of approximately 240 feet below mean lower low water (MLLW).
- Union Bay and WS-BR2 currently have no planned outfalls. Union Bay includes elevated bridge structures with scuppers, and adjacent roadway segments where stormwater is dispersed from the roadway structure. WS-BR2 is the existing Montlake Cut bascule bridge, which does not collect any water for treatment because the deck is steel grating. The new bascule bridge does not include plans for water collection and treatment. These conditions are expected to continue in the proposed condition.

Collection and Conveyance Systems

Proposed collection and conveyance systems will consist of standard WSDOT catch basin and manhole structures as required for conveyance according to the Hydraulics Manual criteria for draining highway surfaces. Minimum pipe sizes will be 12 inches in diameter and will be installed on grades and at depths necessary for proper clearances and hydraulic performance.

Ditches along the edges of the shoulders are the preferred collection system except where they are not feasible. Ditches provide additional sediment deposition, flow control capacity (infiltration and storage), and treatment for vegetative filtration runoff. Existing ditches that are displaced due to project widening of the pavement prism will be replaced where right-of-way and grading conditions allow.

Lid Drainage

The proposed project includes design features where parts of the roadway will be covered by paved and landscaped lids. Surface drainage from each landscaped lid will consist of area drain inlets on most non PGIS paved areas and an underdrain system beneath the landscaped areas. The underdrain system consists of a gravel layer with a perforated pipe network located directly on each lid structural surface. Runoff will be collected in both of these systems and routed to low points at the edge of the structural lid surface, and tightline routed to either a natural dispersion area, or into the road drainage system for discharge. Any PGIS surface on the lid will be routed to a roadway drainage system for treatment and discharge.

Water Quality Modeling with HI-RUN

With the exception of some vegetated ditches present on adjacent county and city roads, stormwater from the 75.46 acres of existing PGIS within the project area is not currently detained for stormwater treatment. Under the proposed project, stormwater from approximately 38 percent (34.49 acres) of all PGIS (91.05 acres) within the project action area will receive enhanced treatment, and approximately 10 percent (8.66 acres) will receive basic treatment.

On February 16, 2009, WSDOT, Federal Highway Administration, National Marine Fisheries Service (NMFS), and the U.S. Fish and Wildlife Service (USFWS) signed an agreement that the probabilistic stormwater model—the HI-RUN model—would be used to evaluate the potential effects of stormwater on listed species within western Washington. Therefore, the April 2009 version of the model was used to calculate the probabilities of changes from pre project and post project conditions regarding loading and concentrations of total suspended solids (TSS), dissolved copper (DCu), dissolved zinc (DZn), and total copper and zinc. Stormwater associated with highway runoff may contain low levels of cadmium, lead, chromium, and polycyclic aromatic hydrocarbon (PAH) compounds. However, these compounds are at or below levels that can be detected with current analytical methods and may be effectively filtered or settled out in stormwater BMPs prior to being discharged to nearby water bodies. Based on the environmental chemistry and biological fate of these compounds in an aquatic system, exposure to ESA listed species is expected to be small.

Stormwater Water Quality Evaluation Methods

The HI-RUN model evaluates end of pipe outfall pollutant loads and pollutant concentrations at the outfall into the receiving water body by estimating the probability that loading for the proposed project will exceed loading for the baseline condition. The first step in using HI-RUN to evaluate water quality effects is running the end of pipe loading subroutine to assess the potential to increase the delivery of pollutant loads to the receiving water in the proposed condition compared to the baseline condition. The results of this assessment (comparison of DZn probability statistics [P(exceed)] to predetermined thresholds) determine the need for a detailed mixing zone analysis in the receiving water using the HI-RUN Receiving Water Dilution Subroutine. The model uses DZn for this initial screening step because monitoring data compiled by WSDOT for this parameter have generally shown it is a good indicator of stormwater treatment system performance. DCu is not used in the model because existing monitoring suggests that concentrations of this parameter in highway runoff are present at levels that are so low as to be considered untreatable with BMPs that are currently used in highway settings.

Dilution modeling for the project area assumed that no infiltration associated with water quality treatment occurs in either the existing or proposed condition. Additionally, all TDAs were modeled assuming that rainfall volumes are equivalent to the Puget Sound West 40-inch rain gauge model. A review of existing data suggests that the treatment for pollutants of concern resulting from the enhanced secondary wastewater treatment facility at West Point is comparable to treatment efficiencies used in the HI-RUN model. Therefore, that treatment location was modeled as if it provides basic water quality treatment. Similarly, the AKART study (WSDOT 2010) documented treatment efficiencies anticipated for the selected treatment regime of high-efficiency sweepers combined with modified catch basins. These treatment efficiencies are comparable to basic water quality treatment and, for simplicity, were modeled as such using HI-RUN.

According to the HI-RUN Guidance Manual, projects with outfalls demonstrating P(exceed) values for DZn greater than a threshold of 0.45 are required to perform a dilution analysis using HI-RUN. Likewise, projects with outfalls demonstrating P(exceed) values for DZn equal to or less than the 0.45 threshold, but greater than 0.35, may require receiving water dilution analysis, primarily based on the water quality of the receiving water. The analysis of receiving water quality is based on the Matrix of Pathways and Indicators (NMFS 1996) framework of classifying surface water quality water as properly functioning, at risk, or not properly functioning. HI-RUN Guidance indicates that for DZn, P(exceed) values of 0.35 to 0.45 dilution analysis should be conducted if background water quality conditions are at risk or not properly functioning. Similarly, if the P(exceed) value is equal to or below the 0.35 threshold, dilution analysis is required if the water quality indicators show the receiving water function is not properly functioning. The basis for rating water quality indicators is the level of chemical contamination from agricultural, industrial, and other sources, and the number of reaches designated as impaired in the 2008 303(d) listings (Ecology 2009).

For this project, all outfalls discharge to a single contiguous receiving water body—Lake Washington, the Ship Canal, and Lake Union. Therefore, a subset of stormwater discharge points was evaluated to characterize the outfalls likely to produce the largest stormwater dilution zones. Because the outfalls conveying the largest volumes of stormwater are evaluated and all outfalls have similar stormwater pollutant concentrations, other outfalls are expected to have dilution zones equal to or less than those evaluated. Exhibit J-20 provides a summary of the receiving water quality function.

EXHIBIT J-20.
WATER QUALITY FUNCTION OF RECEIVING WATERS WITHIN THE PROJECT ACTION AREA

PROJECT LIMIT DISCHARGE POINT	RECEIVING WATER	ECOLOGY 303(d) PARAMETERS	SURFACE WATER QUALITY FUNCTIONS
East Garfield Street and East Allison Street	Lake Union	Total Phosphorous; Lead; Fecal Coliform; Aldrin	Not Properly Functioning
WS-C and WS-D	Portage Bay (Lake Washington Ship Canal)	Total Phosphorous; Lead; Fecal Coliform; Aldrin	Not Properly Functioning
WS-BR2 and COS-M	Montlake Cut (Lake Washington Ship Canal)	Total Phosphorous; Lead; Fecal Coliform; Aldrin	Not Properly Functioning
WS-BR4 (Floating Bridge)	Lake Washington	PCB; Total Chlordane; 4,4-DDD; 4,4-DDE; 2,3,7,8-TDD	Not Properly Functioning
	Lake Washington (Union Bay)		
	Lake Washington (Fairweather Bay)		
	Lake Washington (Evergreen Point)		
	Puget Sound (West Point)		

WS = WSDOT
COS = City of Seattle

HI-RUN End-of-Pipe Subroutine Results

Based on the HI-RUN Guidance (as discussed above), the HI-RUN end-of-pipe subroutine was run for 14 outfalls including the CSS outfall (Exhibit J-21). The P(exceed) value for DZn exceeded the 0.45 threshold for seven outfalls—one outfall had P(exceed) values for DZn between 0.35 and 0.45, while six outfalls indicated a P(exceed) value of below 0.35.

Pollutant Loading Analysis

Of the 14 outfalls modeled for end-of-pipe loading, it was determined that seven outfalls required additional dilution analysis to characterize the potential effects of stormwater on ESA-listed species. This included both outfalls with a P(exceed) DZn value of between 0.35 and 0.45, but none of the outfalls with a P(exceed) DZn value below 0.35. The WS-BR4 (floating bridge) outfall was not evaluated using the HI-RUN analysis, but a pollutant loading analysis was performed and the results are provided in the aforementioned AKART study. The following sections discuss the rationale for deciding whether or not the dilution analysis would be performed.

EXHIBIT J-21.
MODELING RESULTS OF HI-RUN RECEIVING WATER END-OF-PIPE LOADING SUBROUTINE

Stormwater Discharge Point	Existing PGIS (acres)	Post-Project PGIS (acres)	Dissolved Zinc P (exceed) Value	Receiving Water Function	Median Change in Dissolved Zinc Loading (pounds per year)
East Garfield Street	2.45	2.45	0.50	Not Properly Functioning	0.00
East Allison Street	14.25	14.30	0.49	Not Properly Functioning	-0.21
WS-C	3.34	5.47 (2.94)	0.29	Not Properly Functioning	-0.33
WS-D	6.47	9.29	0.48	Not Properly Functioning	-0.12
WS-BR2	0.19	0.27	0.60	Not Properly Functioning	0.02
RWB-C	0.02	0.14	1.00	Properly Functioning	0.02
Union Bay	1.28	0.13	0.04	Properly Functioning	-0.23
RWB-F	0.61	0.36	0.26	Properly Functioning	-.06
WS-PR	12.60	28.99 (23.72)	0.54	Properly Functioning	0.32
WS-BR4	17.28	20.56	0.38	Not Properly Functioning	-1.04
WS-G	1.75	1.70	0.32	Properly Functioning	-0.16
WS-J	5.42	4.48	0.27	Properly Functioning	-0.57
RWB-G	0.16	0.04	0.05	Properly Functioning	-0.03
Combined Sewer System	5.24	5.51	0.52	Properly Functioning	0.03

PGIS = pollutant-generating impervious surface
RWB = receiving water body
WS = WSDOT

East Garfield Street

The existing and proposed PGIS acreage and treatment for this basin are identical. Although the P(exceed) value is above the 0.45 threshold and this outfall discharges into a water body that is not properly functioning for water quality, a HI-RUN dilution analysis was not performed because the project improvements in the TDAs contributing to this outfall do not include additional PGIS or other surface disturbance, but only lane striping. Therefore, although the HI-RUN loading analysis calculates a P(exceed) value greater than the 0.45 threshold, dilution analysis is not required for this outfall because no changes from existing conditions will occur.

East Allison Street

This outfall has a P(exceed) value over the 0.45 threshold and discharges to a water body that is not properly functioning for water quality. This outfall is unique in the project area because it discharges a mix of treated and untreated stormwater. Therefore, a CORMIX dilution analysis was performed for this outfall.

WS-C

This outfall has a DZn P(exceed) value of less than 0.35 and discharges to a water body that is not properly functioning for water quality. Although not required by the existing protocol, this outfall was modeled using the CORMIX dilution analysis.

WS-D

This outfall has a P(exceed) value over the 0.45 threshold and discharges to a water body that is not properly functioning for water quality. Therefore, the CORMIX dilution analysis was performed for this outfall.

WS-BR2

This outfall has a P(exceed) value for DZn over the 0.45 threshold and discharges to a water body that is not properly functioning for water quality. This outfall was modeled as if stormwater falling on all PGIS could be collected for treatment. However, the existing bridge is grated and does not capture stormwater, and final design of the proposed bridge may prohibit collection of stormwater from PGIS surfaces. For these reasons, while the calculations of loading may accurately reflect stormwater pollutants released in this area, the HI-RUN CORMIX methodologies are not well suited for evaluating pollutants in the receiving water body. Therefore, no dilution analysis was completed for this outfall.

RWB-C

This outfall has a P(exceed) DZn value over the 0.45 threshold; however, the total quantity of PGIS in the existing and proposed conditions are both fractions of an acre. Although there is an increase, this increase is magnified by the limited amount of acreage present; moreover, dilution modeling for other outfalls with a greater total acreage of PGIS is likely to predict dilution zones substantially larger than what would be observed at this location. Therefore, no dilution modeling occurred at this discharge point.

RWB-C

This outfall has a P(exceed) DZn value below the 0.35 threshold; therefore, no additional dilution modeling occurred for this discharge location. Although no stormwater treatment is provided for the surfaces in TDAs draining to this outfall, the project results in a substantial decrease in the total amount of PGIS associated with this basin.

RWB-F

This outfall has a P(exceed) DZn value below the 0.35 threshold and discharges to a water body that is properly functioning for water quality. Therefore, the CORMIX dilution analysis was not performed for this outfall.

WS-PR

This outfall has a P(exceed) DZn value over the 0.45 threshold and discharges to a water body that is properly functioning for water quality. Therefore, the CORMIX dilution analysis was performed for this outfall.

WS-BR4 (Floating Bridge)

The WS-BR4 outfalls were not analyzed using the HI-RUN analysis or CORMIX dilution modeling, but were previously analyzed separately as part of the AKART study. The floating bridge is a unique structure because there is no feasible location for stormwater treatment BMPs and the HI-RUN analysis is not suitable to analyze the floating bridge. Pollutant load analysis and dilution analysis were conducted by the AKART study. The results indicated that the replacement bridge alternatives would have no increase in annual mass loading of TSS and metals compared to the existing floating bridge because of the effectiveness of the proposed AKART Alternative 4 treatment measures (WSDOT 2010). Exhibit J-22 summarizes the estimated pollutant loading for the existing floating bridge compared to the proposed 6-lane bridge.

COS-M

This outfall has a P(exceed) DZn value less than the 0.35 threshold, but discharges to a water body that is not properly functioning for water quality. However, project improvements in the TDA contributing to the COS-M outfall do not include additional PGIS or any other surface disturbance, but rather the removal of contributing PGIS from the outfall. Also, the median annual loading of DZn will decrease at the outfall. Based on these factors, dilution analysis was not performed for this outfall.

WS-G

This outfall has a P(exceed) DZn value below the 0.35 threshold and discharges to a water body that is properly functioning for water quality. Therefore, the CORMIX dilution analysis was not performed for this outfall.

WS-J

This outfall has a P(exceed) value over the 0.45 threshold and discharges to a water body considered properly functioning for water quality. Although not required according to the HI-RUN Guidance, a dilution analysis was completed for this outfall as part of the Medina to SR 202 project.

RWB-G

This outfall has a P(exceed) value less than the 0.35 threshold and discharges to a water body considered properly functioning for water quality. Therefore, a dilution analysis is not required for this outfall.

EXHIBIT J-22.
COMPARISON OF ESTIMATED POLLUTANT LOADING FOR THE EXISTING BRIDGE AND PROPOSED 6- LANE BRIDGE (EQUIVALENT 540-FOOT BRIDGE LENGTHS)

Item	Units	Pollutant
		Zinc
Existing Bridge	lb/yr	0.32
6-lane Alternative	lb/yr	0.60
Removal Efficiencies Applied (Average in Efficiency Range)		
Existing Bridge	%	24%
6-lane Alternative	%	58%
Annual Mass Loading With Alternative 4 Removal Efficiencies Applied		
Existing Bridge	lb/yr	0.24
6-lane Alternative	lb/yr	0.25

Data source: 2010 WSDOT AKART Study

The dilution zones have already been established for the floating bridge, and the dilution analysis is presented in the subsequent section.

Summary

Based on the pollutant loading analyses and other analyses performed by WSDOT, the East Allison Street, WS-C, WS-D, and WS-PR outfalls received the dilution analysis. Although not required according to the HI-RUN Guidance, WS-G and WS-J outfalls were evaluated under the Medina to SR 202 project. In addition, the WS-BR4 (floating bridge) outfalls received dilution analysis in the AKART study. No other outfalls require dilution analysis.

Receiving Water Dilution Modeling Results

The HI-RUN Receiving Water Dilution Subroutine is a model intended for unidirectional channels (for example, a stream or river). It was used to separate the discharge points that do not exceed the DZn pollutant load from those that do. The water quality is satisfactory for surface water contributing to seven discharge points. However, for the six outfalls that require the dilution analysis, the HI-RUN dilution subroutine is inappropriate due to the lack of unidirectional flow. Therefore, for these stormwater outfalls in Lake Washington and the Ship Canal, WSDOT used an alternative method of dilution modeling that is more appropriate to the lacustrine environment where unidirectional flow does not occur.

WSDOT, NMFS, and USFWS agreed that the use of a modified HI RUN model and CORMIX dilution model would be an appropriate method for analyzing stormwater discharges within the project area. Because the HI RUN dilution subroutine (based on the dilution model RIVPLUM6A) is only suitable for calculating mixing in unidirectional channels (such as streams), Herrera developed a modified version of HI-RUN to provide input for the CORMIX dilution model suitable for lakes. The modified version of HI-RUN differs from the basic version in that end of pipe flow and concentration data generated by Monte Carlo simulation is output to CSV files for post processing outside of HI-RUN.

Pre- and post-project impervious surface areas, type of BMP, and other data were entered into the modified HI-RUN model. The HI-RUN model loading and concentration subroutine was used to calculate loading, concentrations, and P(exceed) values for the Lake Union and Lake Washington outfalls. As with the original version of HI-RUN, loading statistics, P(exceed) values, and discharge duration combined probability distributions were calculated for months and pollutants of interest, and end of pipe flow and concentration data sets were generated.

The modified HI-RUN model loading and concentration subroutine was used to calculate loading statistics and stormwater discharge rates and concentrations for outfalls for the SR 520, I-5 to Medina project: WS-D (Portage Bay), WS-PR (Union Bay), WS-C (Portage Bay), and East Allison Street (Lake Union). Outfalls for the Medina to SR 202 project—WS-G and WS-J—were modeled as part of a previous ESA consultation and those results are reproduced here. These outfalls are considered to be representative of the range of stormwater discharges and outfalls associated with the project. Outfall flow and concentration data were then evaluated statistically and the values of interest input to a suitable dilution model (CORMIX for these discharges). The statistical evaluation consisted of calculating percentiles (10, 20, 30, 40, 50, 60, 70, 80, 90, 95, 99, and maximum) and creating histograms to approximate the flow and concentration distributions using the percentile values as bins. Flow and concentration distributions for the Lake Union and Lake Washington outfalls are essentially flat through the 90th percentile. The combined distribution is consequently also flat. Because the distributions are flat, it was reasonably conservative and representative to perform the dilution modeling based on 90th percentile flow and concentration. January and August were modeled because they represent the months of highest and lowest mean precipitation, and thus the high and low flow discharge months, respectively. CORMIX dilution modeling was performed using the 90th percentile discharge rates while DCu and DZn concentrations were calculated with the modified HI-RUN, which is consistent with methodology developed for the Medina to SR 202 project. This methodology is conservative, in that it assumes a worst-case scenario where pollutant concentrations and flow are correlated such that high concentrations are assumed to occur at high stormwater flow conditions.

Exhibits J-23 to J-28 present the results of the modified dilution modeling for the six outfalls currently modeled. Model input data results for the HI-RUN end-of-pipe loading report are provided in Attachment 1 and data for the CORMIX dilution model simulations are presented in Attachment 2.

EXHIBIT J-23.
SUMMARY OF MODIFIED HI-RUN AND CORMIX MODEL RESULTS FOR PROPOSED WS-C STORMWATER DISCHARGE

Constituent	Concentration (µg/L) and Discharge by Month[1]		Background Concentration (µg/L)	Excess Concentration (µg/L)		Threshold Concentration (µg/L)	Distance to Dilution Below Threshold (feet)	
	January	August		January	August		January	August
Dissolved Zinc	37.3	37.3	1	36.3	36.3	5.6	10.32	6.37
Dissolved Copper	6.6	6.6	0.96	5.64	5.64	2	2.21	0.99
Flow (cfs)	0.0682	0.0368	--	--	--	--	--	

[1] 90th percentile flow and concentration from the modified HI-RUN Monte Carlo simulation results.

EXHIBIT J-24.
SUMMARY OF MODIFIED HI-RUN AND CORMIX MODEL RESULTS FOR PROPOSED WS-D STORMWATER DISCHARGE

Constituent	Concentration (µg/L) and Discharge by Month[1]		Background Concentration (µg/L)	Excess Concentration (µg/L)		Threshold Concentration (µg/L)	Distance to Dilution Below Threshold (feet)	
	January	August		January	August		January	August
Dissolved Zinc	36.0	36.0	1	35.0	35.0	5.6	8.29	13.22
Dissolved Copper	6.6	6.6	0.96	5.64	5.64	2	4.88	3.49
Flow (cfs)	0.1881	0.0978	--	--	--	--	--	

[1] 90th percentile flow and concentration from the modified HI-RUN Monte Carlo simulation results.

EXHIBIT J-25.
SUMMARY OF MODIFIED HI-RUN AND CORMIX MODEL RESULTS FOR PROPOSED WS-PR STORMWATER DISCHARGE

Constituent	Concentration (µg/L) and Discharge by Month[1]		Background Concentration (µg/L)	Excess Concentration (µg/L)		Threshold Concentration (µg/L)	Distance to Dilution Below Threshold (feet)	
	January	August		January	August		January	August
Dissolved Zinc	37.2	37.2	1	36.2	36.2	5.6	11.12	7.74
Dissolved Copper	6.5	6.5	0.96	5.54	5.54	2	6.74	5.35
Flow (cfs)	0.4528	0.2381	--	--	--	--	--	

[1] 90th percentile flow and concentration from the modified HI-RUN Monte Carlo simulation results.

EXHIBIT J-26.
SUMMARY OF MODIFIED HI-RUN AND CORMIX MODEL RESULTS FOR PROPOSED EAST ALLISON STREET STORMWATER DISCHARGE

Constituent	Concentration (µg/L) and Discharge by Month[1]		Background Concentration (µg/L)	Excess Concentration (µg/L)		Threshold Concentration (µg/L)	Distance to Dilution Below Threshold (feet)	
	January	August		January	August		January	August
Dissolved Zinc	71.9	71.9	1	70.9	70.9	5.6	7.93	6.28
Dissolved Copper	8.7	8.7	0.96	7.74	7.74	2	4.38	2.87
Flow (cfs)	0.2335	0.1274	--	--	--	--	--	

[1] 90th percentile flow and concentration from the modified HI-RUN Monte Carlo simulation results.

EXHIBIT J-27.
SUMMARY OF MODIFIED HI-RUN AND CORMIX MODEL RESULTS FOR PROPOSED WS-G STORMWATER DISCHARGE

Constituent	Concentration (µg/L) and Discharge by Month[1]		Background Concentration (µg/L)	Excess Concentration (µg/L)		Threshold Concentration (µg/L)	Distance to Dilution Below Threshold (feet)	
	January	August		January	August		January	August
Dissolved Zinc	91.1	90.7	1.1	90	89.6	5.6	14	6
Dissolved Copper	10.4	10.6	0.54	9.86	10.06	2	2	1
Flow (cfs)	0.020	0.011	--	--	--	--	--	

[1] 90th percentile flow and concentration from the modified HI-RUN Monte Carlo simulation results.

EXHIBIT J-28.
SUMMARY OF MODIFIED HI-RUN AND CORMIX MODEL RESULTS FOR PROPOSED WS-J STORMWATER DISCHARGE

Constituent	Concentration (µg/L) and Discharge by Month[1]		Background Concentration (µg/L)	Excess Concentration (µg/L)		Threshold Concentration (µg/L)	Distance to Dilution Below Threshold (feet)	
	January	August		January	August		January	August
Dissolved Zinc	35.9	36.0	1.1	34.8	34.9	5.6	17	1
Dissolved Copper	6.6	6.6	0.54	6.06	6.06	2	2	1
Flow (cfs)	0.0235	0.0120	--	--	--	--	--	

[1] 90th percentile flow and concentration from the modified HI-RUN Monte Carlo simulation results.

The CORMIX dilution model generates results that summarize pollutant concentrations at distances from the outfall where concentrations of DZn and DCu exceed predefined effects thresholds. The existing DCu and DZn concentrations, as well as concentrations resulting in the post-project condition, are presented relative to the adverse sub-lethal effect thresholds, above which adverse sub-lethal effects may occur. These thresholds agreed upon by WSDOT, NMFS, and USFWS are:

- The current adverse sub-lethal effect threshold for DZn is 5.6 µg/L over background levels of between 3.0 µg/L and 13 µg/L (Sprague 1968).
- The current adverse sub-lethal effect threshold for DCu is 2.0 µg/L over background levels of 3.0 µg/L or less (Sandahl et al. 2007).

In order to estimate the distance at which the sub-lethal effect thresholds for listed species is exceeded, the CORMIX model requires estimates of DCu and DZn background concentrations. WSDOT, NMFS, and USFWS have agreed to use background concentration values that are based on the average observations at site 0852 from the Lake Washington Existing Conditions Report (http://your.kingcounty.gov/dnrp/library/2003/kcr1479.pdf). These background concentrations are:

- DCu Concentration = 0.96 µg /L
- DZn Concentration = 1.0 µg /L

In addition to the CORMIX modeling described above, dilution modeling on the proposed floating bridge alignment was conducted as a part of the AKART study (WSDOT 2010). The study estimated the concentrations of DCu and DZn at various locations within and outside the pontoon spill control lagoons, but did not calculate the exact distance at which the concentrations of these constituents would be below the sub-lethal effect threshold. Therefore, the AKART dilution modeling results presented in Exhibit J-29 only provides a range of distances between which the sub-lethal effects threshold is exceeded. Stormwater discharge on the floating bridge is such that stormwater is collected from the bridge deck and routed to an outfall that discharges into spill control lagoons within the supplemental stability pontoons. The dilution distances indicated in Exhibit J-29 describe the distance from the outfall, and the first 21 feet describes the distance from the outfall end-of-pipe to the outer edge of the spill control lagoon. Distances beyond 21 feet are beyond the boundaries of the spill control lagoon into unconfined portions of Lake Washington.

EXHIBIT J-29.
SUMMARY OF AKART DILUTION MODEL RESULTS FOR WS-BR4 – FLOATING BRIDGE (LAKE WASHINGTON) STORMWATER DISCHARGE

Location of the Evergreen Point Bridge Span	Dissolved Metal Concentration (µg/L)		Background Concentration (µg/L)		Excess Concentration (µg/L)		Threshold Concentration (µg/L)		Distance to Dilution Below Threshold (feet)	
	Dissolved Zinc	Dissolved Copper	Dissolved Zinc	Dissolved Copper	Dissolved Zinc	Dissolved Copper	Dissolved Zinc	Dissolved Copper	Dissolved Zinc	Dissolved Copper
Mid-Span and Large Lagoon[a]	2.0	2.0	1.0	0.96	1.0	1.04	6.6	2.96	>21 and <71	>0 and <21
East Approach Span and 3 Large Lagoons[b]	3.4	3.3	1.0	0.96	2.4	2.34	6.6	2.96	>21 and <71	>0 and <21

Notes:
[a] Large lagoon size (20 feet wide, 29 feet long, 21 feet deep) selected for mid-span of bridge.
[b] Three large lagoons (20 feet wide, 29 feet long, and 21 feet deep for each) selected for east span of bridge.

Dilution Zone Analysis Summary

The water quality of stormwater runoff entering water bodies in the project area, including Lake Washington and the Ship Canal, will be improved overall as a result of the proposed project. Currently, stormwater runoff in the project alignment is not detained or treated. Modeling results suggest that overall pollutant loadings for TSS and total copper and zinc will decrease, while DCu and DZn loading will increase only slightly (about 0.7 pound/year for DCu and 1.2 pounds/year for DZn). However, the overall receiving water concentration for all pollutants, including DCu and DZn, will not increase as a result of the project.

Five individual stormwater outfalls (Exhibit J-30) will exceed the threshold for sub-lethal effects to fish, for some distance away from the outfall. In most cases, this distance is relatively short, and limited to within about 20 feet of the outfall pipe. The exception to this is the case of DZn on the floating bridge, where the sub-lethal effect threshold extends beyond the spill control lagoon for a distance of between 21 and 71 feet.

EXHIBIT J-30.
SUMMARY OF STORMWATER DILUTION MODELING RESULTS FOR SELECTED OUTFALLS

Outfall Name	Outfall Receiving Water	Distance from Outfall to Dilution Below Sub-lethal Effect Threshold for Dissolved Copper (feet)	Distance from Outfall to Dilution Below Sub-lethal Effect Threshold for Dissolved Zinc (feet)
WS-C	Portage Bay	2.2	10.3
WS-D	Portage Bay	4.9	13.2
WS-PR	Union Bay	6.7	11.1
East Allison Street	Lake Union	4.4	7.9
BR-4 (Floating Bridge)	Lake Washington	>0 and <21	>21 and <71
WS-G	Lake Washington	14	2
WS-J	Lake Washington	17	1

Water Quantity Summary

The project will not affect peak flows in the action area because of three factors: 1) all stormwater discharges into flow-exempt water bodies (Lake Washington and the Ship Canal), 2) the volume of stormwater is insubstantial when compared to the water volume of these water bodies, and 3) any changes are immeasurable and do not have the potential to affect habitat processes or aquatic life. The hydrograph of Lake Washington and the Ship Canal is primarily controlled by operations of the Ship Canal, which is a federal navigation project with an authorized elevation range of 2 feet.

Conclusions

The project will cause substantial changes in water management; therefore, evaluating the results requires careful consideration of the changes from the existing to the proposed conditions for each location. In general, water quality is projected to improve throughout the project vicinity as a result of water quality treatment facilities constructed as part of this project. Changes in water collection mean that under existing conditions, water that is discharged without treatment from scuppers on structures in Portage Bay, the west approach, the floating bridge, and the east approach will be collected and treated before discharge in the future. By collecting the water, the water quality characteristics at the proposed discharge location may be slightly diminished; however, overall water quality tends to improve as a result of treatment.

The results for the pollutant concentration and loading analyses show substantial improvement in the post-project pollutant concentrations as a result of water quality treatment facilities proposed as part of the project. At the project scale, pollutant loads decrease for TSS, total copper, total zinc, and DZn while increasing slightly for DCu as a result of the project. Although water quality treatment facilities typically decrease pollutant loading, they are relatively ineffective at treating dissolved metals. As a result, these pollutant loads are more sensitive to the overall increase in PGIS due to the project. Pollutant loads vary considerably in the individual basins; some basins show dramatic decreases in pollutant loading where PGIS in the basin is being reduced due to the removal or reconfiguration of roadway structures, while in other basins pollutant loads increase due to reconfiguration of drainage patterns and substantial increases in the amount of PGIS within the basin.

Dilution modeling provides predictions of the zone where fish may be affected by dissolved metals associated with stormwater discharges. Predictions of stormwater discharge characteristics during large (90th percentile) storm events suggest that stormwater pollutants are below thresholds for the onset of effects on listed salmonids within approximately 20 feet of outfalls. DZn thresholds are exceeded for greater distances than DCu thresholds. Substantial reconfiguration of drainage patterns as a result of the proposed project prohibits meaningful comparisons of dilution zones between the existing and proposed conditions.

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ATTACHMENT 1: HI-RUN MODELING RESULTS

Highway Runoff Dilution and Loading model (HI-RUN) Version 1.20100315

End of Pipe Loading Subroutine Report

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

Date/Time of Run: 9/5/10 09:31
Outfall ID: E. Garfield
Rain Gauge: Puget East 40

Baseline Conditions
None 0% Infiltration - 2.45 acres

Proposed Conditions
None 0% Infiltration - 2.45 acres

Load Analysis

	TSS Load (lb/yr)		Total Copper Load (lb/yr)		Dissolved Copper Load (lb/yr)		Total Zinc Load (lb/yr)		Dissolved Zinc Load (lb/yr)	
	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
Max	76941	76941	9.93	9.93	3.17	3.17	53.1	53.1	41.2	41.2
75th Percentile	2004	2004	0.446	0.446	0.106	0.106	2.71	2.71	0.835	0.835
Median	978	978	0.253	0.253	0.061	0.061	1.52	1.52	0.439	0.439
25th Percentile	477	477	0.143	0.143	0.035	0.035	0.852	0.852	0.233	0.233
Min	12.6	12.6	0.007	0.007	0.002	0.002	0.031	0.031	0.008	0.008
P (exceed)		0.5		0.5		0.5		0.5		0.5

Concentration Analysis

Subbasin 1	TSS Conc (mg/L)		Total Copper Conc (mg/L)		Dissolved Copper Conc (mg/L)		Total Zinc Conc (mg/L)		Dissolved Zinc Conc (mg/L)	
	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
Max	4473.578	4473.578	0.561	0.561	0.198	0.198	3.134	3.134	1.791	1.791
75th Percentile	124.121	124.121	0.028	0.028	0.007	0.007	0.168	0.168	0.053	0.053
Median	61.488	61.488	0.016	0.016	0.004	0.004	0.096	0.096	0.028	0.028
25th Percentile	30.495	30.495	0.009	0.009	0.002	0.002	0.054	0.054	0.015	0.015
Min	0.7	0.7	0	0	0	0	0.003	0.003	0	0
P (exceed)		0.067		0.117		0.432		0.088		0.319

Highway Runoff Dilution and Loading model (HI-RUN) Version 1.20100315

End of Pipe Loading Subroutine Report

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

Date/Time of Run: 9/7/10 15:01
Outfall ID: E. Allison
Rain Gauge: Puget East 40

Baseline Conditions
None
0% Infiltration - 14.25 acres

Proposed Conditions
None
0% Infiltration - 10.3 acres
Basic
0% Infiltration - 4 acres

Load Analysis

	TSS Load (lb/yr)		Total Copper Load (lb/yr)		Dissolved Copper Load (lb/yr)		Total Zinc Load (lb/yr)		Dissolved Zinc Load (lb/yr)	
	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
Max	676669	853536	55.9	45	19.1	15	338	274	227	117
75th Percentile	13253	10042	2.94	2.3	0.701	0.63	17.9	14	5.5	4.7
Median	6445	5066	1.68	1.4	0.403	0.41	10	8.2	2.91	2.7
25th Percentile	3148	2619	0.947	0.86	0.232	0.27	5.65	4.9	1.54	1.7
Min	56.8	63	0.041	0.084	0.011	0.035	0.155	0.55	0.042	0.13
P (exceed)		0.436		0.439		0.511		0.432		0.49

Concentration Analysis

Subbasin 1	TSS Conc (mg/L)		Total Copper Conc (mg/L)		Dissolved Copper Conc (mg/L)		Total Zinc Conc (mg/L)		Dissolved Zinc Conc (mg/L)	
	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
Max	4473.578	4178.338	0.561	0.39	0.198	0.074	3.134	2.762	1.791	1.921
75th Percentile	124.075	94.528	0.028	0.022	0.007	0.006	0.168	0.129	0.053	0.044
Median	61.48	48.259	0.016	0.013	0.004	0.004	0.096	0.077	0.028	0.026
25th Percentile	30.469	25.296	0.009	0.008	0.002	0.003	0.054	0.047	0.015	0.016
Min	0.7	0.493	0	0.001	0	0	0.003	0.005	0	0.002
P (exceed)		0.436		0.436		0.517		0.427		0.485

Highway Runoff Dilution and Loading model (HI-RUN) Version 1.20100315

End of Pipe Loading Subroutine Report

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

Date/Time of Run: 9/7/10 15:10
Outfall ID: WS-C
Rain Gauge: Puget East 40

Baseline Conditions
None
0% Infiltration - 3.34 acres

Proposed Conditions
Basic
0% Infiltration - 2.94 acres

Load Analysis

	TSS Load (lb/yr)		Total Copper Load (lb/yr)		Dissolved Copper Load (lb/yr)		Total Zinc Load (lb/yr)		Dissolved Zinc Load (lb/yr)	
	Baseline	**Proposed**	**Baseline**	**Proposed**	**Baseline**	**Proposed**	**Baseline**	**Proposed**	**Baseline**	**Proposed**
Max	199300	14518	16.3	1.2	3.64	0.93	105	6.4	43.1	5.2
75th Percentile	3110	281	0.69	0.16	0.165	0.11	4.16	0.8	1.31	0.56
Median	1526	122	0.391	0.11	0.095	0.07	2.33	0.52	0.685	0.36
25th Percentile	746	53	0.222	0.072	0.054	0.046	1.32	0.34	0.361	0.23
Min	12.2	0.6	0.01	0.009	0.003	0.004	0.046	0.019	0.009	0.02
P (exceed)		0.06		0.104		0.385		0.077		0.287

Concentration Analysis

Subbasin 1	TSS Conc (mg/L)		Total Copper Conc (mg/L)		Dissolved Copper Conc (mg/L)		Total Zinc Conc (mg/L)		Dissolved Zinc Conc (mg/L)	
	Baseline	**Proposed**	**Baseline**	**Proposed**	**Baseline**	**Proposed**	**Baseline**	**Proposed**	**Baseline**	**Proposed**
Max	3965.018	1288.928	0.556	0.051	0.122	0.036	2.92	0.297	1.734	0.198
75th Percentile	125.074	12.735	0.028	0.007	0.007	0.005	0.169	0.036	0.052	0.025
Median	61.718	5.629	0.016	0.005	0.004	0.003	0.096	0.024	0.028	0.017
25th Percentile	30.577	2.469	0.009	0.003	0.002	0.002	0.055	0.016	0.015	0.011
Min	0.57	0.033	0	0	0	0	0.003	0.002	0	0.001
P (exceed)		0.068		0.118		0.43		0.089		0.321

Highway Runoff Dilution and Loading model (HI-RUN) Version 1.20100315

End of Pipe Loading Subroutine Report

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

Date/Time of Run: 9/7/10 15:20
Outfall ID: WS-D
Rain Gauge: Puget East 40

Baseline Conditions
None 0% Infiltration - 6.47 acres

Proposed Conditions
None 0% Infiltration - 0.52 acres Basic 0% Infiltration - 8.77 acres

Load Analysis

	TSS Load (lb/yr)		Total Copper Load (lb/yr)		Dissolved Copper Load (lb/yr)		Total Zinc Load (lb/yr)		Dissolved Zinc Load (lb/yr)	
	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
Max	336532	59152	28.7	3.9	5.13	3.2	235	25	88.2	16
75th Percentile	6005	1397	1.33	0.58	0.318	0.34	8.13	3	2.52	1.8
Median	2946	758	0.759	0.41	0.183	0.23	4.56	2.1	1.32	1.2
25th Percentile	1430	419	0.433	0.29	0.104	0.16	2.56	1.4	0.694	0.83
Min	33.5	20	0.024	0.031	0.005	0.017	0.101	0.2	0.024	0.077
P (exceed)		0.171		0.263		0.592		0.22		0.477

Concentration Analysis

Subbasin 1	TSS Conc (mg/L)		Total Copper Conc (mg/L)		Dissolved Copper Conc (mg/L)		Total Zinc Conc (mg/L)		Dissolved Zinc Conc (mg/L)	
	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
Max	4556.482	1686.83	0.45	0.052	0.127	0.034	5.796	0.377	1.392	0.391
75th Percentile	124.907	20.027	0.027	0.008	0.007	0.005	0.167	0.043	0.052	0.026
Median	62.183	11.089	0.016	0.006	0.004	0.003	0.095	0.03	0.028	0.018
25th Percentile	30.717	6.203	0.009	0.004	0.002	0.002	0.054	0.022	0.015	0.012
Min	0.482	0.22	0	0.001	0	0	0.003	0.004	0.001	0.002
P (exceed)		0.107		0.15		0.443		0.122		0.346

Highway Runoff Dilution and Loading model (HI-RUN) Version 1.20100315

End of Pipe Loading Subroutine Report

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

Date/Time of Run: 9/7/10 17:08
Outfall ID: WS-BR2
Rain Gauge: Puget East 40

Baseline Conditions
None
0% Infiltration - 0.19 acres

Proposed Conditions
None
0% Infiltration - 0.27 acres

Load Analysis

	TSS Load (lb/yr)		Total Copper Load (lb/yr)		Dissolved Copper Load (lb/yr)		Total Zinc Load (lb/yr)		Dissolved Zinc Load (lb/yr)	
	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
Max	9798	10463	0.797	0.87	0.193	0.22	5.52	8.1	3.18	4.2
75th Percentile	177	250	0.039	0.056	0.009	0.013	0.238	0.34	0.074	0.1
Median	85.9	123	0.022	0.032	0.005	0.008	0.134	0.19	0.039	0.056
25th Percentile	42	60	0.013	0.018	0.003	0.004	0.076	0.11	0.02	0.029
Min	0.73	1.1	0.001	0.001	0	0	0.002	0.005	0.001	0.001
P (exceed)		0.591		0.616		0.621		0.617		0.604

Concentration Analysis

Subbasin 1	TSS Conc (mg/L)		Total Copper Conc (mg/L)		Dissolved Copper Conc (mg/L)		Total Zinc Conc (mg/L)		Dissolved Zinc Conc (mg/L)	
	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
Max	4260.415	5717.272	0.641	0.704	0.09	0.105	2.631	3.92	1.689	1.641
75th Percentile	125.025	124.835	0.027	0.027	0.007	0.007	0.167	0.167	0.052	0.052
Median	61.84	61.429	0.016	0.016	0.004	0.004	0.096	0.095	0.028	0.028
25th Percentile	30.522	30.465	0.009	0.009	0.002	0.002	0.054	0.054	0.015	0.015
Min	0.335	0.733	0.001	0	0	0	0.002	0.003	0	0.001
P (exceed)		0.5		0.501		0.504		0.5		0.5

Highway Runoff Dilution and Loading model (HI-RUN) Version 1.20100315

End of Pipe Loading Subroutine Report

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

Date/Time of Run: 9/7/10 16:56
Outfall ID: RWB-C
Rain Gauge: Puget East 40

Baseline Conditions
None 0% Infiltration - 0.02 acres

Proposed Conditions
Basic 0% Infiltration - 1.09 acres

Load Analysis

	TSS Load (lb/yr)		Total Copper Load (lb/yr)		Dissolved Copper Load (lb/yr)		Total Zinc Load (lb/yr)		Dissolved Zinc Load (lb/yr)	
	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
Max	634	11326	0.065	0.67	0.015	0.38	0.448	3.4	0.168	2.7
75th Percentile	14.9	104	0.003	0.059	0.001	0.039	0.02	0.29	0.006	0.21
Median	7.21	45	0.002	0.04	0	0.026	0.011	0.19	0.003	0.13
25th Percentile	3.54	20	0.001	0.027	0	0.017	0.006	0.13	0.002	0.085
Min	0.083	0.22	0	0.003	0	0.002	0	0.009	0	0.009
P (exceed)		0.868		0.999		1		0.996		0.999

Concentration Analysis

Subbasin 1	TSS Conc (mg/L)		Total Copper Conc (mg/L)		Dissolved Copper Conc (mg/L)		Total Zinc Conc (mg/L)		Dissolved Zinc Conc (mg/L)	
	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
Max	5863.849	880.194	0.704	0.054	0.105	0.05	3.92	0.303	1.641	0.216
75th Percentile	124.741	12.816	0.027	0.007	0.007	0.005	0.167	0.036	0.052	0.025
Median	61.437	5.611	0.016	0.005	0.004	0.003	0.095	0.024	0.028	0.017
25th Percentile	30.473	2.467	0.009	0.003	0.002	0.002	0.054	0.016	0.015	0.011
Min	0.733	0.03	0	0	0	0	0.003	0.002	0.001	0.001
P (exceed)		0.068		0.118		0.431		0.089		0.319

Highway Runoff Dilution and Loading model (HI-RUN) Version 1.20100315

End of Pipe Loading Subroutine Report

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

Date/Time of Run: 9/7/10 17:17
Outfall ID: Union Bay
Rain Gauge: Puget East 40

Baseline Conditions
None
0% Infiltration - 1.28 acres

Proposed Conditions
None
0% Infiltration - 0.09 acres

Load Analysis

	TSS Load (lb/yr)		Total Copper Load (lb/yr)		Dissolved Copper Load (lb/yr)		Total Zinc Load (lb/yr)		Dissolved Zinc Load (lb/yr)	
	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
Max	56343	4660	5.05	0.48	1.37	0.11	32.8	4.2	19.5	1.6
75th Percentile	1198	121	0.264	0.027	0.063	0.006	1.61	0.16	0.497	0.051
Median	583	59	0.15	0.015	0.036	0.004	0.905	0.092	0.261	0.026
25th Percentile	283	29	0.085	0.009	0.021	0.002	0.508	0.052	0.138	0.014
Min	5.99	0.57	0.004	0	0.001	0	0.021	0.001	0.003	0
P (exceed)		0.063		0.026		0.025		0.029		0.043

Concentration Analysis

Subbasin 1	TSS Conc (mg/L)		Total Copper Conc (mg/L)		Dissolved Copper Conc (mg/L)		Total Zinc Conc (mg/L)		Dissolved Zinc Conc (mg/L)	
	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
Max	6104.713	4260.415	0.545	0.641	0.158	0.09	2.98	2.631	1.789	1.689
75th Percentile	124.866	125.381	0.028	0.027	0.007	0.007	0.168	0.167	0.052	0.052
Median	61.935	62.017	0.016	0.016	0.004	0.004	0.096	0.096	0.028	0.028
25th Percentile	30.685	30.58	0.009	0.009	0.002	0.002	0.055	0.054	0.015	0.015
Min	0.815	0.335	0	0	0	0	0.003	0.002	0.001	0
P (exceed)		0.501		0.499		0.499		0.498		0.5

Highway Runoff Dilution and Loading model (HI-RUN) Version 1.20100315

End of Pipe Loading Subroutine Report

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

Date/Time of Run: 9/5/10 10:19
Outfall ID: RWB-F
Rain Gauge: Puget East 40

Baseline Conditions
None
0% Infiltration - 0.61 acres

Proposed Conditions
Enhanced
0% Infiltration - 0.40 acres

Load Analysis

	TSS Load (lb/yr)		Total Copper Load (lb/yr)		Dissolved Copper Load (lb/yr)		Total Zinc Load (lb/yr)		Dissolved Zinc Load (lb/yr)	
	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
Max	19126	4254	2.47	0.19	0.789	0.15	13.2	1.1	10.2	1.1
75th Percentile	498	41	0.111	0.023	0.026	0.015	0.673	0.12	0.207	0.081
Median	243	18	0.063	0.016	0.015	0.01	0.377	0.076	0.109	0.052
25th Percentile	119	7.7	0.036	0.011	0.009	0.007	0.212	0.05	0.058	0.034
Min	3.14	0.083	0.002	0.001	0	0.001	0.008	0.005	0.002	0.003
P (exceed)		0.053		0.089		0.352		0.066		0.261

Concentration Analysis

Subbasin 1	TSS Conc (mg/L)		Total Copper Conc (mg/L)		Dissolved Copper Conc (mg/L)		Total Zinc Conc (mg/L)		Dissolved Zinc Conc (mg/L)	
	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
Max	4473.578	963.056	0.561	0.047	0.198	0.036	3.134	0.445	1.791	0.24
75th Percentile	124.121	12.716	0.028	0.007	0.007	0.005	0.168	0.036	0.053	0.025
Median	61.488	5.605	0.016	0.005	0.004	0.003	0.096	0.024	0.028	0.016
25th Percentile	30.495	2.454	0.009	0.003	0.002	0.002	0.054	0.016	0.015	0.011
Min	0.7	0.02	0	0.001	0	0	0.003	0.002	0	0.001
P (exceed)		0.067		0.117		0.432		0.088		0.319

Highway Runoff Dilution and Loading model (HI-RUN) Version 1.20100315

End of Pipe Loading Subroutine Report

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

Date/Time of Run: 9/7/10 16:07
Outfall ID: WS-PR
Rain Gauge: Puget East 40

Baseline Conditions
None
0% Infiltration - 12.6 acres

Proposed Conditions
Basic
0% Infiltration - 23.72 acres

Load Analysis

	TSS Load (lb/yr)		Total Copper Load (lb/yr)		Dissolved Copper Load (lb/yr)		Total Zinc Load (lb/yr)		Dissolved Zinc Load (lb/yr)	
	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
Max	438036	284670	52.6	9.8	10.2	8.9	395	84	171	40
75th Percentile	11713	2244	2.61	1.3	0.62	0.85	15.7	6.4	4.88	4.5
Median	5748	981	1.48	0.86	0.357	0.57	8.81	4.2	2.58	2.9
25th Percentile	2792	428	0.841	0.58	0.205	0.37	4.95	2.7	1.35	1.9
Min	38.7	3.8	0.032	0.066	0.012	0.034	0.267	0.19	0.041	0.16
P (exceed)		0.14		0.3		0.672		0.242		0.541

Concentration Analysis

Subbasin 1	TSS Conc (mg/L)		Total Copper Conc (mg/L)		Dissolved Copper Conc (mg/L)		Total Zinc Conc (mg/L)		Dissolved Zinc Conc (mg/L)	
	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
Max	7938.681	1076.861	0.428	0.068	0.136	0.037	3.629	0.29	1.495	0.29
75th Percentile	124.691	12.658	0.028	0.007	0.007	0.005	0.168	0.036	0.052	0.025
Median	61.842	5.596	0.016	0.005	0.004	0.003	0.096	0.024	0.028	0.017
25th Percentile	30.812	2.476	0.009	0.003	0.002	0.002	0.055	0.016	0.015	0.011
Min	0.55	0.027	0	0	0	0	0.003	0.002	0.001	0.001
P (exceed)		0.067		0.119		0.429		0.089		0.322

Highway Runoff Dilution and Loading model (HI-RUN) Version 1.20100315

End of Pipe Loading Subroutine Report

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

Date/Time of Run: 10/7/10 00:42
Outfall ID: WS-BR4
Rain Gauge: Puget East 40

Baseline Conditions
None
0% Infiltration - 17.28 acres

Proposed Conditions
Basic
0% Infiltration - 20.56 acres

Load Analysis

	TSS Load (lb/yr)		Total Copper Load (lb/yr)		Dissolved Copper Load (lb/yr)		Total Zinc Load (lb/yr)		Dissolved Zinc Load (lb/yr)	
	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
Max	1031110	101531	84.4	8.6	18.8	6.5	544	45	223	36
75th Percentile	16090	1962	3.57	1.1	0.852	0.74	21.5	5.6	6.76	3.9
Median	7894	850	2.02	0.75	0.491	0.49	12.1	3.7	3.54	2.5
25th Percentile	3859	371	1.15	0.51	0.282	0.33	6.83	2.4	1.87	1.6
Min	63.3	4.2	0.051	0.064	0.016	0.025	0.238	0.13	0.048	0.14
P (exceed)		0.086		0.165		0.5		0.128		0.381

Concentration Analysis

Subbasin 1	TSS Conc (mg/L)		Total Copper Conc (mg/L)		Dissolved Copper Conc (mg/L)		Total Zinc Conc (mg/L)		Dissolved Zinc Conc (mg/L)	
	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
Max	3965.018	1288.928	0.556	0.051	0.122	0.036	2.92	0.297	1.734	0.198
75th Percentile	125.074	12.735	0.028	0.007	0.007	0.005	0.169	0.036	0.052	0.025
Median	61.718	5.629	0.016	0.005	0.004	0.003	0.096	0.024	0.028	0.017
25th Percentile	30.577	2.469	0.009	0.003	0.002	0.002	0.055	0.016	0.015	0.011
Min	0.57	0.033	0	0	0	0	0.003	0.002	0	0.001
P (exceed)		0.068		0.118		0.43		0.089		0.321

Highway Runoff Dilution and Loading model (HI-RUN) Version 1.20100315

End of Pipe Loading Subroutine Report

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

Date/Time of Run: 9/7/10 15:30
Outfall ID: WS-G
Rain Gauge: Puget East 40

Baseline Conditions
None 0% Infiltration - 1.75 acres

Proposed Conditions
Basic 0% Infiltration - 1.70 acres

Load Analysis

	TSS Load (lb/yr)		Total Copper Load (lb/yr)		Dissolved Copper Load (lb/yr)		Total Zinc Load (lb/yr)		Dissolved Zinc Load (lb/yr)	
	Baseline	**Proposed**	**Baseline**	**Proposed**	**Baseline**	**Proposed**	**Baseline**	**Proposed**	**Baseline**	**Proposed**
Max	99631	10052	5.92	0.79	1.9	0.48	53.5	3.8	30.2	3.6
75th Percentile	1624	159	0.361	0.092	0.087	0.06	2.18	0.46	0.68	0.32
Median	792	69	0.206	0.062	0.049	0.04	1.23	0.3	0.358	0.2
25th Percentile	388	30	0.117	0.042	0.028	0.027	0.693	0.2	0.188	0.13
Min	9.47	0.39	0.006	0.004	0.001	0.002	0.042	0.02	0.008	0.013
P (exceed)		0.068		0.12		0.419		0.092		0.315

Concentration Analysis

Subbasin 1	TSS Conc (mg/L)		Total Copper Conc (mg/L)		Dissolved Copper Conc (mg/L)		Total Zinc Conc (mg/L)		Dissolved Zinc Conc (mg/L)	
	Baseline	**Proposed**	**Baseline**	**Proposed**	**Baseline**	**Proposed**	**Baseline**	**Proposed**	**Baseline**	**Proposed**
Max	3820.911	1178.02	0.41	0.05	0.13	0.033	3.486	0.289	1.286	0.221
75th Percentile	124.815	12.78	0.028	0.007	0.007	0.005	0.168	0.036	0.052	0.025
Median	61.42	5.618	0.016	0.005	0.004	0.003	0.096	0.024	0.028	0.016
25th Percentile	30.43	2.464	0.009	0.003	0.002	0.002	0.055	0.016	0.015	0.011
Min	0.848	0.034	0	0	0	0	0.002	0.002	0	0.001
P (exceed)		0.068		0.118		0.429		0.089		0.318

Highway Runoff Dilution and Loading model (HI-RUN) Version 1.20100315

End of Pipe Loading Subroutine Report

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

Date/Time of Run: 9/7/10 16:45
Outfall ID: WS-J
Rain Gauge: Puget East 40

Baseline Conditions
None
0% Infiltration - 5.42 acres

Proposed Conditions
Basic
0% Infiltration - 4.48 acres

Load Analysis

	TSS Load (lb/yr)		Total Copper Load (lb/yr)		Dissolved Copper Load (lb/yr)		Total Zinc Load (lb/yr)		Dissolved Zinc Load (lb/yr)	
	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
Max	187144	48727	24.1	2	4.19	1.4	160	11	60.5	6.8
75th Percentile	5054	422	1.11	0.24	0.267	0.16	6.83	1.2	2.1	0.84
Median	2476	184	0.634	0.16	0.154	0.11	3.84	0.8	1.11	0.54
25th Percentile	1210	80	0.36	0.11	0.088	0.07	2.15	0.52	0.581	0.35
Min	20.6	0.79	0.015	0.012	0.004	0.008	0.084	0.059	0.017	0.031
P (exceed)		0.055		0.092		0.361		0.07		0.269

Concentration Analysis

Subbasin 1	TSS Conc (mg/L)		Total Copper Conc (mg/L)		Dissolved Copper Conc (mg/L)		Total Zinc Conc (mg/L)		Dissolved Zinc Conc (mg/L)	
	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
Max	7034.451	1428.444	0.398	0.057	0.093	0.036	3.723	0.272	1.569	0.215
75th Percentile	124.247	12.668	0.027	0.007	0.007	0.005	0.168	0.036	0.053	0.025
Median	61.137	5.568	0.016	0.005	0.004	0.003	0.096	0.024	0.028	0.017
25th Percentile	30.287	2.457	0.009	0.003	0.002	0.002	0.055	0.016	0.015	0.011
Min	0.761	0.032	0.001	0	0	0	0.002	0.002	0.001	0.001
P (exceed)		0.067		0.118		0.43		0.09		0.323

Highway Runoff Dilution and Loading model (HI-RUN) Version 1.20100315

End of Pipe Loading Subroutine Report

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

Date/Time of Run: 9/5/10 10:31
Outfall ID: RWB-G
Rain Gauge: Puget East 40

Baseline Conditions
None
0% Infiltration - 0.16 acres

Proposed Conditions
Enhanced
0% Infiltration - 0.04 acres

Load Analysis

	TSS Load (lb/yr)		Total Copper Load (lb/yr)		Dissolved Copper Load (lb/yr)		Total Zinc Load (lb/yr)		Dissolved Zinc Load (lb/yr)	
	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
Max	8135	364	0.592	0.016	0.122	0.012	3.67	0.093	1.82	0.097
75th Percentile	133	3.5	0.03	0.002	0.007	0.001	0.181	0.01	0.056	0.007
Median	65.1	1.5	0.017	0.001	0.004	0.001	0.101	0.007	0.029	0.004
25th Percentile	31.8	0.66	0.01	0.001	0.002	0.001	0.057	0.004	0.015	0.003
Min	0.792	0.01	0	0	0	0	0.003	0	0.001	0
P (exceed)		0.011		0.007		0.068		0.005		0.053

Concentration Analysis

Subbasin 1	TSS Conc (mg/L)		Total Copper Conc (mg/L)		Dissolved Copper Conc (mg/L)		Total Zinc Conc (mg/L)		Dissolved Zinc Conc (mg/L)	
	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
Max	4193.266	1430.394	0.605	0.049	0.127	0.056	3.34	0.294	1.392	0.335
75th Percentile	125.085	12.713	0.027	0.007	0.007	0.005	0.167	0.036	0.052	0.025
Median	62.408	5.555	0.016	0.005	0.004	0.003	0.095	0.024	0.028	0.016
25th Percentile	30.707	2.445	0.009	0.003	0.002	0.002	0.054	0.016	0.015	0.011
Min	0.921	0.018	0	0	0	0	0.003	0.002	0	0.001
P (exceed)		0.067		0.119		0.427		0.089		0.319

Highway Runoff Dilution and Loading model (HI-RUN) Version 1.20100315

End of Pipe Loading Subroutine Report

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

Date/Time of Run: 10/7/10 00:37
Outfall ID: Combined Sewer System (CSS)
Rain Gauge: Puget East 40

Baseline Conditions
Basic
0% Infiltration - 5.24 acres

Proposed Conditions
Basic
0% Infiltration - 5.51 acres

Load Analysis

	TSS Load (lb/yr)		Total Copper Load (lb/yr)		Dissolved Copper Load (lb/yr)		Total Zinc Load (lb/yr)		Dissolved Zinc Load (lb/yr)	
	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
Max	28107	37032	2.29	3.6	1.84	2.4	12.3	16	9.25	10
75th Percentile	494	519	0.284	0.3	0.189	0.2	1.41	1.5	0.986	1
Median	215	226	0.191	0.2	0.125	0.13	0.925	0.98	0.637	0.67
25th Percentile	93.7	99	0.129	0.14	0.083	0.087	0.602	0.64	0.412	0.43
Min	0.991	1.3	0.015	0.004	0.008	0.01	0.042	0.063	0.017	0.038
P (exceed)		0.512		0.528		0.521		0.523		0.523

Concentration Analysis

Subbasin 1	TSS Conc (mg/L)		Total Copper Conc (mg/L)		Dissolved Copper Conc (mg/L)		Total Zinc Conc (mg/L)		Dissolved Zinc Conc (mg/L)	
	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
Max	1288.928	1195.146	0.051	0.049	0.038	0.047	0.297	0.543	0.198	0.313
75th Percentile	12.743	12.78	0.007	0.007	0.005	0.005	0.036	0.036	0.025	0.025
Median	5.628	5.608	0.005	0.005	0.003	0.003	0.024	0.024	0.017	0.016
25th Percentile	2.47	2.453	0.003	0.003	0.002	0.002	0.016	0.016	0.011	0.011
Min	0.033	0.03	0	0	0	0	0.002	0.002	0.001	0.001
P (exceed)		0.499		0.5		0.501		0.498		0.499

Highway Runoff Dilution and Loading model (HI-RUN) Version 1.20100315

End of Pipe Loading Subroutine Report

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

Date/Time of Run: 10/18/10 22:44
Outfall ID: Final_Summary
Rain Gauge: Puget East 40

Baseline Conditions
None
0% Infiltration - 66.82 acres
Basic
0% Infiltration - 5.24 acres

Proposed Conditions
None
0% Infiltration - 13.13 acres
Basic
0% Infiltration - 69.18 acres

Load Analysis

	TSS Load (lb/yr)		Total Copper Load (lb/yr)		Dissolved Copper Load (lb/yr)		Total Zinc Load (lb/yr)		Dissolved Zinc Load (lb/yr)	
	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
Max	3173278	1088716	262	58	89.8	31	1584	357	1067	154
75th Percentile	62577	19921	14	6.4	3.45	3.1	85.1	35	26.6	18
Median	30711	11083	8.1	4.5	2.04	2.2	48.3	24	14.4	12
25th Percentile	15249	6180	4.66	3.2	1.23	1.5	27.6	17	7.98	8.5
Min	452	230	0.353	0.36	0.121	0.22	1.55	1.5	0.298	0.88
P (exceed)		0.226		0.273		0.52		0.245		0.441

Concentration Analysis

Subbasin 1	TSS Conc (mg/L)		Total Copper Conc (mg/L)		Dissolved Copper Conc (mg/L)		Total Zinc Conc (mg/L)		Dissolved Zinc Conc (mg/L)	
	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed	Baseline	Proposed
Max	4148.765	1018.449	0.521	0.089	0.184	0.041	2.908	0.655	1.662	0.438
75th Percentile	115.922	32.606	0.026	0.01	0.006	0.005	0.158	0.056	0.05	0.029
Median	57.897	18.395	0.015	0.007	0.004	0.004	0.091	0.039	0.027	0.02
25th Percentile	29.093	10.44	0.009	0.005	0.002	0.003	0.053	0.028	0.015	0.014
Min	0.7	0.406	0.001	0.001	0	0	0.004	0.005	0.001	0.002
P (exceed)		0.193		0.217		0.469		0.193		0.385

ATTACHMENT 2: CORMIX MODELING INPUT DATA

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 5.0GT
HYDRO1:Version-5.0.2.0 October,2008
SITE NAME/LABEL: WS-G
DESIGN CASE: January, DCu
FILE NAME: C:\Program Files\CORMIX 5.0\SR 520\East Approach\EA DCu Jan prop 40.prd
Using subsystem CORMIX1: Single Port Discharges
Start of session: 05/28/2009--11:51:36
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 2.13 m
Depth at discharge HD = 1.52 m
Ambient velocity UA = 0.0030 m/s
Darcy-Weisbach friction factor F = 0.0381
Calculated from Manning's n = 0.025
Wind velocity UW = 0 m/s
Stratification Type STRCND = U
Surface temperature = 9 degC
Bottom temperature = 9 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 999.7833 kg/m^3
Bottom density RHOAB = 999.7833 kg/m^3

DISCHARGE PARAMETERS: Single Port Discharge
Nearest bank = right
Distance to bank DISTB = 0.00 m
Port diameter D0 = 0.0535 m
Port cross-sectional area A0 = 0.0023 m^2
Discharge velocity U0 = 0.30 m/s
Discharge flowrate Q0 = 0.000665 m^3/s
Discharge port height H0 = 1.52 m
Vertical discharge angle THETA = -55.77 deg
Horizontal discharge angle SIGMA = 90 deg
Discharge temperature (freshwater) = 9 degC
Corresponding density RHO0 = 999.7833 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 0.00606 ppm
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:
LQ = 0.05 m Lm = 4.60 m Lb = 0 m
LM = 99999 m Lm' = 99999 m Lb' = 99999 m

NON-DIMENSIONAL PARAMETERS:
Port densimetric Froude number FR0 = 99999

Velocity ratio R = 97.02

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
Toxic discharge = no
Water quality standard specified = yes
Water quality standard CSTD = 0.002 ppm
Regulatory mixing zone = no
Region of interest = 500 m downstream
****
HYDRODYNAMIC CLASSIFICATION:

| FLOW CLASS = IV4 |

This flow configuration applies to a layer corresponding to the full water depth at the discharge site.
Applicable layer depth = water depth = 1.52 m
****
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
Origin is located at the bottom below the port center:
0.00 m from the right bank/shore.
Number of display steps NSTEP = 50 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.
Pollutant concentration at NFR edge c = 0.0008 ppm
Dilution at edge of NFR s = 7.9
NFR Location: x = 1.59 m
(centerline coordinates) y = 5.24 m
z = 0 m
NFR plume dimensions: half-width (bh) = 0.56 m
thickness (bv) = 1.52 m
Cumulative travel time: 512.6221 sec.

Buoyancy assessment:
The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

Near-field instability behavior:
The discharge flow will experience instabilities with full vertical mixing in the near-field.
There may be benthic impact of high pollutant concentrations.

FAR-FIELD MIXING SUMMARY:
Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 1.59 m downstream and continues as vertically mixed into the far-field.

PLUME BANK CONTACT SUMMARY:

Plume in unbounded section contacts nearest bank at 6.13 m downstream.

************************ TOXIC DILUTION ZONE SUMMARY ************************

No TDZ was specified for this simulation.

********************** REGULATORY MIXING ZONE SUMMARY **********************

No RMZ has been specified.

However:

The ambient water quality standard was encountered at the following
plume position:

Water quality standard = 0.002 ppm
Corresponding dilution s = 3.0
Plume location: x = 0.02 m
(centerline coordinates) y = 0.50 m
z = 0.79 m
Plume dimension: half-width (bh) = 0.10 m

********************* FINAL DESIGN ADVICE AND COMMENTS **********************

REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known technique is NOT AN EXACT SCIENCE.

Extensive comparison with field and laboratory data has shown that the CORMIX predictions on dilutions and concentrations (with associated plume geometries) are reliable for the majority of cases and are accurate to within about +-50% (standard deviation).

As a further safeguard, CORMIX will not give predictions whenever it judges the design configuration as highly complex and uncertain for prediction.

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 5.0GT
HYDRO1:Version-5.0.2.0 October,2008
SITE NAME/LABEL: WS-G
DESIGN CASE: January, DZn
FILE NAME: C:\Program Files\CORMIX 5.0\SR 520\East Approach\EA DZn Jan prop 40.prd
Using subsystem CORMIX1: Single Port Discharges
Start of session: 05/28/2009--11:59:34
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 2.13 m
Depth at discharge HD = 1.52 m
Ambient velocity UA = 0.0030 m/s
Darcy-Weisbach friction factor F = 0.0381
Calculated from Manning's n = 0.025
Wind velocity UW = 0 m/s
Stratification Type STRCND = U
Surface temperature = 9 degC
Bottom temperature = 9 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 999.7833 kg/m^3
Bottom density RHOAB = 999.7833 kg/m^3

DISCHARGE PARAMETERS: Single Port Discharge
Nearest bank = right
Distance to bank DISTB = 0.00 m
Port diameter D0 = 0.0535 m
Port cross-sectional area A0 = 0.0023 m^2
Discharge velocity U0 = 0.30 m/s
Discharge flowrate Q0 = 0.000665 m^3/s
Discharge port height H0 = 1.52 m
Vertical discharge angle THETA = -55.77 deg
Horizontal discharge angle SIGMA = 90 deg
Discharge temperature (freshwater) = 9 degC
Corresponding density RHO0 = 999.7833 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 0.0348 ppm
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:
LQ = 0.05 m Lm = 4.60 m Lb = 0 m
LM = 99999 m Lm' = 99999 m Lb' = 99999 m

NON-DIMENSIONAL PARAMETERS:
Port densimetric Froude number FR0 = 99999

Velocity ratio R = 97.02

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
Toxic discharge = no
Water quality standard specified = yes
Water quality standard CSTD = 0.0056 ppm
Regulatory mixing zone = no
Region of interest = 500 m downstream
****
HYDRODYNAMIC CLASSIFICATION:

| FLOW CLASS = IV4 |

This flow configuration applies to a layer corresponding to the full water depth at the discharge site.
Applicable layer depth = water depth = 1.52 m
****
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
Origin is located at the bottom below the port center:
0.00 m from the right bank/shore.
Number of display steps NSTEP = 50 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.
Pollutant concentration at NFR edge c = 0.0044 ppm
Dilution at edge of NFR s = 7.9
NFR Location: x = 1.59 m
(centerline coordinates) y = 5.24 m
z = 0 m
NFR plume dimensions: half-width (bh) = 0.56 m
thickness (bv) = 1.52 m
Cumulative travel time: 512.6221 sec.

Buoyancy assessment:
The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

Near-field instability behavior:
The discharge flow will experience instabilities with full vertical mixing in the near-field.
There may be benthic impact of high pollutant concentrations.

FAR-FIELD MIXING SUMMARY:
Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 1.59 m downstream and continues as vertically mixed into the far-field.

PLUME BANK CONTACT SUMMARY:

Plume in unbounded section contacts nearest bank at 6.13 m downstream.

************************ TOXIC DILUTION ZONE SUMMARY ************************

No TDZ was specified for this simulation.

********************** REGULATORY MIXING ZONE SUMMARY **********************

No RMZ has been specified.

However:

The ambient water quality standard was encountered at the following plume position:

Water quality standard = 0.0056 ppm
Corresponding dilution s = 6.2
Plume location: x = 0.49 m
(centerline coordinates) y = 5.24 m
z = 0 m
Plume dimensions: half-width (bh) = 0.33 m
thickness (bv) = 1.52 m

********************* FINAL DESIGN ADVICE AND COMMENTS **********************

REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known technique is NOT AN EXACT SCIENCE.

Extensive comparison with field and laboratory data has shown that the CORMIX predictions on dilutions and concentrations (with associated plume geometries) are reliable for the majority of cases and are accurate to within about +-50% (standard deviation).

As a further safeguard, CORMIX will not give predictions whenever it judges the design configuration as highly complex and uncertain for prediction.

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 5.0GT
HYDRO1:Version-5.0.2.0 October,2008
SITE NAME/LABEL: WS-G
DESIGN CASE: August, DCu
FILE NAME: C:\Program Files\CORMIX 5.0\SR 520\East Approach\EA DCu Aug prop 40.prd
Using subsystem CORMIX1: Single Port Discharges
Start of session: 05/28/2009--11:52:49
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 2.13 m
Depth at discharge HD = 1.52 m
Ambient velocity UA = 0.0030 m/s
Darcy-Weisbach friction factor F = 0.0381
Calculated from Manning's n = 0.025
Wind velocity UW = 0 m/s
Stratification Type STRCND = U
Surface temperature = 24 degC
Bottom temperature = 24 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 997.2973 kg/m^3
Bottom density RHOAB = 997.2973 kg/m^3

DISCHARGE PARAMETERS: Single Port Discharge
Nearest bank = right
Distance to bank DISTB = 0.00 m
Port diameter D0 = 0.0409 m
Port cross-sectional area A0 = 0.0013 m^2
Discharge velocity U0 = 0.26 m/s
Discharge flowrate Q0 = 0.000340 m^3/s
Discharge port height H0 = 1.52 m
Vertical discharge angle THETA = -70.84 deg
Horizontal discharge angle SIGMA = 90 deg
Discharge temperature (freshwater) = 24 degC
Corresponding density RHO0 = 997.2973 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 0.00606 ppm
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:
LQ = 0.04 m Lm = 3.08 m Lb = 0 m
LM = 99999 m Lm' = 99999 m Lb' = 99999 m

NON-DIMENSIONAL PARAMETERS:
Port densimetric Froude number FR0 = 99999

Velocity ratio R = 84.92

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
Toxic discharge = no
Water quality standard specified = yes
Water quality standard CSTD = 0.002 ppm
Regulatory mixing zone = no
Region of interest = 500 m downstream
****
HYDRODYNAMIC CLASSIFICATION:

| FLOW CLASS = IV4 |

This flow configuration applies to a layer corresponding to the full water depth at the discharge site.
Applicable layer depth = water depth = 1.52 m
****
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
Origin is located at the bottom below the port center:
0.00 m from the right bank/shore.
Number of display steps NSTEP = 50 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.
Pollutant concentration at NFR edge c = 0.0007 ppm
Dilution at edge of NFR s = 9.3
NFR Location: x = 1.61 m
(centerline coordinates) y = 2.24 m
z = 0 m
NFR plume dimensions: half-width (bh) = 0.34 m
thickness (bv) = 1.52 m
Cumulative travel time: 515.1364 sec.

Buoyancy assessment:
The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

Near-field instability behavior:
The discharge flow will experience instabilities with full vertical mixing in the near-field.
There may be benthic impact of high pollutant concentrations.

FAR-FIELD MIXING SUMMARY:
Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 1.61 m downstream and continues as vertically mixed into the far-field.

PLUME BANK CONTACT SUMMARY:
  Plume in unbounded section contacts nearest bank at 3.99 m downstream.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY ***********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
  plume position:
  Water quality standard = 0.002 ppm
  Corresponding dilution s = 3.0
  Plume location: x = 0.01 m
    (centerline coordinates) y = 0.22 m
    z = 0.89 m
  Plume dimension: half-width (bh) = 0.07 m
********************* FINAL DESIGN ADVICE AND COMMENTS **********************
REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known
  technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
  CORMIX predictions on dilutions and concentrations (with associated
  plume geometries) are reliable for the majority of cases and are accurate
  to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
  the design configuration as highly complex and uncertain for prediction.

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 5.0GT
HYDRO1:Version-5.0.2.0 October,2008
SITE NAME/LABEL: WS-G
DESIGN CASE: August, DZn
FILE NAME: C:\Program Files\CORMIX 5.0\SR 520\East Approach\EA DZn Aug prop 40.prd
Using subsystem CORMIX1: Single Port Discharges
Start of session: 05/28/2009--11:56:28
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 2.13 m
Depth at discharge HD = 1.52 m
Ambient velocity UA = 0.0030 m/s
Darcy-Weisbach friction factor F = 0.0381
Calculated from Manning's n = 0.025
Wind velocity UW = 0 m/s
Stratification Type STRCND = U
Surface temperature = 24 degC
Bottom temperature = 24 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 997.2973 kg/m^3
Bottom density RHOAB = 997.2973 kg/m^3

DISCHARGE PARAMETERS: Single Port Discharge
Nearest bank = right
Distance to bank DISTB = 0.00 m
Port diameter D0 = 0.0409 m
Port cross-sectional area A0 = 0.0013 m^2
Discharge velocity U0 = 0.26 m/s
Discharge flowrate Q0 = 0.000340 m^3/s
Discharge port height H0 = 1.52 m
Vertical discharge angle THETA = -70.84 deg
Horizontal discharge angle SIGMA = 90 deg
Discharge temperature (freshwater) = 24 degC
Corresponding density RHO0 = 997.2973 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 0.0349 ppm
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:
LQ = 0.04 m Lm = 3.08 m Lb = 0 m
LM = 99999 m Lm' = 99999 m Lb' = 99999 m

NON-DIMENSIONAL PARAMETERS:
Port densimetric Froude number FR0 = 99999

Velocity ratio R = 84.92

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
Toxic discharge = no
Water quality standard specified = yes
Water quality standard CSTD = 0.0056 ppm
Regulatory mixing zone = no
Region of interest = 500 m downstream
****
HYDRODYNAMIC CLASSIFICATION:

| FLOW CLASS = IV4 |

This flow configuration applies to a layer corresponding to the full water depth at the discharge site.
Applicable layer depth = water depth = 1.52 m
****
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
Origin is located at the bottom below the port center:
0.00 m from the right bank/shore.
Number of display steps NSTEP = 50 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.
Pollutant concentration at NFR edge c = 0.0038 ppm
Dilution at edge of NFR s = 9.3
NFR Location: x = 1.61 m
(centerline coordinates) y = 2.24 m
z = 0 m
NFR plume dimensions: half-width (bh) = 0.34 m
thickness (bv) = 1.52 m
Cumulative travel time: 515.1364 sec.

Buoyancy assessment:
The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

Near-field instability behavior:
The discharge flow will experience instabilities with full vertical mixing in the near-field.
There may be benthic impact of high pollutant concentrations.

FAR-FIELD MIXING SUMMARY:
Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 1.61 m downstream and continues as vertically mixed into the far-field.

PLUME BANK CONTACT SUMMARY:
Plume in unbounded section contacts nearest bank at 3.99 m downstream.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY **********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
plume position:
Water quality standard = 0.0056 ppm
Corresponding dilution s = 6.2
Plume location: x = 0.08 m
(centerline coordinates) y = 0.45 m
z = 0.24 m
Plume dimension: half-width (bh) = 0.15 m
********************* FINAL DESIGN ADVICE AND COMMENTS *********************
REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known
technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
CORMIX predictions on dilutions and concentrations (with associated
plume geometries) are reliable for the majority of cases and are accurate
to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
the design configuration as highly complex and uncertain for prediction.

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 5.0GT
HYDRO1:Version-5.0.2.0 October,2008
SITE NAME/LABEL: WS-J
DESIGN CASE: WS-J Prop DCU Jan
FILE NAME: C:\Documents and Settings\deutsann\Desktop\New Folder\FWB prop DCu Ja
Using subsystem CORMIX1: Single Port Discharges
Start of session: 05/26/2009--18:06:41
****

SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = bounded
Width BS = 45.72 m
Channel regularity ICHREG = 1
Ambient flowrate QA = 0.08 m^3/s
Average depth HA = 1.83 m
Depth at discharge HD = 1.52 m
Ambient velocity UA = 0.0010 m/s
Darcy-Weisbach friction factor F = 0.0401
Calculated from Manning's n = 0.025
Wind velocity UW = 0 m/s
Stratification Type STRCND = U
Surface temperature = 9 degC
Bottom temperature = 9 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 999.7833 kg/m^3
Bottom density RHOAB = 999.7833 kg/m^3

DISCHARGE PARAMETERS: Single Port Discharge
Nearest bank = left
Distance to bank DISTB = 0.83 m
Port diameter D0 = 0.0543 m
Port cross-sectional area A0 = 0.0023 m^2
Discharge velocity U0 = 5.56 m/s
Discharge flowrate Q0 = 0.012864 m^3/s
Discharge port height H0 = 1.52 m
Vertical discharge angle THETA = -77.33 deg
Horizontal discharge angle SIGMA = 270 deg
Discharge temperature (freshwater) = 9 degC
Corresponding density RHO0 = 999.7833 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 0.00606 mg/l
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:
LQ = 0.05 m Lm = 263.22 m Lb = 0 m

LM = 99999 m   Lm' = 99999 m   Lb' = 99999 m

NON-DIMENSIONAL PARAMETERS:
  Port densimetric Froude number FR0 = 99999
  Velocity ratio R = 5471.80

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge = no
  Water quality standard specified = yes
  Water quality standard CSTD = 0.002 mg/l
  Regulatory mixing zone = no
  Region of interest = 500 m downstream

****

HYDRODYNAMIC CLASSIFICATION:

```
  *------------------------*
  | FLOW CLASS   = IV4 |
  *------------------------*
```

  This flow configuration applies to a layer corresponding to the full water depth at the discharge site.
  Applicable layer depth = water depth = 1.52 m

****

MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
  Origin is located at the bottom below the port center:
    0.83 m from the left bank/shore.
  Number of display steps NSTEP = 50 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.

```
  Pollutant concentration at NFR edge  c = 0.0009 mg/l
  Dilution at edge of NFR              s = 6.5
  NFR Location:                        x = 1.52 m
    (centerline coordinates)           y = -133.10 m
                                       z = 0 m
  NFR plume dimensions:  half-width (bh) = 27.18 m
                         thickness (bv) = 1.52 m
Cumulative travel time:     1500.4781 sec.
```

Buoyancy assessment:
  The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
  Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

Near-field instability behavior:
  The discharge flow will experience instabilities with full vertical mixing in the near-field.

There may be benthic impact of high pollutant concentrations.

FAR-FIELD MIXING SUMMARY:
Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 0 m
downstream and continues as vertically mixed into the far-field.
Plume becomes laterally fully mixed at 1.52 m
downstream.

PLUME BANK CONTACT SUMMARY:
Plume contacts both banks simultaneously.
The x-coordinate for this contact is 1.52 m.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY **********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
plume position:
Water quality standard = 0.002 mg/l
Corresponding dilution s = 3.0
Plume location: x = 0.00 m
(centerline coordinates) y = -0.20 m
z = 0.63 m
Plume dimension: half-width (bh) = 0.10 m
********************* FINAL DESIGN ADVICE AND COMMENTS *********************
REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known
technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
CORMIX predictions on dilutions and concentrations (with associated
plume geometries) are reliable for the majority of cases and are accurate
to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
the design configuration as highly complex and uncertain for prediction.

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CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 5.0GT
HYDRO1:Version-5.0.2.0 October,2008
SITE NAME/LABEL: WS-J
DESIGN CASE: WS-J Prop DZn Jan
FILE NAME: C:\Documents and Settings\deutsann\Desktop\New Folder\FWB prop DZn Ja
Using subsystem CORMIX1: Single Port Discharges
Start of session: 05/26/2009--18:07:32
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = bounded
Width BS = 45.72 m
Channel regularity ICHREG = 1
Ambient flowrate QA = 0.08 m^3/s
Average depth HA = 1.83 m
Depth at discharge HD = 1.52 m
Ambient velocity UA = 0.0010 m/s
Darcy-Weisbach friction factor F = 0.0401
Calculated from Manning's n = 0.025
Wind velocity UW = 0 m/s
Stratification Type STRCND = U
Surface temperature = 9 degC
Bottom temperature = 9 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 999.7833 kg/m^3
Bottom density RHOAB = 999.7833 kg/m^3

DISCHARGE PARAMETERS: Single Port Discharge
Nearest bank = right
Distance to bank DISTB = 0.82 m
Port diameter D0 = 0.0543 m
Port cross-sectional area A0 = 0.0023 m^2
Discharge velocity U0 = 5.56 m/s
Discharge flowrate Q0 = 0.012864 m^3/s
Discharge port height H0 = 1.52 m
Vertical discharge angle THETA = -77.33 deg
Horizontal discharge angle SIGMA = 80 deg
Discharge temperature (freshwater) = 9 degC
Corresponding density RHO0 = 999.7833 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 0.0348 mg/l
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:
LQ = 0.05 m Lm = 263.22 m Lb = 0 m

LM = 99999 m   Lm' = 99999 m   Lb' = 99999 m

NON-DIMENSIONAL PARAMETERS:

Port densimetric Froude number FR0 = 99999
Velocity ratio R = 5471.80

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:

Toxic discharge = no
Water quality standard specified = yes
Water quality standard CSTD = 0.0056 mg/l
Regulatory mixing zone = no
Region of interest = 500 m downstream

****

HYDRODYNAMIC CLASSIFICATION:

| FLOW CLASS = IV4 |

This flow configuration applies to a layer corresponding to the full water depth at the discharge site.
Applicable layer depth = water depth = 1.52 m

****

MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:

Origin is located at the bottom below the port center:
0.82 m from the right bank/shore.
Number of display steps NSTEP = 50 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :

Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.

Pollutant concentration at NFR edge c = 0.0053 mg/l
Dilution at edge of NFR s = 6.5
NFR Location: x = 1.58 m
(centerline coordinates) y = 4.49 m
z = 0 m
NFR plume dimensions: half-width (bh) = 27.19 m
thickness (bv) = 1.52 m
Cumulative travel time: 1500.4779 sec.

Buoyancy assessment:

The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

Near-field instability behavior:

The discharge flow will experience instabilities with full vertical mixing in the near-field.

There may be benthic impact of high pollutant concentrations.

FAR-FIELD MIXING SUMMARY:
Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 1.58 m downstream and continues as vertically mixed into the far-field.

PLUME BANK CONTACT SUMMARY:
Plume in bounded section contacts one bank only at 1.58 m downstream.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY **********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following plume position:
Water quality standard = 0.0056 mg/l
Corresponding dilution s = 6.2
Plume location: x = 1.06 m
(centerline coordinates) y = 4.49 m
z = 0 m
Plume dimensions: half-width (bh) = 22.60 m
thickness (bv) = 1.52 m
********************* FINAL DESIGN ADVICE AND COMMENTS *********************
REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the CORMIX predictions on dilutions and concentrations (with associated plume geometries) are reliable for the majority of cases and are accurate to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges the design configuration as highly complex and uncertain for prediction.

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CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 5.0GT
HYDRO1:Version-5.0.2.0 October,2008
SITE NAME/LABEL: WS-J
DESIGN CASE: WS-J Prop DCu Aug
FILE NAME: C:\Documents and Settings\deutsann\Desktop\New Folder\FWB prop DCu Au
Using subsystem CORMIX1: Single Port Discharges
Start of session: 05/26/2009--18:06:29
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = bounded
Width BS = 45.72 m
Channel regularity ICHREG = 1
Ambient flowrate QA = 0.08 m^3/s
Average depth HA = 1.83 m
Depth at discharge HD = 1.52 m
Ambient velocity UA = 0.0010 m/s
Darcy-Weisbach friction factor F = 0.0401
Calculated from Manning's n = 0.025
Wind velocity UW = 0 m/s
Stratification Type STRCND = U
Surface temperature = 24 degC
Bottom temperature = 24 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 997.2973 kg/m^3
Bottom density RHOAB = 997.2973 kg/m^3

DISCHARGE PARAMETERS: Single Port Discharge
Nearest bank = left
Distance to bank DISTB = 0.83 m
Port diameter D0 = 0.0398 m
Port cross-sectional area A0 = 0.0012 m^2
Discharge velocity U0 = 5.56 m/s
Discharge flowrate Q0 = 0.006921 m^3/s
Discharge port height H0 = 1.52 m
Vertical discharge angle THETA = -77.33 deg
Horizontal discharge angle SIGMA = 270 deg
Discharge temperature (freshwater) = 24 degC
Corresponding density RHO0 = 997.2973 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 0.00606 mg/l
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:
LQ = 0.04 m Lm = 193.06 m Lb = 0 m

LM = 99999 m Lm' = 99999 m Lb' = 99999 m

NON-DIMENSIONAL PARAMETERS:

Port densimetric Froude number FR0 = 99999
Velocity ratio R = 5471.80

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:

Toxic discharge = no
Water quality standard specified = yes
Water quality standard CSTD = 0.002 mg/l
Regulatory mixing zone = no
Region of interest = 500 m downstream

****

HYDRODYNAMIC CLASSIFICATION:

```
*------------------------*
| FLOW CLASS   = IV4 |
*------------------------*
```

This flow configuration applies to a layer corresponding to the full water depth at the discharge site.

Applicable layer depth = water depth = 1.52 m

****

MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:

Origin is located at the bottom below the port center:
0.83 m from the left bank/shore.
Number of display steps NSTEP = 50 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :

Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.

Pollutant concentration at NFR edge c = 0.0007 mg/l
Dilution at edge of NFR s = 9.0
NFR Location: x = 1.53 m
(centerline coordinates) y = -93.15 m
z = 0 m
NFR plume dimensions: half-width (bh) = 20.02 m
thickness (bv) = 1.52 m
Cumulative travel time: 1500.6677 sec.

Buoyancy assessment:

The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

Near-field instability behavior:

The discharge flow will experience instabilities with full vertical mixing in the near-field.

There may be benthic impact of high pollutant concentrations.

FAR-FIELD MIXING SUMMARY:
Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 0 m
downstream and continues as vertically mixed into the far-field.
Plume becomes laterally fully mixed at 1.53 m
downstream.

PLUME BANK CONTACT SUMMARY:
Plume contacts both banks simultaneously.
The x-coordinate for this contact is 1.53 m.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY **********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
plume position:
Water quality standard = 0.002 mg/l
Corresponding dilution s = 3.0
Plume location: x = 0.00 m
(centerline coordinates) y = -0.15 m
z = 0.87 m
Plume dimension: half-width (bh) = 0.07 m
********************* FINAL DESIGN ADVICE AND COMMENTS *********************
REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known
technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
CORMIX predictions on dilutions and concentrations (with associated
plume geometries) are reliable for the majority of cases and are accurate
to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
the design configuration as highly complex and uncertain for prediction.

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CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 5.0GT
HYDRO1:Version-5.0.2.0 October,2008
SITE NAME/LABEL: WS-J
DESIGN CASE: WS-J Prop DZn Aug
FILE NAME: C:\Documents and Settings\deutsann\Desktop\New Folder\FWB prop DZn Aug.prd
Using subsystem CORMIX1: Single Port Discharges
Start of session: 05/26/2009--18:06:58
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = bounded
Width BS = 45.72 m
Channel regularity ICHREG = 1
Ambient flowrate QA = 0.08 m^3/s
Average depth HA = 1.83 m
Depth at discharge HD = 1.52 m
Ambient velocity UA = 0.0010 m/s
Darcy-Weisbach friction factor F = 0.0401
Calculated from Manning's n = 0.025
Wind velocity UW = 0 m/s
Stratification Type STRCND = U
Surface temperature = 24 degC
Bottom temperature = 24 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 997.2973 kg/m^3
Bottom density RHOAB = 997.2973 kg/m^3

DISCHARGE PARAMETERS: Single Port Discharge
Nearest bank = left
Distance to bank DISTB = 0.83 m
Port diameter D0 = 0.0398 m
Port cross-sectional area A0 = 0.0012 m^2
Discharge velocity U0 = 5.56 m/s
Discharge flowrate Q0 = 0.006921 m^3/s
Discharge port height H0 = 1.52 m
Vertical discharge angle THETA = -77.33 deg
Horizontal discharge angle SIGMA = 270 deg
Discharge temperature (freshwater) = 24 degC
Corresponding density RHO0 = 997.2973 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 0.035 mg/l
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:
LQ = 0.04 m Lm = 193.06 m Lb = 0 m
LM = 99999 m Lm' = 99999 m Lb' = 99999 m

NON-DIMENSIONAL PARAMETERS:
Port densimetric Froude number FR0 = 99999
Velocity ratio R = 5471.80

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
Toxic discharge = no
Water quality standard specified = yes
Water quality standard CSTD = 0.0056 mg/l
Regulatory mixing zone = no
Region of interest = 500 m downstream
****
HYDRODYNAMIC CLASSIFICATION:

| FLOW CLASS = IV4 |

This flow configuration applies to a layer corresponding to the full water depth at the discharge site.
Applicable layer depth = water depth = 1.52 m
****
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
Origin is located at the bottom below the port center:
0.83 m from the left bank/shore.
Number of display steps NSTEP = 50 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.
Pollutant concentration at NFR edge c = 0.0039 mg/l
Dilution at edge of NFR s = 9.0
NFR Location: x = 1.53 m
(centerline coordinates) y = -93.15 m
z = 0 m
NFR plume dimensions: half-width (bh) = 20.02 m
thickness (bv) = 1.52 m
Cumulative travel time: 1500.6677 sec.

Buoyancy assessment:
The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

Near-field instability behavior:
The discharge flow will experience instabilities with full vertical mixing in the near-field.
There may be benthic impact of high pollutant concentrations.

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 6.0GT
HYDRO1:Version-6.0.0.0 October,2009
SITE NAME/LABEL: 520 West Side Allison
DESIGN CASE: Allison January DCu
FILE NAME: C:\Program Files\CORMIX 6.0\Allison Jan DCu.prd
Using subsystem CORMIX1: Single Port Discharges
Start of session: 04/16/2010--14:44:16
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 3.05 m
Depth at discharge HD = 3.05 m
Ambient velocity UA = 0.01 m/s
Darcy-Weisbach friction factor F = 0.0338
Calculated from Manning's n = 0.025
Wind velocity UW = 0 m/s
Stratification Type STRCND = U
Surface temperature = 9 degC
Bottom temperature = 9 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 999.7833 kg/m^3
Bottom density RHOAB = 999.7833 kg/m^3

DISCHARGE PARAMETERS: Single Port Discharge
Nearest bank = left
Distance to bank DISTB = 150 m
Port diameter D0 = 0.3048 m
Port cross-sectional area A0 = 0.0730 m^2
Discharge velocity U0 = 0.09 m/s
Discharge flowrate Q0 = 0.006612 m^3/s
Discharge port height H0 = 2.67 m
Vertical discharge angle THETA = 0 deg
Horizontal discharge angle SIGMA = 90 deg
Discharge temperature (freshwater) = 9 degC
Corresponding density RHO0 = 999.7833 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 0.00774 mg/l
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:
LQ = 0.27 m Lm = 2.45 m Lb = 0 m
LM = 99999 m Lm' = 99999 m Lb' = 99999 m

NON-DIMENSIONAL PARAMETERS:

Port densimetric Froude number FR0 = 99999
Velocity ratio R = 9.06

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
Toxic discharge = no
Water quality standard specified = yes
Water quality standard CSTD = 0.002 mg/l
Regulatory mixing zone = no
Region of interest = 500 m downstream

****

HYDRODYNAMIC CLASSIFICATION:

| FLOW CLASS = IPH5 |

This flow configuration applies to a layer corresponding to the full water depth at the discharge site.
Applicable layer depth = water depth = 3.05 m

****

MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
Origin is located at the bottom below the port center:
150 m from the left bank/shore.
Number of display steps NSTEP = 50 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.
Pollutant concentration at NFR edge c = 0.0002 mg/l
Dilution at edge of NFR s = 46.8
NFR Location: x = 39.04 m
(centerline coordinates) y = 11.74 m
z = 3.05 m
NFR plume dimensions: half-width (bh) = 1.63 m
thickness (bv) = 3.05 m
Cumulative travel time: 3256.1077 sec.

Buoyancy assessment:
The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

Near-field instability behavior:
The discharge flow will experience instabilities with full vertical mixing in the near-field.
There may be benthic impact of high pollutant concentrations.

FAR-FIELD MIXING SUMMARY:

Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 39.04 m
downstream and continues as vertically mixed into the far-field.

PLUME BANK CONTACT SUMMARY:

Plume in unbounded section contacts nearest bank at 190.46 m downstream.

************************ TOXIC DILUTION ZONE SUMMARY ************************

No TDZ was specified for this simulation.

********************** REGULATORY MIXING ZONE SUMMARY ***********************

No RMZ has been specified.

However:

The ambient water quality standard was encountered at the following
plume position:

Water quality standard = 0.002 mg/l
Corresponding dilution s = 3.9
Plume location: x = 1.50 m
(centerline coordinates) y = 4.38 m
z = 3.05 m
Plume dimension: half-width (bh) = 0.85 m

********************* FINAL DESIGN ADVICE AND COMMENTS **********************

The discharge port or nozzle points towards the nearest bank.
Since this is an UNUSUAL DESIGN, check whether you have specified
correctly the port horizontal angle (SIGMA).

REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known
technique is NOT AN EXACT SCIENCE.

Extensive comparison with field and laboratory data has shown that the
CORMIX predictions on dilutions and concentrations (with associated
plume geometries) are reliable for the majority of cases and are accurate
to within about +-50% (standard deviation).

As a further safeguard, CORMIX will not give predictions whenever it judges
the design configuration as highly complex and uncertain for prediction.

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 6.0GT
HYDRO1:Version-6.0.0.0 October,2009
SITE NAME/LABEL: 520 West Side Allison
DESIGN CASE: Allison August DCu
FILE NAME: C:\Program Files\CORMIX 6.0\Allison Aug DCu.prd
Using subsystem CORMIX1: Single Port Discharges
Start of session: 04/16/2010--14:46:37
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 3.05 m
Depth at discharge HD = 3.05 m
Ambient velocity UA = 0.01 m/s
Darcy-Weisbach friction factor F = 0.0338
Calculated from Manning's n = 0.025
Wind velocity UW = 0 m/s
Stratification Type STRCND = U
Surface temperature = 24 degC
Bottom temperature = 24 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 997.2973 kg/m^3
Bottom density RHOAB = 997.2973 kg/m^3

DISCHARGE PARAMETERS: Single Port Discharge
Nearest bank = left
Distance to bank DISTB = 150 m
Port diameter D0 = 0.3048 m
Port cross-sectional area A0 = 0.0730 m^2
Discharge velocity U0 = 0.05 m/s
Discharge flowrate Q0 = 0.003608 m^3/s
Discharge port height H0 = 2.67 m
Vertical discharge angle THETA = 0 deg
Horizontal discharge angle SIGMA = 90 deg
Discharge temperature (freshwater) = 24 degC
Corresponding density RHO0 = 997.2973 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 0.00774 mg/l
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:
LQ = 0.27 m Lm = 1.34 m Lb = 0 m
LM = 99999 m Lm' = 99999 m Lb' = 99999 m

NON-DIMENSIONAL PARAMETERS:

Port densimetric Froude number FR0   = 99999
Velocity ratio   R   = 4.94

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
Toxic discharge   = no
Water quality standard specified   = yes
Water quality standard   CSTD   = 0.002 mg/l
Regulatory mixing zone   = no
Region of interest   = 500 m downstream
****
HYDRODYNAMIC CLASSIFICATION:

| FLOW CLASS   = IPH4A5I |

This flow configuration applies to a layer corresponding to the full water depth at the discharge site.
Applicable layer depth = water depth = 3.05 m
****
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
Origin is located at the bottom below the port center:
150 m from the left bank/shore.
Number of display steps NSTEP = 50 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.
Pollutant concentration at NFR edge c = 0.001 mg/l
Dilution at edge of NFR   s = 7.6
NFR Location: x = 3.66 m
(centerline coordinates)   y = 3.50 m
                                     z = 3.05 m
NFR plume dimensions: half-width (bh) = 1.17 m
                       thickness (bv) = 1.17 m
Cumulative travel time: 291.822 sec.

Buoyancy assessment:
The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

Benthic attachment:
For the present combination of discharge and ambient conditions, the discharge plume becomes attached to the channel bottom within the NFR immediately following the efflux. High benthic concentrations may occur.

FAR-FIELD MIXING SUMMARY:

Plume becomes vertically fully mixed at 68.21 m downstream.

PLUME BANK CONTACT SUMMARY:
Plume in unbounded section contacts nearest bank at 173.53 m downstream.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY ***********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
plume position:
Water quality standard = 0.002 mg/l
Corresponding dilution s = 3.9
Plume location: x = 1.67 m
(centerline coordinates) y = 2.87 m
z = 3.05 m
Plume dimension: half-width (bh) = 0.71 m
********************* FINAL DESIGN ADVICE AND COMMENTS **********************
The discharge port or nozzle points towards the nearest bank.
Since this is an UNUSUAL DESIGN, check whether you have specified
correctly the port horizontal angle (SIGMA).

REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known
technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
CORMIX predictions on dilutions and concentrations (with associated
plume geometries) are reliable for the majority of cases and are accurate
to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
the design configuration as highly complex and uncertain for prediction.

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 6.0GT
HYDRO1:Version-6.0.0.0 October,2009

SITE NAME/LABEL: 520 West Side Allison
DESIGN CASE: Allison January DZn
FILE NAME: C:\Program Files\CORMIX 6.0\Allison Jan DZn.prd
Using subsystem CORMIX1: Single Port Discharges
Start of session: 04/16/2010--14:45:46

****

SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 3.05 m
Depth at discharge HD = 3.05 m
Ambient velocity UA = 0.01 m/s
Darcy-Weisbach friction factor F = 0.0338
Calculated from Manning's n = 0.025
Wind velocity UW = 0 m/s
Stratification Type STRCND = U
Surface temperature = 9 degC
Bottom temperature = 9 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 999.7833 kg/m^3
Bottom density RHOAB = 999.7833 kg/m^3

DISCHARGE PARAMETERS: Single Port Discharge
Nearest bank = left
Distance to bank DISTB = 150 m
Port diameter D0 = 0.3048 m
Port cross-sectional area A0 = 0.0730 m^2
Discharge velocity U0 = 0.09 m/s
Discharge flowrate Q0 = 0.006612 m^3/s
Discharge port height H0 = 2.67 m
Vertical discharge angle THETA = 0 deg
Horizontal discharge angle SIGMA = 90 deg
Discharge temperature (freshwater) = 9 degC
Corresponding density RHO0 = 999.7833 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 0.0709 mg/l
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:
LQ = 0.27 m Lm = 2.45 m Lb = 0 m
LM = 99999 m Lm' = 99999 m Lb' = 99999 m

NON-DIMENSIONAL PARAMETERS:

Port densimetric Froude number FR0   = 99999
Velocity ratio   R   = 9.06

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
Toxic discharge   = no
Water quality standard specified   = yes
Water quality standard   CSTD   = 0.0056 mg/l
Regulatory mixing zone   = no
Region of interest   = 500 m downstream
****
HYDRODYNAMIC CLASSIFICATION:

| FLOW CLASS   = IPH5 |

This flow configuration applies to a layer corresponding to the full water depth at the discharge site.
Applicable layer depth = water depth = 3.05 m
****
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
Origin is located at the bottom below the port center:
150 m from the left bank/shore.
Number of display steps NSTEP = 50 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.
Pollutant concentration at NFR edge c = 0.0015 mg/l
Dilution at edge of NFR   s = 46.8
NFR Location: x = 39.04 m
(centerline coordinates)   y = 11.74 m
z = 3.05 m
NFR plume dimensions: half-width (bh) = 1.63 m
thickness (bv) = 3.05 m
Cumulative travel time: 3256.1077 sec.

Buoyancy assessment:
The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

Near-field instability behavior:
The discharge flow will experience instabilities with full vertical mixing in the near-field.
There may be benthic impact of high pollutant concentrations.

FAR-FIELD MIXING SUMMARY:

Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 39.04 m
downstream and continues as vertically mixed into the far-field.

PLUME BANK CONTACT SUMMARY:

Plume in unbounded section contacts nearest bank at 190.46 m downstream.

************************ TOXIC DILUTION ZONE SUMMARY ************************

No TDZ was specified for this simulation.

********************** REGULATORY MIXING ZONE SUMMARY **********************

No RMZ has been specified.

However:

The ambient water quality standard was encountered at the following
plume position:

Water quality standard = 0.0056 mg/l
Corresponding dilution s = 12.7
Plume location: x = 7.93 m
(centerline coordinates) y = 7.67 m
z = 3.05 m
Plume dimension: half-width (bh) = 1.80 m

********************* FINAL DESIGN ADVICE AND COMMENTS *********************

The discharge port or nozzle points towards the nearest bank.
Since this is an UNUSUAL DESIGN, check whether you have specified
correctly the port horizontal angle (SIGMA).

REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known
technique is NOT AN EXACT SCIENCE.

Extensive comparison with field and laboratory data has shown that the
CORMIX predictions on dilutions and concentrations (with associated
plume geometries) are reliable for the majority of cases and are accurate
to within about +-50% (standard deviation).

As a further safeguard, CORMIX will not give predictions whenever it judges
the design configuration as highly complex and uncertain for prediction.

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 6.0GT
HYDRO1:Version-6.0.0.0 October,2009
SITE NAME/LABEL: 520 West Side Allison
DESIGN CASE: Allison August DZn
FILE NAME: C:\Program Files\CORMIX 6.0\Allison Aug DZn.prd
Using subsystem CORMIX1: Single Port Discharges
Start of session: 04/16/2010--14:47:33
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 3.05 m
Depth at discharge HD = 3.05 m
Ambient velocity UA = 0.01 m/s
Darcy-Weisbach friction factor F = 0.0338
Calculated from Manning's n = 0.025
Wind velocity UW = 0 m/s
Stratification Type STRCND = U
Surface temperature = 24 degC
Bottom temperature = 24 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 997.2973 kg/m^3
Bottom density RHOAB = 997.2973 kg/m^3

DISCHARGE PARAMETERS: Single Port Discharge
Nearest bank = left
Distance to bank DISTB = 150 m
Port diameter D0 = 0.3048 m
Port cross-sectional area A0 = 0.0730 m^2
Discharge velocity U0 = 0.05 m/s
Discharge flowrate Q0 = 0.003608 m^3/s
Discharge port height H0 = 2.67 m
Vertical discharge angle THETA = 0 deg
Horizontal discharge angle SIGMA = 90 deg
Discharge temperature (freshwater) = 24 degC
Corresponding density RHO0 = 997.2973 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 0.0709 mg/l
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:
LQ = 0.27 m Lm = 1.34 m Lb = 0 m
LM = 99999 m Lm' = 99999 m Lb' = 99999 m

NON-DIMENSIONAL PARAMETERS:

Port densimetric Froude number FR0 = 99999
Velocity ratio R = 4.94

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
Toxic discharge = no
Water quality standard specified = yes
Water quality standard CSTD = 0.0056 mg/l
Regulatory mixing zone = no
Region of interest = 500 m downstream
****
HYDRODYNAMIC CLASSIFICATION:

| FLOW CLASS = IPH4A5I |

This flow configuration applies to a layer corresponding to the full water depth at the discharge site.
Applicable layer depth = water depth = 3.05 m
****
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
Origin is located at the bottom below the port center:
150 m from the left bank/shore.
Number of display steps NSTEP = 50 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.
Pollutant concentration at NFR edge c = 0.0093 mg/l
Dilution at edge of NFR s = 7.6
NFR Location: x = 3.66 m
(centerline coordinates) y = 3.50 m
z = 3.05 m
NFR plume dimensions: half-width (bh) = 1.17 m
thickness (bv) = 1.17 m
Cumulative travel time: 291.822 sec.

Buoyancy assessment:
The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

Benthic attachment:
For the present combination of discharge and ambient conditions, the discharge plume becomes attached to the channel bottom within the NFR immediately following the efflux. High benthic concentrations may occur.

FAR-FIELD MIXING SUMMARY:

Plume becomes vertically fully mixed at 68.21 m downstream.

PLUME BANK CONTACT SUMMARY:
Plume in unbounded section contacts nearest bank at 173.53 m downstream.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY ***********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
plume position:
Water quality standard = 0.0056 mg/l
Corresponding dilution s = 12.7
Plume location: x = 6.28 m
(centerline coordinates) y = 3.50 m
z = 3.05 m
Plume dimensions: half-width (bh) = 1.90 m
thickness (bv) = 1.30 m
********************* FINAL DESIGN ADVICE AND COMMENTS *********************
The discharge port or nozzle points towards the nearest bank.
Since this is an UNUSUAL DESIGN, check whether you have specified
correctly the port horizontal angle (SIGMA).

REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known
technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
CORMIX predictions on dilutions and concentrations (with associated
plume geometries) are reliable for the majority of cases and are accurate
to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
the design configuration as highly complex and uncertain for prediction.

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 6.0GT
HYDRO3:Version-6.0.0.0 October,2009

SITE NAME/LABEL: 520 West Side COS-O&N
DESIGN CASE: COS-O&N January DCu
FILE NAME: C:\Program Files\CORMIX 6.0\COS-O&N Jan DCu.prd
Using subsystem CORMIX3: Buoyant Surface Discharges
Start of session: 04/16/2010--15:00:15

****

SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 2.13 m
Depth at discharge HD = 1.52 m
Ambient velocity UA = 0.01 m/s
Darcy-Weisbach friction factor F = 0.0381
Calculated from Manning's n = 0.025
Wind velocity UW = 0 m/s
Stratification Type STRCND = U
Surface temperature = 9 degC
Bottom temperature = 9 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 999.7833 kg/m^3
Bottom density RHOAB = 999.7833 kg/m^3

DISCHARGE PARAMETERS: Surface Discharge
Discharge located on = left bank/shoreline
Discharge configuration = flush discharge
Distance from bank to outlet DISTB = 0 m
Discharge angle SIGMA = 90 deg
Depth near discharge outlet HD0 = 1.52 m
Bottom slope at discharge SLOPE = 0 deg
Rectangular discharge:
Discharge cross-section area A0 = 0.1524 m^2
Discharge channel width B0 = 1 m
Discharge channel depth H0 = 0.1524 m
Discharge aspect ratio AR = 0.1524
Discharge flowrate Q0 = 0.012822 m^3/s
Discharge velocity U0 = 0.08 m/s
Discharge temperature (freshwater) = 9 degC
Corresponding density RHO0 = 999.7833 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 0.00554 mg/l
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:

```
  LQ  = 0.39 m        Lm  = 3.28 m        Lbb = 0 m
  LM  = 99999 m
-----------------------------------------------------------------------------
NON-DIMENSIONAL PARAMETERS:
  Densimetric Froude number       FR0    = 99999 (based on LQ)
  Channel densimetric Froude no.  FRCH   = 99999 (based on H0)
  Velocity ratio                  R      = 8.41
-----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                        = no
  Water quality standard specified       = yes
  Water quality standard          CSTD   = 0.002 mg/l
  Regulatory mixing zone                 = no
  Region of interest                     = 500 m downstream
*****************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS   = SA1 |
  *------------------------*
*****************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

-----------------------------------------------------------------------------
X-Y-Z Coordinate system:
Origin is located at water surface and at centerline of discharge channel:
    0 m from the left bank/shore.
  Number of display steps NSTEP = 50 per module.
-----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 0.0003 mg/l
  Dilution at edge of NFR             s = 17.7
  NFR Location:                       x = 129.22 m
    (centerline coordinates)          y = -4.58 m
                                      z = 0 m
  NFR plume dimensions:  half-width (bh) = 4.76 m
                         thickness (bv) = 1.52 m
Cumulative travel time:       9270.8564 sec.
-----------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is equal or about about equal to the surrounding
  ambient water density at the discharge level.
  Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.
-----------------------------------------------------------------------------
FAR-FIELD MIXING SUMMARY:
  Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 144.05 m
  downstream and continues as vertically mixed into the far-field.
-----------------------------------------------------------------------------
```

PLUME BANK CONTACT SUMMARY:
Plume in unbounded section contacts nearest bank at 0 m downstream.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY **********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
plume position:
Water quality standard = 0.002 mg/l
Corresponding dilution s = 2.8
Plume location: x = 0.99 m
(centerline coordinates) y = -6.74 m
z = 0 m
Plume dimensions: half-width (bh) = 1.11 m
thickness (bv) = 0.82 m
********************* FINAL DESIGN ADVICE AND COMMENTS *********************
REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known
technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
CORMIX predictions on dilutions and concentrations (with associated
plume geometries) are reliable for the majority of cases and are accurate
to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
the design configuration as highly complex and uncertain for prediction.

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 6.0GT
HYDRO3:Version-6.0.0.0 October,2009
SITE NAME/LABEL: 520 West Side COS-O&N
DESIGN CASE: COS-O&N August DCu
FILE NAME: C:\Program Files\CORMIX 6.0\COS-O&N Aug DCu.prd
Using subsystem CORMIX3: Buoyant Surface Discharges
Start of session: 04/16/2010--15:01:49
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 2.13 m
Depth at discharge HD = 1.52 m
Ambient velocity UA = 0.01 m/s
Darcy-Weisbach friction factor F = 0.0381
Calculated from Manning's n = 0.025
Wind velocity UW = 0 m/s
Stratification Type STRCND = U
Surface temperature = 24 degC
Bottom temperature = 24 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 997.2973 kg/m^3
Bottom density RHOAB = 997.2973 kg/m^3

DISCHARGE PARAMETERS: Surface Discharge
Discharge located on = left bank/shoreline
Discharge configuration = flush discharge
Distance from bank to outlet DISTB = 0 m
Discharge angle SIGMA = 90 deg
Depth near discharge outlet HD0 = 1.52 m
Bottom slope at discharge SLOPE = 0 deg
Rectangular discharge:
Discharge cross-section area A0 = 0.1524 m^2
Discharge channel width B0 = 1 m
Discharge channel depth H0 = 0.1524 m
Discharge aspect ratio AR = 0.1524
Discharge flowrate Q0 = 0.006742 m^3/s
Discharge velocity U0 = 0.04 m/s
Discharge temperature (freshwater) = 24 degC
Corresponding density RHO0 = 997.2973 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 0.00554 mg/l
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:

LQ = 0.39 m Lm = 1.73 m Lbb = 0 m
LM = 99999 m

NON-DIMENSIONAL PARAMETERS:
Densimetric Froude number FR0 = 99999 (based on LQ)
Channel densimetric Froude no. FRCH = 99999 (based on H0)
Velocity ratio R = 4.42

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
Toxic discharge = no
Water quality standard specified = yes
Water quality standard CSTD = 0.002 mg/l
Regulatory mixing zone = no
Region of interest = 500 m downstream
****
HYDRODYNAMIC CLASSIFICATION:

| FLOW CLASS = SA1 |

****
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
Origin is located at water surface and at centerline of discharge channel:
0 m from the left bank/shore.
Number of display steps NSTEP = 50 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.
Pollutant concentration at NFR edge c = 0.0004 mg/l
Dilution at edge of NFR s = 14.2
NFR Location: x = 53.72 m
(centerline coordinates) y = -2.21 m
z = 0 m
NFR plume dimensions: half-width (bh) = 2.38 m
thickness (bv) = 1.52 m
Cumulative travel time: 4116.9312 sec.

Buoyancy assessment:
The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

FAR-FIELD MIXING SUMMARY:
Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 71.57 m downstream and continues as vertically mixed into the far-field.

PLUME BANK CONTACT SUMMARY:
Plume in unbounded section contacts nearest bank at 0 m downstream.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY **********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
plume position:
Water quality standard = 0.002 mg/l
Corresponding dilution s = 2.8
Plume location: x = 1.29 m
(centerline coordinates) y = -5.35 m
z = 0 m
Plume dimensions: half-width (bh) = 1.01 m
thickness (bv) = 0.70 m
********************* FINAL DESIGN ADVICE AND COMMENTS *********************
REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known
technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
CORMIX predictions on dilutions and concentrations (with associated
plume geometries) are reliable for the majority of cases and are accurate
to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
the design configuration as highly complex and uncertain for prediction.

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 6.0GT
HYDRO3:Version-6.0.0.0 October,2009
SITE NAME/LABEL: 520 West Side COS-O&N
DESIGN CASE: COS-O&N January DZn
FILE NAME: C:\Program Files\CORMIX 6.0\COS-O&N Jan DZn.prd
Using subsystem CORMIX3: Buoyant Surface Discharges
Start of session: 04/16/2010--15:01:05
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 2.13 m
Depth at discharge HD = 1.52 m
Ambient velocity UA = 0.01 m/s
Darcy-Weisbach friction factor F = 0.0381
Calculated from Manning's n = 0.025
Wind velocity UW = 0 m/s
Stratification Type STRCND = U
Surface temperature = 9 degC
Bottom temperature = 9 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 999.7833 kg/m^3
Bottom density RHOAB = 999.7833 kg/m^3

DISCHARGE PARAMETERS: Surface Discharge
Discharge located on = left bank/shoreline
Discharge configuration = flush discharge
Distance from bank to outlet DISTB = 0 m
Discharge angle SIGMA = 90 deg
Depth near discharge outlet HD0 = 1.52 m
Bottom slope at discharge SLOPE = 0 deg
Rectangular discharge:
Discharge cross-section area A0 = 0.1524 m^2
Discharge channel width B0 = 1 m
Discharge channel depth H0 = 0.1524 m
Discharge aspect ratio AR = 0.1524
Discharge flowrate Q0 = 0.012822 m^3/s
Discharge velocity U0 = 0.08 m/s
Discharge temperature (freshwater) = 9 degC
Corresponding density RHO0 = 999.7833 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 0.0362 mg/l
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:

LQ = 0.39 m   Lm = 3.28 m   Lbb = 0 m
LM = 99999 m

NON-DIMENSIONAL PARAMETERS:
Densimetric Froude number   FR0   = 99999 (based on LQ)
Channel densimetric Froude no. FRCH   = 99999 (based on H0)
Velocity ratio   R   = 8.41

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
Toxic discharge   = no
Water quality standard specified   = yes
Water quality standard   CSTD   = 0.0056 mg/l
Regulatory mixing zone   = no
Region of interest   = 500 m downstream
****
HYDRODYNAMIC CLASSIFICATION:

| FLOW CLASS   = SA1 |

****
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
Origin is located at water surface and at centerline of discharge channel:
0 m from the left bank/shore.
Number of display steps NSTEP = 50 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.
Pollutant concentration at NFR edge c = 0.002 mg/l
Dilution at edge of NFR   s = 17.7
NFR Location: x = 129.22 m
(centerline coordinates)   y = -4.58 m
z = 0 m
NFR plume dimensions: half-width (bh) = 4.76 m
thickness (bv) = 1.52 m
Cumulative travel time: 9270.8564 sec.

Buoyancy assessment:
The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

FAR-FIELD MIXING SUMMARY:
Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 144.05 m downstream and continues as vertically mixed into the far-field.

PLUME BANK CONTACT SUMMARY:
Plume in unbounded section contacts nearest bank at 0 m downstream.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY **********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
plume position:
Water quality standard = 0.0056 mg/l
Corresponding dilution s = 6.5
Plume location: x = 5.88 m
(centerline coordinates) y = -11.12 m
z = 0 m
Plume dimensions: half-width (bh) = 1.88 m
thickness (bv) = 1.52 m
********************* FINAL DESIGN ADVICE AND COMMENTS **********************
REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known
technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
CORMIX predictions on dilutions and concentrations (with associated
plume geometries) are reliable for the majority of cases and are accurate
to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
the design configuration as highly complex and uncertain for prediction.

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 6.0GT
HYDRO3:Version-6.0.0.0 October,2009
SITE NAME/LABEL: 520 West Side COS-O&N
DESIGN CASE: COS-O&N August DZn
FILE NAME: C:\Program Files\CORMIX 6.0\COS-O&N Aug DZn.prd
Using subsystem CORMIX3: Buoyant Surface Discharges
Start of session: 04/16/2010--15:02:25
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 2.13 m
Depth at discharge HD = 1.52 m
Ambient velocity UA = 0.01 m/s
Darcy-Weisbach friction factor F = 0.0381
Calculated from Manning's n = 0.025
Wind velocity UW = 0 m/s
Stratification Type STRCND = U
Surface temperature = 24 degC
Bottom temperature = 24 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 997.2973 kg/m^3
Bottom density RHOAB = 997.2973 kg/m^3

DISCHARGE PARAMETERS: Surface Discharge
Discharge located on = left bank/shoreline
Discharge configuration = flush discharge
Distance from bank to outlet DISTB = 0 m
Discharge angle SIGMA = 90 deg
Depth near discharge outlet HD0 = 1.52 m
Bottom slope at discharge SLOPE = 0 deg
Rectangular discharge:
Discharge cross-section area A0 = 0.1524 m^2
Discharge channel width B0 = 1 m
Discharge channel depth H0 = 0.1524 m
Discharge aspect ratio AR = 0.1524
Discharge flowrate Q0 = 0.006742 m^3/s
Discharge velocity U0 = 0.04 m/s
Discharge temperature (freshwater) = 24 degC
Corresponding density RHO0 = 997.2973 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 0.0362 mg/l
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:

LQ = 0.39 m   Lm = 1.73 m   Lbb = 0 m
LM = 99999 m

NON-DIMENSIONAL PARAMETERS:
Densimetric Froude number   FR0   = 99999 (based on LQ)
Channel densimetric Froude no. FRCH   = 99999 (based on H0)
Velocity ratio   R   = 4.42

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
Toxic discharge   = no
Water quality standard specified   = yes
Water quality standard   CSTD   = 0.0056 mg/l
Regulatory mixing zone   = no
Region of interest   = 500 m downstream
****
HYDRODYNAMIC CLASSIFICATION:

| FLOW CLASS   = SA1 |

****
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
Origin is located at water surface and at centerline of discharge channel:
0 m from the left bank/shore.
Number of display steps NSTEP = 50 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing. It has no regulatory
implication. However, this information may be useful for the discharge
designer because the mixing in the NFR is usually sensitive to the
discharge design conditions.
Pollutant concentration at NFR edge c = 0.0025 mg/l
Dilution at edge of NFR   s = 14.2
NFR Location: x = 53.72 m
(centerline coordinates)   y = -2.21 m
z = 0 m
NFR plume dimensions: half-width (bh) = 2.38 m
thickness (bv) = 1.52 m
Cumulative travel time: 4116.9312 sec.

Buoyancy assessment:
The effluent density is equal or about about equal to the surrounding
ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

FAR-FIELD MIXING SUMMARY:
Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 71.57 m
downstream and continues as vertically mixed into the far-field.

PLUME BANK CONTACT SUMMARY:
Plume in unbounded section contacts nearest bank at 0 m downstream.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY **********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
plume position:
Water quality standard = 0.0056 mg/l
Corresponding dilution s = 6.5
Plume location: x = 6.70 m
(centerline coordinates) y = -7.74 m
z = 0 m
Plume dimensions: half-width (bh) = 1.46 m
thickness (bv) = 1.25 m
********************* FINAL DESIGN ADVICE AND COMMENTS *********************
REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known
technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
CORMIX predictions on dilutions and concentrations (with associated
plume geometries) are reliable for the majority of cases and are accurate
to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
the design configuration as highly complex and uncertain for prediction.

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 6.0GT
HYDRO3:Version-6.0.0.0 October,2009
SITE NAME/LABEL: 520 West Side WS-C
DESIGN CASE: WS-C January DCu
FILE NAME: C:\Program Files\CORMIX 6.0\WS-C Jan DCu.prd
Using subsystem CORMIX3: Buoyant Surface Discharges
Start of session: 04/16/2010--15:10:27
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 2.13 m
Depth at discharge HD = 1.52 m
Ambient velocity UA = 0.01 m/s
Darcy-Weisbach friction factor F = 0.0381
Calculated from Manning's n = 0.025
Wind velocity UW = 0 m/s
Stratification Type STRCND = U
Surface temperature = 9 degC
Bottom temperature = 9 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 999.7833 kg/m^3
Bottom density RHOAB = 999.7833 kg/m^3

DISCHARGE PARAMETERS: Surface Discharge
Discharge located on = left bank/shoreline
Discharge configuration = flush discharge
Distance from bank to outlet DISTB = 0 m
Discharge angle SIGMA = 90 deg
Depth near discharge outlet HD0 = 1.52 m
Bottom slope at discharge SLOPE = 0 deg
Rectangular discharge:
Discharge cross-section area A0 = 0.1524 m^2
Discharge channel width B0 = 1 m
Discharge channel depth H0 = 0.1524 m
Discharge aspect ratio AR = 0.1524
Discharge flowrate Q0 = 0.001931 m^3/s
Discharge velocity U0 = 0.01 m/s
Discharge temperature (freshwater) = 9 degC
Corresponding density RHO0 = 999.7833 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 0.00564 mg/l
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:

LQ = 0.39 m   Lm = 0.49 m   Lbb = 0 m
LM = 99999 m

NON-DIMENSIONAL PARAMETERS:
Densimetric Froude number   FR0   = 99999 (based on LQ)
Channel densimetric Froude no. FRCH   = 99999 (based on H0)
Velocity ratio   R   = 1.27

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
Toxic discharge   = no
Water quality standard specified   = yes
Water quality standard   CSTD   = 0.002 mg/l
Regulatory mixing zone   = no
Region of interest   = 500 m downstream

****

HYDRODYNAMIC CLASSIFICATION:

```
*------------------------*
| FLOW CLASS   = SA1 |
*------------------------*
```

****

MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
Origin is located at water surface and at centerline of discharge channel:
0 m from the left bank/shore.
Number of display steps NSTEP = 50 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.

Pollutant concentration at NFR edge c = 0.0004 mg/l
Dilution at edge of NFR   s = 14.1
NFR Location: x = 19.64 m
(centerline coordinates)   y = -1.13 m
                                     z = 0 m
NFR plume dimensions: half-width (bh) = 1.18 m
                        thickness (bv) = 1.09 m
Cumulative travel time: 2988.9966 sec.

Buoyancy assessment:
The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

FAR-FIELD MIXING SUMMARY:
Plume becomes vertically fully mixed at 58.07 m downstream.

PLUME BANK CONTACT SUMMARY:

Plume in unbounded section contacts nearest bank at 0 m downstream.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY **********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
plume position:
Water quality standard = 0.002 mg/l
Corresponding dilution s = 2.8
Plume location: x = 1.90 m
(centerline coordinates) y = -2.21 m
z = 0 m
Plume dimensions: half-width (bh) = 0.82 m
thickness (bv) = 0.40 m
********************* FINAL DESIGN ADVICE AND COMMENTS *********************
REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known
technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
CORMIX predictions on dilutions and concentrations (with associated
plume geometries) are reliable for the majority of cases and are accurate
to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
the design configuration as highly complex and uncertain for prediction.

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 6.0GT
HYDRO3:Version-6.0.0.0 October,2009
SITE NAME/LABEL: 520 West Side WS-C
DESIGN CASE: WS-C August DCu
FILE NAME: C:\Program Files\CORMIX 6.0\WS-C Aug DCu.prd
Using subsystem CORMIX3: Buoyant Surface Discharges
Start of session: 04/16/2010--15:11:46
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 2.13 m
Depth at discharge HD = 1.52 m
Ambient velocity UA = 0.01 m/s
Darcy-Weisbach friction factor F = 0.0381
Calculated from Manning's n = 0.025
Wind velocity UW = 0 m/s
Stratification Type STRCND = U
Surface temperature = 24 degC
Bottom temperature = 24 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 997.2973 kg/m^3
Bottom density RHOAB = 997.2973 kg/m^3

DISCHARGE PARAMETERS: Surface Discharge
Discharge located on = left bank/shoreline
Discharge configuration = flush discharge
Distance from bank to outlet DISTB = 0 m
Discharge angle SIGMA = 90 deg
Depth near discharge outlet HD0 = 1.52 m
Bottom slope at discharge SLOPE = 0 deg
Rectangular discharge:
Discharge cross-section area A0 = 0.1524 m^2
Discharge channel width B0 = 1 m
Discharge channel depth H0 = 0.1524 m
Discharge aspect ratio AR = 0.1524
Discharge flowrate Q0 = 0.001042 m^3/s
Discharge velocity U0 = 0.01 m/s
Discharge temperature (freshwater) = 24 degC
Corresponding density RHO0 = 997.2973 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 0.00564 mg/l
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:

LQ = 0.39 m Lm = 0.27 m Lbb = 0 m
LM = 99999 m

NON-DIMENSIONAL PARAMETERS:
Densimetric Froude number FR0 = 99999 (based on LQ)
Channel densimetric Froude no. FRCH = 99999 (based on H0)
Velocity ratio R = 0.68

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
Toxic discharge = no
Water quality standard specified = yes
Water quality standard CSTD = 0.002 mg/l
Regulatory mixing zone = no
Region of interest = 500 m downstream

****

HYDRODYNAMIC CLASSIFICATION:

```
*------------------------*
| FLOW CLASS   = SA1 |
*------------------------*
```

****

MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
Origin is located at water surface and at centerline of discharge channel:
0 m from the left bank/shore.
Number of display steps NSTEP = 50 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.
Pollutant concentration at NFR edge c = 0.0011 mg/l
Dilution at edge of NFR s = 4.9
NFR Location: x = 3.71 m
(centerline coordinates) y = 0 m
z = 0 m
NFR plume dimensions: half-width (bh) = 1.42 m
thickness (bv) = 0.41 m
Cumulative travel time: 1340.6046 sec.

Buoyancy assessment:
The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

FAR-FIELD MIXING SUMMARY:
Plume becomes vertically fully mixed at 53.34 m downstream.

PLUME BANK CONTACT SUMMARY:

Plume in unbounded section contacts nearest bank at 0 m downstream.
************************* TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
*********************** REGULATORY MIXING ZONE SUMMARY ***********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following plume position:
Water quality standard = 0.002 mg/l
Corresponding dilution s = 2.8
Plume location: x = 0.99 m
(centerline coordinates) y = -0.56 m
z = 0 m
Plume dimensions: half-width (bh) = 0.68 m
thickness (bv) = 0.31 m
********************** FINAL DESIGN ADVICE AND COMMENTS **********************
REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the CORMIX predictions on dilutions and concentrations (with associated plume geometries) are reliable for the majority of cases and are accurate to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges the design configuration as highly complex and uncertain for prediction.

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 6.0GT
HYDRO3:Version-6.0.0.0 October,2009
SITE NAME/LABEL: 520 West Side WS-C
DESIGN CASE: WS-C January DZn
FILE NAME: C:\Program Files\CORMIX 6.0\WS-C Jan DZn.prd
Using subsystem CORMIX3: Buoyant Surface Discharges
Start of session: 04/16/2010--15:11:06
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 2.13 m
Depth at discharge HD = 1.52 m
Ambient velocity UA = 0.01 m/s
Darcy-Weisbach friction factor F = 0.0381
Calculated from Manning's n = 0.025
Wind velocity UW = 0 m/s
Stratification Type STRCND = U
Surface temperature = 9 degC
Bottom temperature = 9 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 999.7833 kg/m^3
Bottom density RHOAB = 999.7833 kg/m^3

DISCHARGE PARAMETERS: Surface Discharge
Discharge located on = left bank/shoreline
Discharge configuration = flush discharge
Distance from bank to outlet DISTB = 0 m
Discharge angle SIGMA = 90 deg
Depth near discharge outlet HD0 = 1.52 m
Bottom slope at discharge SLOPE = 0 deg
Rectangular discharge:
Discharge cross-section area A0 = 0.1524 m^2
Discharge channel width B0 = 1 m
Discharge channel depth H0 = 0.1524 m
Discharge aspect ratio AR = 0.1524
Discharge flowrate Q0 = 0.001931 m^3/s
Discharge velocity U0 = 0.01 m/s
Discharge temperature (freshwater) = 9 degC
Corresponding density RHO0 = 999.7833 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 0.0363 mg/l
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:

LQ = 0.39 m Lm = 0.49 m Lbb = 0 m
LM = 99999 m

NON-DIMENSIONAL PARAMETERS:
Densimetric Froude number FR0 = 99999 (based on LQ)
Channel densimetric Froude no. FRCH = 99999 (based on H0)
Velocity ratio R = 1.27

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
Toxic discharge = no
Water quality standard specified = yes
Water quality standard CSTD = 0.0056 mg/l
Regulatory mixing zone = no
Region of interest = 500 m downstream
****
HYDRODYNAMIC CLASSIFICATION:

| FLOW CLASS = SA1 |

****
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
Origin is located at water surface and at centerline of discharge channel:
0 m from the left bank/shore.
Number of display steps NSTEP = 50 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.
Pollutant concentration at NFR edge c = 0.0026 mg/l
Dilution at edge of NFR s = 14.1
NFR Location: x = 19.64 m
(centerline coordinates) y = -1.13 m
z = 0 m
NFR plume dimensions: half-width (bh) = 1.18 m
thickness (bv) = 1.09 m
Cumulative travel time: 2988.9966 sec.

Buoyancy assessment:
The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

FAR-FIELD MIXING SUMMARY:
Plume becomes vertically fully mixed at 58.07 m downstream.

PLUME BANK CONTACT SUMMARY:

Plume in unbounded section contacts nearest bank at 0 m downstream.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY **********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
plume position:
Water quality standard = 0.0056 mg/l
Corresponding dilution s = 6.5
Plume location: x = 10.32 m
(centerline coordinates) y = -2.37 m
z = 0 m
Plume dimensions: half-width (bh) = 0.86 m
thickness (bv) = 0.73 m
********************* FINAL DESIGN ADVICE AND COMMENTS *********************
REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known
technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
CORMIX predictions on dilutions and concentrations (with associated
plume geometries) are reliable for the majority of cases and are accurate
to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
the design configuration as highly complex and uncertain for prediction.

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 6.0GT
HYDRO3:Version-6.0.0.0 October,2009
SITE NAME/LABEL: 520 West Side WS-C
DESIGN CASE: WS-C August DZn
FILE NAME: C:\Program Files\CORMIX 6.0\WS-C Aug DZn.prd
Using subsystem CORMIX3: Buoyant Surface Discharges
Start of session: 04/16/2010--15:12:22
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 2.13 m
Depth at discharge HD = 1.52 m
Ambient velocity UA = 0.01 m/s
Darcy-Weisbach friction factor F = 0.0381
Calculated from Manning's n = 0.025
Wind velocity UW = 0 m/s
Stratification Type STRCND = U
Surface temperature = 24 degC
Bottom temperature = 24 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 997.2973 kg/m^3
Bottom density RHOAB = 997.2973 kg/m^3

DISCHARGE PARAMETERS: Surface Discharge
Discharge located on = left bank/shoreline
Discharge configuration = flush discharge
Distance from bank to outlet DISTB = 0 m
Discharge angle SIGMA = 90 deg
Depth near discharge outlet HD0 = 1.52 m
Bottom slope at discharge SLOPE = 0 deg
Rectangular discharge:
Discharge cross-section area A0 = 0.1524 m^2
Discharge channel width B0 = 1 m
Discharge channel depth H0 = 0.1524 m
Discharge aspect ratio AR = 0.1524
Discharge flowrate Q0 = 0.001042 m^3/s
Discharge velocity U0 = 0.01 m/s
Discharge temperature (freshwater) = 24 degC
Corresponding density RHO0 = 997.2973 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 0.0363 mg/l
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:

LQ = 0.39 m   Lm = 0.27 m   Lbb = 0 m
LM = 99999 m

NON-DIMENSIONAL PARAMETERS:
Densimetric Froude number   FR0   = 99999 (based on LQ)
Channel densimetric Froude no. FRCH   = 99999 (based on H0)
Velocity ratio   R   = 0.68

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
Toxic discharge   = no
Water quality standard specified   = yes
Water quality standard   CSTD   = 0.0056 mg/l
Regulatory mixing zone   = no
Region of interest   = 500 m downstream

****

HYDRODYNAMIC CLASSIFICATION:

```
*------------------------*
| FLOW CLASS   = SA1 |
*------------------------*
```

****

MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
Origin is located at water surface and at centerline of discharge channel:
0 m from the left bank/shore.
Number of display steps NSTEP = 50 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.

Pollutant concentration at NFR edge c = 0.0074 mg/l
Dilution at edge of NFR   s = 4.9
NFR Location: x = 3.71 m
(centerline coordinates)   y = 0 m
                                     z = 0 m
NFR plume dimensions: half-width (bh) = 1.42 m
                       thickness (bv) = 0.41 m
Cumulative travel time: 1340.6046 sec.

Buoyancy assessment:
The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

FAR-FIELD MIXING SUMMARY:
Plume becomes vertically fully mixed at 53.34 m downstream.

PLUME BANK CONTACT SUMMARY:

Plume in unbounded section contacts nearest bank at 0 m downstream.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY **********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
plume position:
Water quality standard = 0.0056 mg/l
Corresponding dilution s = 6.5
Plume location: x = 6.37 m
(centerline coordinates) y = 0 m
z = 0 m
Plume dimensions: half-width (bh) = 2.21 m
thickness (bv) = 0.56 m
********************* FINAL DESIGN ADVICE AND COMMENTS *********************
REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known
technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
CORMIX predictions on dilutions and concentrations (with associated
plume geometries) are reliable for the majority of cases and are accurate
to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
the design configuration as highly complex and uncertain for prediction.

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 6.0GT
HYDRO3:Version-6.0.0.0 October,2009
SITE NAME/LABEL: 520 West Side WS-D
DESIGN CASE: WS-D January DCu
FILE NAME: C:\Program Files\CORMIX 6.0\WS-D Jan DCu.prd
Using subsystem CORMIX3: Buoyant Surface Discharges
Start of session: 04/16/2010--15:13:06
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 2.13 m
Depth at discharge HD = 1.52 m
Ambient velocity UA = 0.01 m/s
Darcy-Weisbach friction factor F = 0.0381
Calculated from Manning's n = 0.025
Wind velocity UW = 0 m/s
Stratification Type STRCND = U
Surface temperature = 9 degC
Bottom temperature = 9 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 999.7833 kg/m^3
Bottom density RHOAB = 999.7833 kg/m^3

DISCHARGE PARAMETERS: Surface Discharge
Discharge located on = left bank/shoreline
Discharge configuration = flush discharge
Distance from bank to outlet DISTB = 0 m
Discharge angle SIGMA = 90 deg
Depth near discharge outlet HD0 = 1.52 m
Bottom slope at discharge SLOPE = 0 deg
Rectangular discharge:
Discharge cross-section area A0 = 0.1524 m^2
Discharge channel width B0 = 1 m
Discharge channel depth H0 = 0.1524 m
Discharge aspect ratio AR = 0.1524
Discharge flowrate Q0 = 0.005326 m^3/s
Discharge velocity U0 = 0.03 m/s
Discharge temperature (freshwater) = 9 degC
Corresponding density RHO0 = 999.7833 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 0.00564 mg/l
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:

LQ = 0.39 m   Lm = 1.36 m   Lbb = 0 m
LM = 99999 m

NON-DIMENSIONAL PARAMETERS:
Densimetric Froude number   FR0 = 99999 (based on LQ)
Channel densimetric Froude no. FRCH = 99999 (based on H0)
Velocity ratio   R = 3.50

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
Toxic discharge   = no
Water quality standard specified   = yes
Water quality standard   CSTD = 0.002 mg/l
Regulatory mixing zone   = no
Region of interest   = 500 m downstream
****
HYDRODYNAMIC CLASSIFICATION:

| FLOW CLASS = SA1 |

****
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
Origin is located at water surface and at centerline of discharge channel:
0 m from the left bank/shore.
Number of display steps NSTEP = 50 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.
Pollutant concentration at NFR edge c = 0.0004 mg/l
Dilution at edge of NFR   s = 13.0
NFR Location: x = 42.91 m
(centerline coordinates)   y = -1.85 m
z = 0 m
NFR plume dimensions: half-width (bh) = 1.93 m
thickness (bv) = 1.52 m
Cumulative travel time: 3773.2646 sec.

Buoyancy assessment:
The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

FAR-FIELD MIXING SUMMARY:
Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 70.34 m downstream and continues as vertically mixed into the far-field.

PLUME BANK CONTACT SUMMARY:
  Plume in unbounded section contacts nearest bank at 0 m downstream.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY **********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
  plume position:
  Water quality standard = 0.002 mg/l
  Corresponding dilution s = 2.8
  Plume location: x = 1.48 m
    (centerline coordinates) y = -4.88 m
    z = 0 m
  Plume dimensions: half-width (bh) = 0.97 m
    thickness (bv) = 0.65 m
********************* FINAL DESIGN ADVICE AND COMMENTS **********************
REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known
  technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
  CORMIX predictions on dilutions and concentrations (with associated
  plume geometries) are reliable for the majority of cases and are accurate
  to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
  the design configuration as highly complex and uncertain for prediction.

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 6.0GT
HYDRO3:Version-6.0.0.0 October,2009
SITE NAME/LABEL: 520 West Side WS-D
DESIGN CASE: WS-D August DCu
FILE NAME: C:\Program Files\CORMIX 6.0\WS-D Aug DCu.prd
Using subsystem CORMIX3: Buoyant Surface Discharges
Start of session: 04/16/2010--15:14:15
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 2.13 m
Depth at discharge HD = 1.52 m
Ambient velocity UA = 0.01 m/s
Darcy-Weisbach friction factor F = 0.0381
Calculated from Manning's n = 0.025
Wind velocity UW = 0 m/s
Stratification Type STRCND = U
Surface temperature = 24 degC
Bottom temperature = 24 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 997.2973 kg/m^3
Bottom density RHOAB = 997.2973 kg/m^3

DISCHARGE PARAMETERS: Surface Discharge
Discharge located on = left bank/shoreline
Discharge configuration = flush discharge
Distance from bank to outlet DISTB = 0 m
Discharge angle SIGMA = 90 deg
Depth near discharge outlet HD0 = 1.52 m
Bottom slope at discharge SLOPE = 0 deg
Rectangular discharge:
Discharge cross-section area A0 = 0.1524 m^2
Discharge channel width B0 = 1 m
Discharge channel depth H0 = 0.1524 m
Discharge aspect ratio AR = 0.1524
Discharge flowrate Q0 = 0.002769 m^3/s
Discharge velocity U0 = 0.02 m/s
Discharge temperature (freshwater) = 24 degC
Corresponding density RHO0 = 997.2973 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 0.00564 mg/l
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:

LQ = 0.39 m Lm = 0.71 m Lbb = 0 m
LM = 99999 m

NON-DIMENSIONAL PARAMETERS:
Densimetric Froude number FR0 = 99999 (based on LQ)
Channel densimetric Froude no. FRCH = 99999 (based on H0)
Velocity ratio R = 1.82

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
Toxic discharge = no
Water quality standard specified = yes
Water quality standard CSTD = 0.002 mg/l
Regulatory mixing zone = no
Region of interest = 500 m downstream
****
HYDRODYNAMIC CLASSIFICATION:

| FLOW CLASS = SA1 |

****
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
Origin is located at water surface and at centerline of discharge channel:
0 m from the left bank/shore.
Number of display steps NSTEP = 50 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.
Pollutant concentration at NFR edge c = 0.0003 mg/l
Dilution at edge of NFR s = 18.2
NFR Location: x = 28.07 m
(centerline coordinates) y = -1.48 m
z = 0 m
NFR plume dimensions: half-width (bh) = 1.57 m
thickness (bv) = 1.48 m
Cumulative travel time: 3539.3262 sec.

Buoyancy assessment:
The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

FAR-FIELD MIXING SUMMARY:
Plume becomes vertically fully mixed at 56.39 m downstream.

PLUME BANK CONTACT SUMMARY:

Plume in unbounded section contacts nearest bank at 0 m downstream.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY **********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
plume position:
Water quality standard = 0.002 mg/l
Corresponding dilution s = 2.8
Plume location: x = 2.35 m
(centerline coordinates) y = -3.49 m
z = 0 m
Plume dimensions: half-width (bh) = 0.81 m
thickness (bv) = 0.52 m
********************* FINAL DESIGN ADVICE AND COMMENTS *********************
REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known
technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
CORMIX predictions on dilutions and concentrations (with associated
plume geometries) are reliable for the majority of cases and are accurate
to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
the design configuration as highly complex and uncertain for prediction.

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 6.0GT
HYDRO3:Version-6.0.0.0 October,2009
SITE NAME/LABEL: 520 West Side WS-D
DESIGN CASE: WS-D January DZn
FILE NAME: C:\Program Files\CORMIX 6.0\WS-D Jan DZn.prd
Using subsystem CORMIX3: Buoyant Surface Discharges
Start of session: 04/16/2010--15:13:39
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 2.13 m
Depth at discharge HD = 1.52 m
Ambient velocity UA = 0.01 m/s
Darcy-Weisbach friction factor F = 0.0381
Calculated from Manning's n = 0.025
Wind velocity UW = 0 m/s
Stratification Type STRCND = U
Surface temperature = 9 degC
Bottom temperature = 9 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 999.7833 kg/m^3
Bottom density RHOAB = 999.7833 kg/m^3

DISCHARGE PARAMETERS: Surface Discharge
Discharge located on = left bank/shoreline
Discharge configuration = flush discharge
Distance from bank to outlet DISTB = 0 m
Discharge angle SIGMA = 90 deg
Depth near discharge outlet HD0 = 1.52 m
Bottom slope at discharge SLOPE = 0 deg
Rectangular discharge:
Discharge cross-section area A0 = 0.1524 m^2
Discharge channel width B0 = 1 m
Discharge channel depth H0 = 0.1524 m
Discharge aspect ratio AR = 0.1524
Discharge flowrate Q0 = 0.005326 m^3/s
Discharge velocity U0 = 0.03 m/s
Discharge temperature (freshwater) = 9 degC
Corresponding density RHO0 = 999.7833 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 0.035 mg/l
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:

LQ = 0.39 m Lm = 1.36 m Lbb = 0 m
LM = 99999 m

NON-DIMENSIONAL PARAMETERS:
Densimetric Froude number FR0 = 99999 (based on LQ)
Channel densimetric Froude no. FRCH = 99999 (based on H0)
Velocity ratio R = 3.50

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
Toxic discharge = no
Water quality standard specified = yes
Water quality standard CSTD = 0.0056 mg/l
Regulatory mixing zone = no
Region of interest = 500 m downstream
****
HYDRODYNAMIC CLASSIFICATION:

| FLOW CLASS = SA1 |

****
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
Origin is located at water surface and at centerline of discharge channel:
0 m from the left bank/shore.
Number of display steps NSTEP = 50 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.
Pollutant concentration at NFR edge c = 0.0027 mg/l
Dilution at edge of NFR s = 13.0
NFR Location: x = 42.91 m
(centerline coordinates) y = -1.85 m
z = 0 m
NFR plume dimensions: half-width (bh) = 1.93 m
thickness (bv) = 1.52 m
Cumulative travel time: 3773.2646 sec.

Buoyancy assessment:
The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

FAR-FIELD MIXING SUMMARY:
Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 70.34 m downstream and continues as vertically mixed into the far-field.

PLUME BANK CONTACT SUMMARY:
Plume in unbounded section contacts nearest bank at 0 m downstream.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY **********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
plume position:
Water quality standard = 0.0056 mg/l
Corresponding dilution s = 6.3
Plume location: x = 8.29 m
(centerline coordinates) y = -6.93 m
z = 0 m
Plume dimensions: half-width (bh) = 1.30 m
thickness (bv) = 1.12 m
********************* FINAL DESIGN ADVICE AND COMMENTS *********************
REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known
technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
CORMIX predictions on dilutions and concentrations (with associated
plume geometries) are reliable for the majority of cases and are accurate
to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
the design configuration as highly complex and uncertain for prediction.

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 6.0GT
HYDRO3:Version-6.0.0.0 October,2009
SITE NAME/LABEL: 520 West Side WS-D
DESIGN CASE: WS-D August DZn
FILE NAME: C:\Program Files\CORMIX 6.0\WS-D Aug DZn.prd
Using subsystem CORMIX3: Buoyant Surface Discharges
Start of session: 04/16/2010--15:14:49
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 2.13 m
Depth at discharge HD = 1.52 m
Ambient velocity UA = 0.01 m/s
Darcy-Weisbach friction factor F = 0.0381
Calculated from Manning's n = 0.025
Wind velocity UW = 0 m/s
Stratification Type STRCND = U
Surface temperature = 24 degC
Bottom temperature = 24 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 997.2973 kg/m^3
Bottom density RHOAB = 997.2973 kg/m^3

DISCHARGE PARAMETERS: Surface Discharge
Discharge located on = left bank/shoreline
Discharge configuration = flush discharge
Distance from bank to outlet DISTB = 0 m
Discharge angle SIGMA = 90 deg
Depth near discharge outlet HD0 = 1.52 m
Bottom slope at discharge SLOPE = 0 deg
Rectangular discharge:
Discharge cross-section area A0 = 0.1524 m^2
Discharge channel width B0 = 1 m
Discharge channel depth H0 = 0.1524 m
Discharge aspect ratio AR = 0.1524
Discharge flowrate Q0 = 0.002769 m^3/s
Discharge velocity U0 = 0.02 m/s
Discharge temperature (freshwater) = 24 degC
Corresponding density RHO0 = 997.2973 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 0.035 mg/l
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:

LQ = 0.39 m Lm = 0.71 m Lbb = 0 m
LM = 99999 m

NON-DIMENSIONAL PARAMETERS:
Densimetric Froude number FR0 = 99999 (based on LQ)
Channel densimetric Froude no. FRCH = 99999 (based on H0)
Velocity ratio R = 1.82

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
Toxic discharge = no
Water quality standard specified = yes
Water quality standard CSTD = 0.0056 mg/l
Regulatory mixing zone = no
Region of interest = 500 m downstream
****
HYDRODYNAMIC CLASSIFICATION:

| FLOW CLASS = SA1 |

****
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
Origin is located at water surface and at centerline of discharge channel:
0 m from the left bank/shore.
Number of display steps NSTEP = 50 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.
Pollutant concentration at NFR edge c = 0.0019 mg/l
Dilution at edge of NFR s = 18.2
NFR Location: x = 28.07 m
(centerline coordinates) y = -1.48 m
z = 0 m
NFR plume dimensions: half-width (bh) = 1.57 m
thickness (bv) = 1.48 m
Cumulative travel time: 3539.3262 sec.

Buoyancy assessment:
The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

FAR-FIELD MIXING SUMMARY:
Plume becomes vertically fully mixed at 56.39 m downstream.

PLUME BANK CONTACT SUMMARY:

Plume in unbounded section contacts nearest bank at 0 m downstream.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY **********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
plume position:
Water quality standard = 0.0056 mg/l
Corresponding dilution s = 6.3
Plume location: x = 13.22 m
(centerline coordinates) y = -3.92 m
z = 0 m
Plume dimensions: half-width (bh) = 0.97 m
thickness (bv) = 0.86 m
********************* FINAL DESIGN ADVICE AND COMMENTS **********************
REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known
technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
CORMIX predictions on dilutions and concentrations (with associated
plume geometries) are reliable for the majority of cases and are accurate
to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
the design configuration as highly complex and uncertain for prediction.

FAR-FIELD MIXING SUMMARY:
  Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 0 m
  downstream and continues as vertically mixed into the far-field.
  Plume becomes laterally fully mixed at 1.53 m
  downstream.

PLUME BANK CONTACT SUMMARY:
  Plume contacts both banks simultaneously.
  The x-coordinate for this contact is 1.53 m.
************************ TOXIC DILUTION ZONE SUMMARY ************************
No TDZ was specified for this simulation.
********************** REGULATORY MIXING ZONE SUMMARY ***********************
No RMZ has been specified.
However:
The ambient water quality standard was encountered at the following
  plume position:
  Water quality standard = 0.0056 mg/l
  Corresponding dilution s = 6.3
  Plume location: x = 0.00 m
   (centerline coordinates) y = -0.30 m
  z = 0.19 m
  Plume dimension: half-width (bh) = 0.15 m
********************* FINAL DESIGN ADVICE AND COMMENTS **********************
REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known
  technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
  CORMIX predictions on dilutions and concentrations (with associated
  plume geometries) are reliable for the majority of cases and are accurate
  to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
  the design configuration as highly complex and uncertain for prediction.