May 2015 Revision

Seattle Biological Evaluation

Seattle Biological Evaluation

Corrections and Updates Page

This page lists corrections and other changes made to the October 2011 and 2012 versions of the Seattle Biological Evaluation, as of the given dates. Please replace the pages as indicated below for the 2015 changes. The 2011 and 2012 list of changes are retained and on the next page.

Date and Description	Location
06/11/2015	
Provided a list of 2015 document changes and noted the SBE pages to be replaced	Replace the Corrections and Updates Page
May 2015 revisions date added to the report cover	Replace report cover sheet
Table of Contents: Appendix B.2 had been deleted	Replace Table of Contents pages i-ii
Introduction has been revised for clarity, including adding section 1.4	Replace section 1
Seattle's standard plans and specifications reference has been updated and a slight clarification of sensitive areas added	Replace pages 3-1 to 3-4
Section 4.1, CM 1 first paragraph and last sentence have been changed	Replace pages 4-3 to 4-6
In Section 5, Status of the Species: (1) Deleted Stellar sea lion and (2) added critical habitat for steelhead, Bocaccio, Canary Rockfish and Yelloweye Rockfish	Replace all of Section 5 and be sure to keep and reinsert the large figures, Figure 2 and 3 (When printing, note that some of the pictures are in color.)
Addition to climate change information and minor update of other information in Section 8, Cumulative Effects	Replace Section 8
Species and critical habitat listings have been updated and use of Appendix B compared to the SPIF Cover Page has been clarified	Replace the entire SPIF Cover Page in Appendix A
Added climate change references	Replace the entire References section
Appendix B introduction and the Appendix B.2 template have been deleted	Replace all Appendix B
Sections C.5 and C.6 were changed and the appendix reorganized	Replace all Appendix C

10/2/2012	
Addition of reference for eelgrass and large rocks	Table 4-2
Conservation Measure (CM) #52 clarified by specifying “maximum” extent	Chapter 4 and throughout where CM #52 is cited
Conservation Measure (CM) #56 expanded to restore information from the former Pile Driving Table	Chapter 4 and throughout where CM $56 is cited
Bald eagle text and Table 7-3 moved from Chapter 7 and incorporated into Appendix C Remaining Chapter 7 tables renumbered	Chapter 7 and Appendix C
Broken web links repaired and new ones provided Referenced, cited and/or web-linked documents upgraded	Chapter 10 and throughout SBE, as applicable
Table renumbered List of Tables added to the Table of Contents	Primarily the Table of Contents and Chapters 4, 6 and 7
Fish Barrier Maps (Figures 6, 8, 9, 11, and 12) updated to include current watershed boundaries. Upstream locations of steelhead sightings on Thornton Creek eliminated from Figure 6 due to species misidentifications discussed in Chapter 5, Status of Species.	Chapter 6
11/16/2012	
SPIF Cover letter updated to include all of the ESA-listed species in the SBE	SPIF Cover Letter

Acknowledgements

Many thanks go to the staff of multiple City of Seattle departments, the U.S. Army Corps of Engineers, the National Marine Fisheries Service and the U.S. Fish and Wildlife Service who have made the concept of this biological evaluation a reality.

Abbreviations

BMP	best management practice
CFR	Code of Federal Register
Corps	U.S. Army Corp of Engineers
FR	Federal Register
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
PCEs	Primary Constituent Elements
pers. comm.	personal communication
RCW	Revised Code of Washington
RM	river mile
SMC	Seattle Municipal Code
SPCP	Spill Prevention Control Plan
SPU	Seattle Public Utilities
TESC	Temporary Erosion and Sediment Control
unpub. data	unpublished data
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
WAC	Washington Administrative Code
WDF	Washington Department of Fisheries (now WDFW)
WDFW	Washington Department of Fish and Wildlife
WRIA	Watershed Resource Inventory Area

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Glossary

action area	Under ESA, all areas to be affected directly or indirectly by the action and not merely the immediate area involved in the action.
BE	Biological Evaluation. Information prepared by or under the direction of a federal agency to determine whether a proposed action is likely to 1) adversely affect listed species or designated critical habitat 2) jeopardize the continued existence of species that are proposed for listing or 3) adversely modify proposed critical habitat. The outcome of a biological evaluation determines whether formal consultation or informal conference is necessary between an agency and the Services under the ESA. Sometimes this is called a biological assessment (BA).
conservation	As defined by the ESA is the use of all methods and procedures necessary to bring any endangered or threatened species to the point at which the measures provided under the ESA are no longer necessary.
critical habitat	1) Specific areas within the geographical area occupied by the species at the time of listing, if they contain physical or biological features essential to conservation, and those features may require special management considerations or protections; and 2) Specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation.
DPS	Distinct Population Segment. Under the ESA, vertebrates are listed if they are distinct population segments. For a group of salmon to be a DPS, they must be an evolutionary significant unit. See ESU below.
EFH	Essential Fish Habitat. Those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.
ESA	Endangered Species Act of 1973. Federal law that mandates preservation of listed threatened and endangered species.
ESU	Evolutionarily Significant Unit. A population of group of populations that is 1) substantially reproductively isolated from populations and 2) represents an important component of the evolutionary legacy of the species.
endangered	Any species which is in danger of extinction throughout all or a significant portion of its range.
environmental baseline	Past and present impacts of all federal, state or private actions and other human activities in an action area.
MHHW	The average of the higher high water height of each tidal day observed over the National Tidal Datum Epoch. For stations with shorter series, comparison of simultaneous observations with a control tide station is made in order to derive the equivalent datum of the National Tidal Datum Epoch.

MHW The average of all the high water heights observed over the National Tidal Datum Epoch. For stations with shorter series, comparison of simultaneous observations with a control tide station is made in order to derive the equivalent datum of the National Tidal Datum Epoch.

MLLW The average of the lower low water height of each tidal day observed over the National Tidal Datum Epoch. For stations with shorter series, comparison of simultaneous observations with a control tide station is made in order to derive the equivalent datum of the National Tidal Datum Epoch.

OHW Ordinary high water. Also called the OHWM or ordinary high water mark or OHWL or ordinary high water line. A freshwater datum for the visible line on a bank where the presence or action of waters are so common as to leave a mark on soil or vegetation. Indicated by a clear natural line on the bank, shelving, changes in soil character, destruction of terrestrial vegetation, or presence of litter or debris or other characteristics of the surrounding area. Make sure you use the Corps of Engineers definition as it is not necessarily the same as that of Washington State.

PCE Primary Constituent Element. Physical or biological feature essential to the conservation of a given species and that may require special management considerations or protection. Such requirements include but are not limited to the following: 1) Space for individual and population growth, and for normal behavior; 2) food, water, air, light, minerals, or other nutritional or physiological requirements; 3) cover or shelter; 4) site for breeding, reproduction, rearing of offspring, germination, or seed dispersal; and generally, (5) habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species.

SBE Seattle Biological Evaluation. An inclusive, reference document that allows routine methods and conservation measures to be applied to a range of small capital improvement projects and routine maintenance activities performed by the City of Seattle within the city limits. The SBE replaces the need to prepare a biological evaluation (BE) or a biological assessment (BA).

Std Spec Standard Specifications. City of Seattle Standard Specifications for road, bridge, and municipal construction projects.

Std Plan Standard Plans. City of Seattle Standard Plans for municipal construction projects. These show frequently recurring components or work that has been standardized for use by various departments within the City of Seattle.

the Services The National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS).

threatened Any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Section 1

Introduction

1.1 Purpose of the SBE

The Seattle Biological Evaluation (SBE) is intended to satisfy Endangered Species Act (ESA) requirements for many City of Seattle (City) projects and maintenance activities that require a federal permit, obtain federal funding, and/or affect federal land (that is, that have a federal nexus). Most projects and activities affecting Waters of the United States[1] typically trigger federal regulatory permits issued by the U.S. Army Corps of Engineers (Corps) under authority of Section 10 of the Rivers and Harbors Act and/or Section 404 of the Clean Water Act. When issuing such permits, the Corps must consider the presence of species listed as threatened or endangered under ESA (or their critical habitat). As addressed in ESA Section 7(a)(2), the information required for ESA evaluation is usually prepared in the form of a biological evaluation (BE). This SBE replaces the individual project-specific BEs that would otherwise be required under Section 7 for many separate projects/activities conducted by the City. In addition to ESA requirements, the SBE is intended to satisfy Essential Fish Habitat requirements of the Magnuson-Stevens Fishery Conservation and Management Act (MSA).

Although the bald eagle is no longer listed under ESA as a threatened or endangered species, there are permitting requirements under the Bald and Golden Eagle Protection Act. Information on these requirements is provided in Appendix C.

1.2 Using the SBE

This SBE primarily supports those projects and activities requiring a Corps permit and where ESA-listed species (or their critical habitat) are located in the project or activity area. During the early planning or design phases of a project /activity, the Corps should be consulted to determine if a permit is needed and the U.S. Fish and Wildlife Service

[1] Waters of the United States is defined by 33 CFR 328. It refers to waters used for commerce and subject to tides, interstate waters including wetlands, intrastate waters such as lakes, rivers, streams, mudflats, sandflats, sloughs, natural ponds, impoundments of waters, tributaries and territorial seas.

and National Marine Fisheries Service (jointly the "Services") consulted to as to whether ESA-listed species (or critical habitat) occur in the area.

In addition, the project or activity must be located within the City's municipal boundaries and all of the project's or activity's construction methods must be included in the SBE. If all construction methods for the project or activity are not included in the SBE, then the Corps and Services should be queried on whether and how the SBE might be used. The Corps, along with the Services will use this SBE to review federal permit applications for City projects and activities and their compliance with ESA and MSA requirements. Other federal agencies may also require a BE. In those cases, the specific agency so requesting should be queried to determine their specific agency requirements and that agency's ability to use this SBE.

Generally, the SBE consists of a number of descriptions of construction methods and the conservation measures that the City agrees to implement to mitigate environmental impacts of those construction methods. A project manager would review the methods, select those methods to be used on their project or activity, review the conservation measures specific to those methods, and then complete a Specific Project Information Form (SPIF) for each of the selected methods and its associated conservation measures. Projects and activities claiming ESA coverage under this SBE should be certain to select all applicable construction methods (Section 3) and conservation measures (Section 4) and fill out the correct SPIFs. The SPIFs (Appendix A) are usually submitted to the Corps as an attachment to the Joint Aquatic Resources Permit Application (JARPA).

1.3 Organization of the SBE

The SBE is organized as follows:

- Section 1: Introduction
- Section 2: Permitting and Consultation
- Section 3: Description of Proposed Action: Methods
- Section 4: Conservation Measures
- Section 5: Status of the Species
- Section 6: Environmental Baseline
- Section 7: Effects of the Action
- Section 8: Cumulative Effects
- Section 9: Essential Fish Habitat
- Section 10: References
- Appendix A: Specific Project Information Forms (SPIFs)
- Appendix B: Effects Template
- Appendix C: Bald Eagle Permit Process

1.4 Submission of Documents to the Corps of Engineers

The use of this SBE replaces the submission of a separate biological evaluation or biological assessment for individual projects. For each project the following documents should be filled out and submitted to the Corps of Engineers (Corps), after review by the U.S. Fish and Wildlife/National Marine Fisheries (the "Services") representative for the City of Seattle. The Services representative can help prepare the documents and is available for questions.

Specific Project Information Forms (SPIFs, Appendix A of the SBE)

The SPIF Cover Page is to be submitted with the applicable SPIF methods. The cover page provides an overview of the project, identifies which species are within the project action area, identifies the different construction methods, and describes the effects determinations, as well as the justification for them. The Cover Page and individual SPIFs should be sent to the Service's representative for review and comment. The Cover Page should be signed by the Service's representative prior to submittal to the Corps.

Individual SPIFs for each Method Each proposed construction method or activity has a correlated SPIF that must to be filled out with pertinent information. This includes a table that is used to identify which conservation measures will be implemented with the project. Please read each conservation measure and only check those that are applicable to the project and will be implemented.

Effects Template (Appendix B of the SBE)

For projects that will have no effect (NE) to or will not adversely affect (NAA) listed species and designated critical habitat, neither SPIF Cover Page nor the SPIFs are required for application submission. The NE and NAA Effect Template should be filled out, reviewed by the Service's representative, and then sent to the Corps. If the Corps does not agree with the determination, the SPIF cover letter and individual SPIFs must be filled.

Joint Aquatic Resources Permit Application (JARPA) – This document must be completely filled out and is available on the internet.

Vicinity Map and Project Drawings

A vicinity map and project drawings are required with JARPA submission. The vicinity map and project drawings should meet the Corps' required format and content. Engineering drawings are not recommended for submission as they provide more detail than is necessary. Please contact the Seattle Corps representative if you have questions on requirements for a vicinity map and project drawings.

Map Showing Location of Sensitive Areas

Sensitive areas should be identified on a map so they are avoided during construction. See SBE Section 3.1 Method 1 for a definition of "sensitive Area." Protection of sensitive areas (wetlands, buffers, etc.) is important to minimize adverse environmental impacts.

Hydraulic Project Approval (HPA)

The HPA is issued by the Washington State Department of Fish and Wildlife. If the HPA has been issued prior to submittal of material to the Corps, it should be sent with the Corps' document. The HPA may provide mitigation or conservation measures that must be included with the project and this information may not be provided in other documents.

Section 2

Permitting and Consultation

2.1 Corps of Engineers Permitting

2.1.1 Statutory Authority

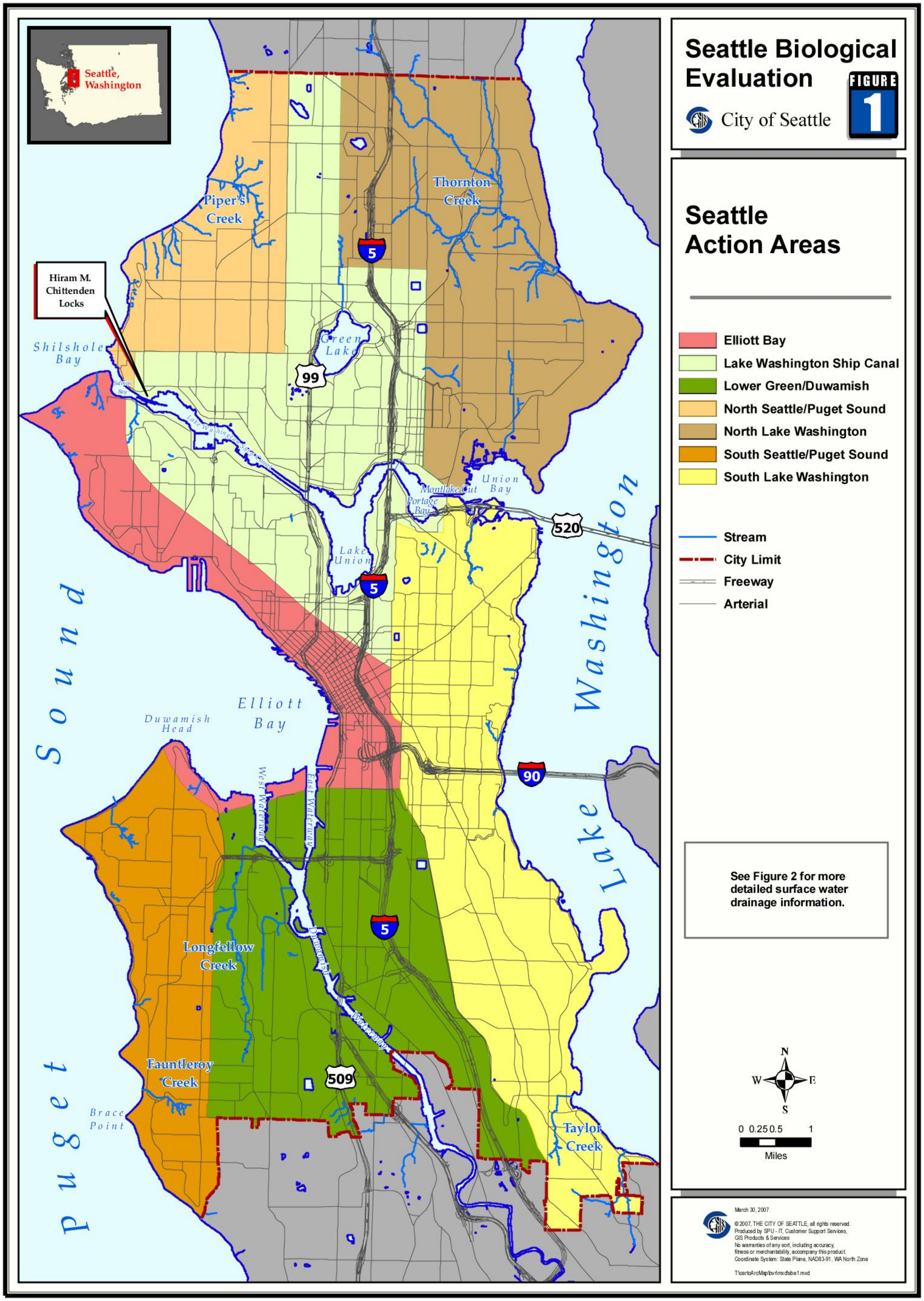
The Corps regulates activities under Section 10 of the Rivers and Harbors Act and/or Section 404 of the Clean Water Act. A Section 10 permit is required for any work that would occur above or below Navigable Waters of the United States. The Corps regulates all activities below the ordinary high water (OHW)[1] mark in non-tidal waters and below the mean high water (MHW)[2] line in tidal waters. Navigable waters in and near the City of Seattle (City) are listed below and shown on Figure 1.

- Duwamish River (the entire length within City limits is navigable)
- Lake Washington Ship Canal (entire length is navigable)
- Cedar River from its mouth at Lake Washington to Northern Pacific Railroad Bridge approximately at River Mile 1.25
- Lake Union (entire length is navigable)
- Lake Washington (entire length is navigable)
- Puget Sound (entire length is navigable)

Section 404 of the Clean Water Act regulates the discharge of dredged or fill material into Waters of the United States, which include Navigable Waters and other parts of the surface water tributary system down to the smallest of streams (e.g., a tributary that only

[1] OHW: The visible line on a bank where the presence and action of waters are so common as to leave a mark on soil or vegetation. As used by the Corps, this means the line on the shore of non-tidal (freshwater) streams and lakes. For tidally influenced (marine) water bodies, OHW correlates to the mean higher high water (MHHW). The Corps uses a reference system that sets 0 at Mean Lower Low Water (MLLW) (whereas MLLW in NAVD88 is at approx. -2.35). Make sure you use the Corps datum.

[2] MHW: A tidal datum that is the average high water height. As used by the Corps, this term means the elevation on the shore of tidal waters (ocean, bays estuaries, and certain rivers) reached by the plane of the average high water. The Corps uses a reference system that sets 0 at Mean Lower Low Water (MLLW) (whereas MLLW in NAVD88 is at approx. -2.35). Make sure you use the Corps datum.


Seattle Biological Evaluation
FIGURE 1
City of Seattle
Seattle Action Areas
Elliott Bay
Lake Washington Ship Canal
Lower Green/Duwamish
North Seattle/Puget Sound
North Lake Washington
South Seattle/Puget Sound
South Lake Washington
Stream
City Limit
Freeway
Arterial
See Figure 2 for more detailed surface water drainage information.
N
W
E
S
0 0.25 0.5 1
Miles
Seattle, Washington
Hiram M. Chittenden Locks
Shilshole Bay
Piper's Creek
Thornton Creek
Green Lake
Union Bay
Portage Bay
Montlake Cut
Lake Union
Lake Washington
Puget Sound
Elliott Bay
Duwamish Head
West Waterway
East Waterway
Longfellow Creek
Fauntleroy Creek
Brace Point
Taylor Creek
5
99
520
90
509

contains water after storm events), lakes, ponds, or other water bodies on those streams, and adjacent wetlands (e.g. sloughs, swamps, and some seasonally flooded areas) if they meet certain criteria. A Section 404 permit is required for all fill or discharge activities waterward of the OHW mark in non-tidal waters and waterward of the mean higher high water (MHHW)[3] line in tidal waters. When adjacent wetlands are present, Corps jurisdiction extends beyond the OHW mark to the limit of the adjacent wetlands. When the Water of the United States consists only of wetlands, Corps jurisdiction extends to the boundaries of the wetlands.

2.1.2 Corps Permitting with the City of Seattle

The City and Corps have developed a program to streamline permitting in which the City financially supports a designated Corps liaison to coordinate and prioritize City permit applications. Authorized under Section 214 of the Water Resources Development Act, the program is implemented through a Memorandum of Agreement (MOA) between the City and the Corps. The MOA covers all City departments and is facilitated through Seattle Public Utilities.

2.2 Consultation with the Services

When issuing permits, the Corps must consider the presence of species listed as threatened or endangered under the Endangered Species Act (ESA) (or their critical habitat). As addressed in ESA Section 7(a)(2), the information required for ESA evaluation is usually prepared in the form of a biological evaluation (BE). The Corps uses BEs to conduct ESA Section 7 and Essential Fish Habitat (EFH) consultation with the Services to assess potential effects of a project action on listed species and their designated critical habitat. BEs must include all areas directly and indirectly affected by the project.

Direct effects are the immediate effects of a project. For example, work in or along a stream can affect Chinook salmon in that stream.

Indirect effects are those caused later by an action, or in a broader geographic area, and are reasonably likely to occur. For example, removal of a fish barrier could result in an adverse affect if Chinook salmon move upstream into a polluted area above the former fish barrier.

In the spring of 1999, several species of salmon in Washington waters were listed under the ESA. Because these listed species may be affected by in-water work in many areas of Washington, including the City, the Corps [as mandated by Section 7 of the ESA and Department of the Army permit regulations at 33 CFR 325.2(b)(5)] consults with the Services on most permit applications it receives.

[3] MHHW: A tidal (marine) datum that is the mean (average) of the two highest tides. The Corps uses a reference system that sets 0 at Mean Lower Low Water (MLLW) (whereas MLLW in NAVD88 is at approx. -2.35). Make sure you are use the Corps datum.

2.3 What to Submit to the Corps

This Seattle Biological Evaluation (SBE) replaces the numerous individual BEs that would otherwise be required for Section 7 consultation. For the projects or activities covered under this SBE, the City would submit the following application package to the Corps:

- **Permit application**. Use the Joint Aquatic Resources Permit Application (JARPA) form, available at http://www.epermitting.org/ along with permit drawings.
- **Specific Project Information Form (SPIF)**. Fill out the SPIF Cover Page and, based on project or activity construction methods, the other applicable SPIFs. The SPIFs are found in Appendix A. The SPIF requires identification of ESA-listed species and their EFH that occur in the project area. SBE Section 5 can assist in making these identifications. Other scientists may also be consulted in the effort to write the information on which ESA-listed species are found in a project area and which of them may be affected by the proposed project or maintenance activity.

Upon receipt of these documents, the Corps will request, if necessary, additional information to complete the application package. The Corps then initiates individual ESA and EFH consultation with the Services.

Section 3

Description of Proposed Action: Methods

This section describes the 13 construction methods that are covered in this SBE. These are activities required to construct, maintain, repair, or replace City of Seattle facilities; improve the environment; or to improve or maintain operations to ensure public safety and the longevity of infrastructure or project feature. Conservation measures (CM) are used in conjunction with these construction methods. Each required measure for each method is summarized in this Section 3 and detailed in Section 4.

In addition to the SBE construction methods and conservation measures, applicable requirements in the 2014 Edition of the City of Seattle's *Standard Specifications and Standard Plans for Road, Bridge and Municipal Construction* should be followed.

The 13 construction methods are listed below, with details following:

1. Delineation of work areas and project startup
2. Clearing, grubbing, grading and placement of temporary fill
3. Work area isolation and fish removal in streams, large waterbodies and for pipe bypass
4. Pipe, culvert, and outfall installation, removal, and replacement
5. Vactoring, jetting, and excavating accumulated sediments and debris, sediment test boring, and pipe, culvert and bridge maintenance
6. Bank stabilization
7. Habitat addition and maintenance
8. Beach nourishment and substrate addition
9. Boat launch improvement, repair and maintenance
10. In-water/overwater structure repair and replacement
11. Seawall repair and maintenance
12. Site restoration
13. Landscaping and planting

3.1 Method 1: Delineation of Work Areas and Project Startup

Delineation of environmentally sensitive areas, project staging areas or other work areas is a common construction activity before project startup. This routine construction activity includes flagging, installing stormwater pollution prevention best management practices (BMPs) and other actions, as needed, to protect sensitive areas. Environmentally sensitive areas are identified and protected to keep people and equipment out of them (unless the project area lies within a sensitive area) and to limit the impact of construction activities on the site. Staging areas are used to secure materials and equipment. Identifying staging areas is necessary to initiate project site work. Other work areas may include temporary access roads or stream access points.

Some activities identified in this method may be more appropriate after completion of clearing, grubbing, or grading work (see Method 2).

A. Sensitive Areas

Before project start, environmentally sensitive areas are protected as appropriate. Environmentally sensitive areas are areas that contain natural features, such as the habitat of a rare species, and are often protected by government regulations. These include marine shorelines, lakes, streams, riparian corridors or wetlands and their buffers. These areas may be protected using flagging, fencing, wood pallets, mulch, or other appropriate method, which shall be maintained throughout construction. Project managers and/or designers are responsible for consulting with a professional in this field to determine environmentally sensitive areas as well as features that are regulated. Also it is prudent to understand that federal, state and/or local regulators may apply their jurisdiction differently for the same feature. It is necessary to check with all applicable regulatory agencies for jurisdictional determinations.

B. Work Areas

Project startup includes delineating work areas where the following may occur:

- Access roads and access points (such as along a stream)
- Contractor administrative offices
- Earth, wood, plastic, concrete and metal products storage
- Fencing installed for security and/or to protect areas not to be disturbed
- Fuel and other potential pollutants storage
- Material delivery or removal or temporary storage
- Vehicle wash areas
- Vehicles, trailers and construction equipment, such as excavators, trucks, etc., storage, parking or servicing.

Delineation of these areas may include use of flagging, fencing, mulch, coir rolls, or other appropriate materials that must be maintained throughout construction.

C. Stormwater Pollution Prevention

Project startup also involves installation of stormwater pollution prevention measures. Among these measures are temporary erosion and sediment control measures, which are specified on a Construction Stormwater and Erosion Control Plan (CSECP). Note that the City of Seattle has replaced the Temporary Erosion and Sedimentation Control Plan (TESC) plan with the Construction Stormwater and Erosion Control Plan (CSECP). The 2011 Edition of the City of Seattle's *Standard Specifications and Standard Plans for Road, Bridge and Municipal Construction* uses the term CSECP, whereas the older 2008 version uses TESC plan. CSECP measures are used to minimize erosion and offsite sediment transport that could damage environmentally sensitive areas and aquatic life. CSECP measures must be maintained throughout construction.

Equipment Used
Bulldozer, car, excavator, tractor, fork-lift, hand tools, hydro-seeding truck, pick-up truck, portable storage facilities, tanks, trailer, water truck, wheelbarrow

Conservation Measures • Approved work windows • Stormwater pollution prevention	
CM #	
	Approved Work Windows
1	All work shall comply with the approved work windows/timing restrictions for the protection of ESA-listed species or species they forage upon in the Seattle action areas.
	Stormwater Pollution Prevention
	Develop a CSECP
2	Each project shall have onsite a written Construction Stormwater and Erosion Control Plan (CSECP) that includes all information needed to reduce erosion and sedimentation on the project. All projects will require the contractor to assign an onsite Erosion Control Lead to oversee the work and ensure compliance with the CSECP.
	Ensure City crew/contractor has SPCP
3	The City crew/contractor shall have onsite a written Spill Prevention and Control Plan (SPCP) that describes materials to be used and measures to prevent or reduce impacts from potential spills (fuel, hydraulic fluid, etc)
4	Maintain a spill kit onsite to respond to accidental spills during construction. Ensure that spill kit is stocked with adequate containment material and other supplies to suit the specific job site and potential containment distances.
	Minimize site- preparation-related impacts
5	Confine construction impacts to the minimum area necessary to complete the project and delineate impact areas on project plans. Flag boundaries of clearing limits associated with site access, construction, and staging areas as well as wetland and riparian corridor where work has been authorized.
6	Establish staging and site access areas along existing roadways or other disturbed areas to minimize erosion into or contamination of sensitive areas or their buffers. Confine work to the area noted using flagging or other barriers.
8	Divert run-off from entering the project (disturbed) area.
9	Ensure proper BMPs, such as covering, berming, matting, seeding, or mulching, are implemented to prevent erosion of any excavated material.
	Minimize earthmoving-related erosion
22	<u>If equipment wash areas are required</u>, they shall be located where washwater, sediment, and pollutants cannot enter waterbodies, including wetlands.
23	No sediment shall be tracked onto paved streets or roadways. Sediment shall be removed from trucks and equipment before leaving the site.

3.2 Method 2: Clearing, Grubbing, Grading and Placement of Temporary Fill

Clearing, grubbing, and grading are done to access staging areas and the project work site including the construction of temporary roads and to establish basic grades for project sites. Clearing is the removal (or pruning) of vegetation including trees. Grubbing is root and organic debris removal. Grading is moving earth with large equipment, generally to establish access or staging areas or to prepare sites for installation of structural elements and final site preparation.

If the City of Seattle's Environmentally Critical Areas Ordinance (SMC Chapter 25.09) thresholds for vegetation removal are reached, a plan to restore native vegetation will be prepared. See Seattle's Department of Planning and Development website for more information.

When temporary fill is needed for access roads or work platforms, the preferred method should reduce impacts to sensitive and beach areas. Such methods include placing timber mats, pallets, or metal sheeting under the fill. If those methods are not feasible, hog fuel (wood waste), hay or other easily biodegradable material can be used and complete removal of those materials is not required.

When no low-impact alternative exists, temporary backfill for roadways and work platforms may be necessary to provide a stable surface in mucky or marshy areas. If imported soil or rock is used as temporary backfill, a geotextile separator is recommended to create a barrier between the existing soil and the fill material. Geotextile also helps to define the plane between the native material and the fill material to ease post-project fill removal.

Equipment Used

Backhoe/excavator, brush cutter, bulldozer, car, chain saw, dump truck, front-end loader, hand tools, hydro-seeding truck, pick-up truck, scraper, tractor, trailer, weed trimmer, wheelbarrow

Conservation Measures • Approved work windows • Stormwater pollution prevention • Pesticides	
CM #	
	Approved Work Windows
1	All work shall comply with the approved work windows/timing restrictions for the protection of ESA-listed species or species they forage upon in the Seattle action areas.
	Stormwater Pollution Prevention
	Minimize site-preparation-related impacts
7	Limit clearing and grubbing area to minimum required. Retain vegetation to maximum extent possible. Minimize clearing and grubbing effects by cutting vegetative stems but not removing the root systems, which can help to reduce erosion potential and allow native plants to regenerate.
9	Ensure proper BMPs, such as covering, berming, matting, seeding, or mulching, are implemented to prevent erosion of any excavated material.
12	Place sediment barriers (e.g., silt fences, coir logs, wood straw or other effective erosion control method) around disturbed sites to prevent erosion from sediment deposition into a waterbody.
13	Keep a supply of erosion control materials (e.g., silt fence or mulch) on hand to respond to sediment emergencies. For wetland areas with high likelihood of germination, use wood straw.
14	Use curb inlet sediment traps, geotextile filters, along with silt fencing, to capture sediment before it leaves the site.
	Minimize earthmoving-related erosion
19	Operate machinery from existing roads and paved areas where they exist in proximity to the site. In many cases, wood chippings and timber mats can provide a temporary surface where heavy equipment can access a work site.
20	Use temporary materials such as geotextile barriers, hog fuel or wood pellets to stabilize haul and access routes, staging areas and stockpile areas.
23	No sediment shall be tracked onto paved streets or roadways. Sediment shall be removed from trucks and equipment before leaving the site.
	Pesticides
75	Pesticides will be applied only under direct supervision (within line of sight) of a licensed applicator.
77	Within the shoreline and riparian zone of all waterbodies, use only herbicide products containing glyphosate for general weed control and/or selected Washington State Department of Ecology-approved herbicides mandated for aquatic noxious weed control.

3.3 Method 3: Work Area Isolation and Fish Removal in Streams, Large Waterbodies and for Pipe Bypass

Dewatering work areas and fish removal are standard practices to minimize impacts to aquatic species. To reduce turbidity, construction areas that occur within natural drainage systems and shorelines or pipe infrastructure are isolated before and during project work to prevent scour and eliminate the creation of sediment. This method includes removing all fish from the isolated area using the fish handling and capture protocol described below under section *3.C. Fish Removal and Handling*. Method 3 includes the following:

- **Temporary bypass for stream flow in a partial channel***:* Occurs when a full bypass is not required because work occurs in a limited area of a stream. This method requires fish removal before installation of the bypass.
- **Temporary bypass for stream flow in a full channel.** Occurs when a full bypass is required because work occurs within a full channel. This method requires that fish be removed before installation.
- **Isolating the work area in large waterbodies**. Typically, this method involves using a silt curtain to contain sediment.
- **Isolation/dewatering of piped infrastructure**. This method involves bypassing stormwater and combined sewers that discharge to a creek or other waterbody.

All work must occur in isolation from flowing waters except for the following:

- Install and remove stream isolation structures (coffer dams, bypass flow devices, pumps, and screens)
- Fish removal procedures
- Place wood and rock structures (that do not require in-water excavation).

For any bypass that will be in place for longer than **1 day**, a contingency plan must be developed to account for unexpected high flows.

In certain work situations, isolating and dewatering the construction site is not needed and could ultimately cause more disturbance than just working in the water. These situations would **not** involve any excavation within wetted areas and do include activities such as placing rock or wood structures. For this work, Method 3 is **not** required and should be noted as **not required** on the SPIF (See Appendix A).

A. Isolation of In-water Work Area

Typically, an in-water work area is isolated with a diversion structure that is a temporary dam consisting of sand bags filled with clean gravel and covered with plastic sheeting and built just upstream of the project site. A portable bladder dam or other non-erosive diversion technologies may be used to contain stream flow. Stream or floodplain rock and sediment cannot be used to construct a diversion dam. In most cases, a pipe carries the stream flow from the diversion dam around the project site to a location immediately downstream of the construction zone.

1. Temporary Bypass for Stream Flow: Partial Channel

Stream flow may be temporarily bypassed to one side of the existing channel by placing diversion structures around the work area to prevent any stream flow from entering the work area. Scour and the potential for transport of sediment should be minimized.

The following project conditions allow in-water rerouting:

- Stream channel that is wide enough to accommodate rerouting
- Diversion path that is essentially non-erosive
- Flows that support these methods.

The diversion path will be, but is not limited to, one side of the existing channel. Temporary bypass of this type is most often associated with project activities that reshape a bank, remove armoring below the OHW[1] line or add structure or channel substrate. Under this scenario, fish can pass freely up or downstream. However, fish within the isolated portion of the stream will need to be relocated. Fish are often hidden in the substrate so care should be taken to avoid killing fish when placing a diversion structure in a waterway.

2. Temporary Bypass for Stream Flow: Full Channel

In most cases, a gravity or pump system will bypass stream flow from an upstream containment berm or dam around the project site to a location immediately downstream of the construction zone. The length of the isolated stream channel can vary, depending on project size.

All projects will have a method to dissipate flow at the downstream end of the diversion. The following are examples of site-specific options for dissipating flow at the downstream end of the diversion:

- Ecology block 'box' filled with gravel and riprap with option to place on plastic sheet or geotextile
- Porous geotextile bags for water to seep out
- Flow spreaders that spread flow from a concentrated point source to a widespread sheet flow
- Visqueen sheets or geotextile fabric to protect the streambed within the discharge area to reduce the energy of the discharge
- 90-degree elbow on the end of the pipe with the water falling into a small pool created by using visqueen and straw bales.

It may be necessary to have temporary equipment access through the riparian area to the site of the dewatering structure.

3. Isolating Work Areas in Large Waterbodies

This section applies to isolating work areas along the shoreline in both marine and freshwater. In marine waters, isolation of the work area may be needed when construction cannot be completed during low tide. Isolation of areas in large waterbodies like Lake Washington or the Lake Washington Ship Canal may be needed to minimize construction related impacts to water quality and aquatic species. Work may include, but is not limited to, such activities as sediment removal or maintenance, repair, or installation of outfalls, pilings, bulkheads, or

[1] Ordinary high water (OHW): The visible line on a bank where the presence and action of waters are so common as to leave a mark on soil or vegetation.

shoreline stabilization. Schedule the majority of work to occur in the dry, not in water.

Isolation of work areas in large waterbodies may include the installation of a sediment or silt curtain around the outside perimeter of the work area. Dewatering a work area in a large waterbody may be necessary. Methods such as free standing steel support frames or ecology blocks and visqueen or plastic have been successful in dewatering work areas.

B. Isolation/Bypassing of Piped Infrastructure

This method applies only to Seattle Public Utilities stormwater and combined sewers that discharge to a creek or other waterbody. It includes any bypass within a 0.25 mile of a creek discharge point and outfalls into waterbodies that may extend some distance into the water body.

Bypassing around piped infrastructure is necessary to isolate the pipe from the flow so that the pipe or culvert is accessible for maintenance or repair. Bypassing reduces turbidity, prevents scour, and eliminates sediment transport. Set the bypass at the most convenient upstream maintenance hole. Determine the design level flow in the pipe to determine pump size and pumping rates. Pumping can create a head in the maintenance hole where the pump is located. Determine the maximum head allowable for the size of bypass system to prevent flooding. The following conditions can occur:

- If backwater from the pumped flows impacts the upstream system, flows may be pumped to the nearest downstream maintenance hole. Stormwater should be pumped to a stormwater maintenance hole and combined sewer should be pumped to a combined sewer maintenance hole. If laterals are connected to the mainlines being maintained or repaired, similar bypass procedures should be implemented
- The bypass system should account for specific backwater conditions. If it is possible that potential rain events could create flows greater than the design bypass system, provisions for high-water bypass should be made.
- For stormwater systems, if no maintenance hole is available, flows may be pumped to the receiving stream if it meets state water quality standards. For combined sewers, provisions need to be made to discharge flows to the combined mainline located downstream of the maintenance or repair.
- If treatment is required, the flow may be pumped to a tank for settling. Onsite infiltration and dispersion is possible if conditions permit. Re-introduction back into the stream is an option once the water meets state water quality standards. The project manager will need to show some sort of evidence that this will work.
- If the discharge exceeds the capacity of a nearby stream, the flows may be pumped to a tank or truck for offsite disposal.

C. Fish Removal and Handling

Before dewatering a stream section or beginning construction in an isolated work area in a large waterbody, fish must be removed.

1. Streams

The sequence for stream flow diversion and fish capture is shown on Table 3-1. Block nets are placed upstream and downstream from the work area to prevent fish from entering the stream segment to be dewatered. City crew/contractors will install block nets, capture and relocate all fish, divert streamflow around the project area, then remove the block nets all in the same day. On rare occasions, block nets may remain in the stream overnight when the fish capture and diversion activities require additional time to complete. Once the project area has been isolated with block nets, fish will be captured and relocated outside of the work area.

Table 3-1
Stream flow diversion technique

	Method
1	Install fish block nets above and below project.
2	Conduct initial fish removal procedure. This may include seining and electrofishing. Remove as many fish as possible at this time. Multiple passes to remove fish may be required. Fish removal should continue until catch rates reach zero fish for 3 consecutive passes.
3	Install flow conveyance devices (pumps, discharge lines, gravity drain lines, conduits, and channels) directly below the fish block nets, but do not divert flow. Suction devices should be outfitted with a fine mesh screen in addition to the factory screen.
4	Install upstream diversion dam in stages allowing water to dissipate from the downstream area in a controlled orderly fashion. This can be assisted by manipulating the pump if the unit rented for the project is self-priming. During this process, fish relocation in the downstream section should continue.
5	Coordinate stream flow reduction with fish relocation so the bypass is not fully installed until the fish relocation protocol has been completed.
6	Install downstream diversion dam if necessary (only in low gradient, backwatered reaches). Installation of downstream diversion may be required earlier (during step 4) to facilitate complete dewatering of stream section.

2. Large Waterbodies

Isolation and fish removal of a work area in a large waterbody should be conducted in a manner best suited to the proposed project. Different alternatives may be used to remove fish from the work area. The following are 2 methods that may be used.

14. Isolate the work area by installing a barrier such as a sediment or silt curtain around the perimeter of the work area. Fish inside the enclosure can be removed by seining or pulling a large net through the work area. Multiple passes may be needed to ensure removal of all fish.

15. Exclude fish within the work area during installation of the sediment or silt curtain. This method involves expanding the work area from a central location. The work area remains fish free as the sediment or silt curtain is installed. A seine or large net may be needed to exclude fish during installation because sediment or silt curtains do not easily allow water through the curtain. A weighted net can be easily moved through the water to exclude fish while the sediment or silt curtain is installed.

For either alternative, the work area should be checked by divers to verify that fish are removed before work begins. Additional alternatives may be used but a complete description on how fish will be removed or isolated will be needed.

If a work area in a large waterbody must be dewatered (usually near shore), the sequence for fish removal and dewatering should be followed like that described above for streams.

D. Rewatering Work Area

The following is general practice for rewatering an instream or large waterbody work area or piped infrastructure:

1. Remove diversion dam and temporary bypass equipment. This activity may have to occur slowly, in a stepwise fashion to ensure rewatering the construction site occurs at a rate that prevents:
   - Loss of surface water downstream as the site streambed absorbs water
   - Sudden increase in stream turbidity
   - Scour
   - Damage to newly installed improvement.
2. Heavy machinery (operating from the bank) may be used to aid in removal of diversion structures. Use of the machinery may require a CSECP. Look downstream during rewatering to prevent stranding aquatic organisms below the construction site.

Equipment Used
Backhoe/excavator, car, chain saw, cofferdam, diversion dam materials, dump truck. pick-up truck, pump, hoses, trailer, weed trimmer, wheelbarrow.

Conservation Measures • Work area isolation • Fish handling	
CM #	
	Work Area Isolation
31	Follow proper work area isolation measures (see Table 4-3 in Section 4).
	Fish Handling
32	Follow proper fish capture and handing measures (see Tables 4-4 through 4-6 in Section 4)

3.4 Method 4: Pipe, Culvert, and Outfall Installation, Removal and Replacement

This method includes the installation, removal and replacement of pipes, culverts and outfalls. Pipes include those for conveyance of drinking water, as well as for stormwater and sewage wastewater.

Culverts that are installed or replaced should be appropriately sized, bottomless, or arched culverts. Culverts should be designed to restore natural hydrology, stream alignment, and provide downstream and upstream passage for juvenile and adult fish. Guidelines for culvert design to facilitate fish passage include:

- NMFS' Anadromous Salmonid Passage Facility Design document located at http://www.nwr.noaa.gov/Salmon-Hydropower/FERC/upload/Fish-Passage-Design.pdf
- WDFW's technical guidance manual Design of Road Culverts for Fish Passage available at http://www.fws.gov/midwest/Fisheries/StreamCrossings/images/PDF/FishPassage.pdf.

Replacement of pipes and culverts often requires a bypass of any water in the project area. Refer to **Method 3,** Work Area Isolation and Fish Removal in Streams, Large Waterbodies and for Pipe Bypass for bypass information.

If repairs or installations are required, excavate and replace the section of the pipe or culvert, excavate for spot repair work, or use a trenchless technology (e.g. cured-in-place pipe, slip lining, directional drilling) where feasible to reline or repair the deficiency. In some cases, spot repair work or trenchless technologies will not be feasible, in which case the pipe or culvert must be replaced. Where a pipe or culvert is replaced or spot repair work performed, properly bed and fill the excavation. When replacing outfalls along shorelines, special methods must be used to minimize aquatic impacts, such as constructing temporary berms. Consider whether work will be done above water, in-water, or in the dry.

Additional methods that may be applicable include Methods 5 and 8.

Equipment Used
Backhoe/excavator, compressor, dump truck, equipment/vehicles used for relining, front-end loader, hand tools, chain saw, jetting/root cutter truck, pump, hoses, tractor**,** TV inspection equipment, vactor truck, wheelbarrow. Especially for outfalls, barges, cranes, equipment to install sheets and piles, boats, concrete trucks and pumpers, and silt curtains.

Conservation Measures • Approved work windows • Stormwater pollution prevention • Pesticides	
CM #	
	Approved Work Windows
1	All work shall comply with the approved work windows/timing restrictions for the protection of ESA-listed species or species they forage upon in the Seattle action areas.

CM #	**Stormwater Pollution Prevention**
	Develop a CSECP
2	Each project shall have onsite a written or Construction Stormwater and Erosion Control Plan (CSECP) that includes all information needed to reduce erosion and sedimentation on the project. All projects will require the contractor to assign an onsite Erosion Control Lead to oversee the work and ensure compliance with the CSECP.
	Ensure City crew/contractor has SPCP
3	The City crew/contractor shall have onsite a written Spill Prevention and Control Plan (SPCP) that describes materials to be used and measures to prevent or reduce impacts from potential spills (fuel, hydraulic fluid, etc).
4	Maintain a spill kit onsite to respond to accidental spills during construction. Ensure that spill kit is stocked with adequate containment material and other supplies to suit the specific job site and potential containment distances.
	Minimize site- preparation-related impacts
12	Place sediment barriers (e.g., silt fences, coir logs, wood straw or other effective erosion control method) around disturbed sites to prevent erosion from sediment deposition from entering a waterbody.
13	Keep a supply of erosion control materials (e.g., silt fence or mulch) on hand to respond to sediment emergencies. For wetland areas with high likelihood of germination, use wood straw.
14	Use curb inlet sediment traps and geotextile filters, along with silt fencing, to capture sediment before it leaves the site.
	Avoid heavy equipment fuel/oil leakage
15	Equipment used for work below the OHW or MHHW or in riparian zones or shoreline areas shall be cleaned of accumulated grease, oil, mud, etc. and leaks repaired before arriving at the project.
16	Equipment shall be fueled and serviced in an established staging area. Thereafter, all equipment shall be inspected daily for leaks or accumulation of grease, and any identified problems fixed before equipment enters areas typically covered with water.
17	Two oil absorbing floating booms appropriate for the size of the work shall be available onsite during all phases of work whenever heavy equipment is used below the OHW or MHHW. The boom shall be placed in a location that facilitates an immediate response to potential petroleum leakage and shall be deployed for all petroleum leaks.
18	Vegetable-based hydraulic fluid should be substituted when machines will operate in sensitive areas or their buffer for more than incidental work.
	Temporary Dewatering Plan requirements
30	Develop a Temporary Dewatering Plan (TDP) for any dewatering lasting more than 1 day or requiring the installation of a trench safety system.
	Pesticides
78	Other chemicals, such as foaming agents used to kill roots growing into utility pipes, will be subject to Tier 1 chemical applications that will require approval from the Parks IMP coordinator and the Office of Sustainability and Environment.

3.5 Method 5: Vactoring, Jetting, and Excavating Accumulated Sediments; Debris, Sediment Test Boring; and Pipe, Culvert and Bridge Maintenance

This method covers a variety of actions that remove sediment and debris from pipes, culverts, and bridges. Over time, accumulated sediment or other blockages (e.g., roots, large woody material) restrict flow capacity and reduce the performance of the water, stormwater and sewer systems. Overflows or backups can decrease water quality if they reach surface waterbodies. Removal of accumulated sediments in drainage systems, creek systems, around outfalls and along shorelines may be necessary to prevent flooding problems and maintain access for both fish and boats.

If not repaired, structural deficiencies can threaten pipe and culvert integrity and could significantly impact roads, buildings, infrastructure and groundwater and surface water quality. They can also induce piping of surrounding soils, causing turbidity, local subsidence, and downstream flow blockages. Pipes and culverts serving drainage, sanitary sewer, and potable water systems are currently inspected and maintained on an as-needed basis. The frequency of inspection and maintenance depends on the type, age and condition of the pipe and its proximity to trees, structures, or facilities, and the risk incurred if it is not maintained.

Pipe inspection generally includes the use of closed-circuit cameras to identify blockages, sags, root intrusion or pipe damages, such as cracks, holes and separated joints.

- If blockages are due to sediment or other material, maintain the pipe by vactoring out the blockage to a vactor truck and transporting it to a vactor pit. If high-pressure jets are required to remove the debris from the pipe wall, then a temporary barrier may be installed to contain the washed sediment or debris before it is vactored out.
- If blockages are due to root intrusion, hydro-cut. Chemical treatment may be done in sewer pipes, where no chemicals would enter any surface waterbody, directly or indirectly.

Activities under this method include vactoring, jetting and excavating accumulated sediment.[2] Excavation is necessary to provide access to existing facilities or to install new infrastructure and to maintain facilities specifically designed for stormwater quality. Sediment is removed to allow structures to function as designed by removing blockages and accumulated sediment.

Additional methods that may be applicable include **Methods 4 and 8**.

A. Vactoring and Jetting

Vactoring is removal of sediment and turbid water using vactor trucks with suction hoses. Jet cleaning (jetting water into a culvert) is occasionally required to loosen sediment in a pipe or culvert. Typically, material is flushed down to a catchbasin or sump where it can be captured and vactored out. Vehicles are staged adjacent to the work area, typically in an upland area. Vactored material is stored in trucks and disposed of at one of the City's vactor waste facilities.

[2] The Corps' defines 'dredging' as the removal of sediment to facilitate navigation. The City does not remove sediment for navigational purposes. All other sediment removal from waters of the United States would be considered 'excavation.'

B. In-Water Excavating

This method is used to remove accumulated sediments and other debris from boat ramps/launches, near floats or docks, around culverts or outfalls, within creek channels, in-line/off-line sedimentation pond, fish ladders, restoration areas and around bridges. Excavation removes accumulated sediment below the MHHW[3] line that interferes with boat movement or below the OHW line that impedes conveyance. Bank and shoreline stabilization may require excavation as part of repairs.

As sediments accumulate on and adjacent to boat launches, culverts, outfalls, or other structures, these sediments are periodically removed. Work is typically done when the water level is low to minimize the amount of work required within the wetted perimeter. Equipment is hauled or driven onto the ramp using existing roadways. For work that occurs in the dry, a tractor or backhoe is operated directly from the launch. Sediments are excavated and hauled to an upland disposal site. If work in the wetted perimeter is necessary, sediments are removed with hand tools or, if mechanized equipment is used, only an extension arm and bucket operate in the water. If the extension arm is not able to reach the accumulated sediments, a barge-operated excavator may be used.

C Sediment Test Boring

Sediment test boring is conducted to determine if any sediment contamination issues are present at a project site.

D Pipe, Culvert and Bridge Maintenance

Pipe, culvert, and bridge maintenance includes the correction of structural deficiencies that affect pipe, culvert and outfall integrity plus the removal of non-embedded large woody debris and other material. This material if not removed can be a safety hazard to users of the river as well as potentially causing damage to pipes and bridges. Large wood that is extracted is either:

- Cut into three-foot pieces and disposed of at an approved facility, or
- The entire log will be saved and used for City restoration projects.

Work will be conducted from the shore during low water or from a boat.

Equipment Used
Backhoe/excavator, boat/barge combinations, car, concrete trucks and pumpers, crane, dump truck, equipment to install sheets and piles, hand tools, rake, silt curtain, pickup truck, pumps for by passing flows, tractor, trailer, vactor truck, wheelbarrow, boring drill and equipment.

Conservation Measures • Approved work windows • Stormwater pollution prevention • Shoreline and aquatic habitat protection	
CM #	
	Approved Work Windows
1	All work shall comply with the approved work windows/timing restrictions for the protection of ESA-listed species or species they forage upon in the Seattle action areas.

[3] Mean higher high water (MHHW) is a tidal (marine water) datum that is the average high water height.

CM #	**Stormwater Pollution Prevention**
	Develop a CSECP
2	Each project shall have onsite a written Construction Stormwater and Erosion Control Plan (CSECP) that includes all information needed to reduce erosion and sedimentation on the project. All projects will require the contractor to assign an onsite Erosion Control Lead to oversee the work and ensure compliance with the CSECP.
	Ensure City crew/contractor has SPCP
3	The City crew/contractor shall have onsite a written Spill Prevention and Control Plan (SPCP) that describes materials to be used and measures to prevent or reduce impacts from potential spills (fuel, hydraulic fluid, etc).
4	Maintain a spill kit onsite to respond to accidental spills during construction. Ensure that spill kit is stocked with adequate containment material and other supplies to suit the specific job site and potential containment distances.
	Avoid heavy equipment fuel/oil leakage
15	Equipment used for work below the OHW or MHHW or in riparian zones or shoreline areas shall be cleaned of accumulated grease, oil, mud, etc. and leaks repaired before arriving at the project.
16	Equipment shall be fueled and serviced in an established staging area. Thereafter, all equipment shall be inspected daily for leaks or accumulation of grease, and any identified problems fixed before equipment enters areas typically covered with water.
17	Two oil absorbing floating booms appropriate for the size of the work shall be available onsite during all phases of work whenever heavy equipment is used below the OHW or MHHW. The booms shall be placed in a location that facilitates an immediate response to potential petroleum leakage and shall be deployed for all petroleum leaks.
18	Vegetable-based hydraulic fluid should be substituted when machines will operate in sensitive areas or their buffer for more than incidental work.
	Minimize earthmoving-related erosion
21	Stockpile native streambed or substrate materials above the OHW for later use in project restoration. To prevent contamination from fine soils, these materials shall be kept separate from other stockpiled material not native to streambed or substrate.
	Minimize stream crossing sedimentation
25	Minimize stream and riparian crossings. If possible, cross at right angles to the main channel.
26	Where temporary stream crossings are essential, crossings shall be managed to minimize the risk of creating erosion.
	General restoration in open waters
27	For in-water work at or below OHW or MHHW, appropriate and effective erosion control devices or other water quality control devices will be in place before project work begins. Control devices include sealed sand or gravel bags, silt curtains, silt fencing or other containment systems. Deploy and maintain curtain at sufficient depth to reach bottom and contain sediment

CM #	**Stormwater Pollution Prevention**
28	If mechanized equipment is used within the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters). This prevents material from entering the water during construction. It is recommended that a tarp be placed on the substrate of the work area. All debris removed shall be disposed of offsite in an approved upland disposal area.
29	Confine use of equipment operating below OHW or MHHW to designated access corridors.
	Shoreline and Aquatic Habitat Protection
	All projects/all structures
57	Perform all work in the dry whenever possible (80-90% of the time)
58	Minimize construction impacts by conducting work during minus tides or low water levels.
60	To avoid entraining fish, an excavated trench exposed to open water between tidal cycles should be sloped or filled with sand and gravel to optimize fish habitat.
61	Equipment and materials are mobilized to and from the site via upland access or construction barge. If the project area is not isolated and dewatered, a silt curtain will be installed.
62	If a construction barge is used, it shall not ground or rest on the substrate at anytime or anchor over vegetated shallows.
65	Require City crew/contractor to retrieve any debris generated during construction that has entered the water and sunk to dispose of it at an upland facility.

3.6 Method 6: Bank Stabilization

This method is the demolition or replacement and repair of existing banks, construction of new bank stabilization, and placement of toe/logs in various waterbodies. Stabilization measures are structural remedies to arrest eroded or slumped streambanks or marine shorelines. Banks and shorelines need stabilization when projects call for removing, repairing, or maintaining fixed structures. Bank stabilization may also be needed in areas of high slope erosion. Stabilizing disturbed or unstable water edges eliminates upland erosion deposition of sediment into a waterbody. Bank stabilization is used to improve existing structures, to enhance habitat for juvenile salmonids, to prevent erosion and scour, and to minimize the risk of failure of adjacent roadways, utilities or other public facilities. Bank stabilization includes these activities:

- Demolition of bulkheads, revetments and groins
- Construction of sheet piling bulkhead
- Construction of cast-in-place concrete bulkheads
- Construction of log or rock toes
- Biotechnical stabilization
- Repair of bulkheads.

Erosion control methods that use ecological principles and techniques to achieve stabilization of the shoreline while enhancing habitat (creation of coves), improving aesthetics and reducing costs should be considered first before any other bank protection method. Where appropriate, rounded gravel, vegetation, wood and other natural materials should be used to protect shorelines and maintain shallow water and shallow gradients to re-establish the integrity of the shoreline. The range of gravel gradation is determined based on site specific conditions such as exposure, wave fetch and slope. Larger gravel is more resistant to higher wave action and will remain more stable on a steeper slope than smaller sized gravel. Because the functional effectiveness of gravel fill increases (and the cost of gravel decreases) as the extent of coverage increases, multiple lot projects are encouraged.

Gravel fill acts like other shore protection structures to prevent erosion of the backshore. At the same time gravel fill provides a shallow slope and substrate that is better for native juvenile salmonids by creating shallow water conditions. A shallow gravel beach is also a safe way for humans to access the water. Depending on site conditions, coarse sand may be retained on the beach too. See Method 8: Beach Nourishment and Substrate Addition.

The shoreline or streambank will typically be graded with at least a 2H:1V slope or shallower. See WDFW *Integrated Streambank Protection Guidelines* for methods (WDFW 2003). If none of the methods listed below provide adequate stabilization to the slope, it may be necessary to install rock facing or retaining walls.

As part of the project design and selection of appropriate bank stabilization methods a geotechnical investigation should be conducted to ensure long-term viability of the project. The geotechnical investigation could include groundwater movement and characterization of the soil. The Integrated Streambank Protection Guidelines recommend both a site and reach assessment of the project area be conducted to understand all the specific mechanisms and causes of the processes affecting the project area. Only after these assessments are conducted can appropriate methods be selected to address project objectives.

A. Demolish Bulkheads, Revetments or Groins

Bulkheads are retaining walls along a waterfront. Revetment is the term for a facing (either stone or concrete) to sustain an embankment. A groin is a rigid structure built out from shore to protect the shore from erosion, to trap sand, or to direct a current. These structures can be found in several City parks.

Where possible, utilities are relocated from the work area. The bank stabilization and fill material behind it are removed by a variety of equipment types including, but not limited to, an upland-based excavator, trackhoe, bulldozer and/or barge mounted crane. The excavated material is exported to an established stockpile area for disposal or reuse depending on the needs of the project. For sheet pile bulkheads, if piling cannot be fully extracted, they are cut at or below (2 feet) the mudline and dismantled.

B. Construct Sheet Piling Bulkhead

Where a new bulkhead will be replaced, a toe is excavated to the required depth. The excavated material is exported to the established stockpile area for later transport to an approved upland disposal site. In some cases typically involving deeper sheet piling installation, sheet piling may be driven using vibratory hammers. In other cases, auger cast piling may used along with sheet piling, concrete panels, or heavy timber lagging installed to create the wall. If necessary, tie-backs are installed at intervals along the sheet piling and attached to deadman anchors located landward of the structure. If necessary, aggregate backfill and drainage piping may be installed to relieve hydrostatic pressures behind such walls. Structural backfill and a drainage system are placed behind the sheet piling. Clean gravel is then placed in the excavated toe along the waterward face of the sheet piling. If necessary to buttress the sheet pile wall or reduce its vertical height, riprap shoreline protection is placed in front of the wall. This armoring includes a toe at the waterward edge and a topping of gravel (habitat mix) to fill in the interstitial spaces.

C. Construct Cast-in-place Concrete Bulkhead

A footing area is excavated to a sufficient depth to prevent undercutting of the new bulkhead. The excavated material is exported to the established stockpile area for later transport to an approved upland disposal site. Reinforcing bars and forms for the footings and walls are constructed and the forms are sealed. For tidal waters, concrete is poured into the forms when the tide is out. Once the concrete is cured, the forms are removed. The drainage system is installed for the following:

- Weep holes built into the bulkhead. The landward face of the bulkhead is lined with filter fabric and the area within ~ 18 inches of the wall is backfilled with a clean, free-draining sand and gravel
- Lateral drainage system. A perforated pipe surrounded by a layer of drain gravel and wrapped in filter fabric is located and sloped to a suitable discharge area.

Filter fabric is laid on the excavated soil and structural backfill is placed and compacted. If necessary, substrate material (e.g., fish habitat mix) is placed waterward of the bulkhead.

D. Construct Log or Rock Toe

Toe protection treatments are generally constructed in conjunction with upper-bank treatments such as woody vegetation planting (see below *section E, Biotechnical Stabilization*). The toe and anchor points are excavated to the maximum calculated depth of scour. Logs and/or rocks are installed and anchored in the toe. The top elevation of the toe generally reaches the lower level of bank vegetation (OHW). Voids in the toe, depending on the size, are filled with rock and gravel. Root wads, large woody debris, and live staking can be incorporated into the toe design.

The bank is excavated to prepare the subgrade to a smooth slope no more than 1H to 1.5V, and preferably flatter, such as 2H to 1V. Any debris or deleterious materials are removed as part of the work. A bedding layer of crushed rock, typically 2-1/2 inch minus or 4-6 inch minus is installed to cover all of the exposed soils. Large, heavy toe rock (using fractured two-man or three-man rock), depending on the site, is then installed at the lower end of the slope to create a toe. Several layers of larger rock are then installed above the toe rock and on top of the bedding layer. These layers may be in the form of light, loose riprap or several layers of light riprap covered by heavy riprap to armor the underlying layers. The outer layer should be set as tightly as possible to minimize void spaces between the rocks and to seal these inner layers. The overall effect is to create a flexible revetment of rock that will harden an exposed bank. All rock is typically placed by track excavator, reaching the work area from atop the bank. In some situations, work may need to be done from a barge mounted excavator. Habitat mix is needed to fill interstitial spaces.

E. Biotechnical Stabilization[4]

As necessary, the shoreline is graded to a stable, and if possible, gentler slope and excavated for placement of biotechnical (biodegradable) components and/or internal subsurface drainage components (e.g., gravel seams, collection drains, etc.). The excavated material is exported to the established stockpile area for later transport to an approved upland disposal site. If native soil (bank soil), is used in backfilling soil wraps/other structures, it need not be removed from the site. Typical biotechnical stabilization techniques include herbaceous cover, native woody vegetation (e.g., willow live stakes, cottonwood poles, containerized plants, bare-root stock, salvaged plants, etc.), brush layering, fascines, brush matting, coir blankets, reinforced soil lifts and coir logs. Depending on the cause of erosion and geotechnical considerations, these techniques are used alone, in combination with other biotechnical approaches, or in combination with structural toe protection (see section D, Construct Log and Rock Toe, above). Design and installation guidelines for these techniques are provided in Chapter 6 of the *Integrated Streambank Protection Guidelines* (WDFW et al 2003).

F. Repair Bulkheads

Several methods are available to repair damage to a bulkhead with and without the need for removal and replacement.

Replacing Eroded Substrate

If the toe of a bulkhead is exposed or undermined, the eroded area is filled with new material, typically clean sand and/or gravel to optimize habitat. The replacement material is placed and spread in the affected area by an excavator operated from the uplands or barge-based crane.

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[4]*Biotechnical stabilization* as defined in this document is a stabilization method consisting entirely of biodegradable components (e.g., natural erosion control fabric, large woody debris, native vegetation, brush mats). This definition is taken from the *Integrated Streambank Protection Guidelines* WDFW et al 2003.

Facing a Concrete or Timber Bulkhead with Riprap

New riprap is placed in front of a bulkhead that is eroding at the base and/or from behind. The clean riprap is placed in the affected area by an excavator operated from the uplands or barge-based crane. To optimize habitat, voids may be filled with new rock, riprap, spalls, and clean sand and gravel

Resetting and/or Replacing Rock, Riprap, and Spalls

If rock material has been displaced from a bulkhead or the rock material has settled, the displaced material is reset and, if necessary, new clean material is placed into the bulkhead. The displaced rocks are grabbed by excavator or crane and repositioned into voids in the bulkhead. The heavy equipment is either operated from the barge or from uplands. To optimize habitat, voids may be filled with new rock, riprap, spalls, and clean sand and gravel.

Replacing Broken Sections of Concrete Bulkhead

The broken concrete pieces and soil behind the affected area are excavated as necessary. The excavated material is exported to an established stockpile area for later disposal at an approved facility. The broken edge of the bulkhead is smoothed/cleaned with a power wash, steel bars are embedded in the bulkhead (if the original bars are damaged or destroyed), a form is built and sealed, and the form is filled with fast-curing concrete. The form is left in place until the concrete is fully cured. Filter fabric is placed in the excavated area behind the bulkhead, and the area is backfilled with clean crushed rock.

Repairing Cantilever Soldier (Parallel) Piling on Landward Face of Bulkhead

The area behind the bulkhead is excavated by open cuts, shoring, and/or casing. The excavated material is exported to an established stockpile area for later disposal at an approved facility. Holes are drilled, casing is placed, H-beams are positioned into the holes, and the holes are backfilled with concrete. If necessary, additional drainage is provided by installing new drainage holes or a new lateral perforated drain pipe sloped to a suitable discharge location. Filter fabric is placed along the landward face of a bulkhead with weep holes and/or around the lateral drain system. After the concrete backfill around the soldier piling is cured, free-draining structural backfill is placed behind the wall and compacted.

Equipment Used
Backhoe/excavator, cars, chain saw, concrete mixer, concrete pump, crane, drilling rig, dump truck, front-end loader, hand tools, hydro-seeding truck, pick-up truck, piling and lagging, sheet driving, tractor, trailer, weed trimmer, wheelbarrow

Conservation Measures

- Approved work windows
- Stormwater pollution prevention
- Piling installation and noise abatement
- Shoreline and aquatic habitat protection

CM #	
	Approved Work Windows
1	All work shall comply with the approved work windows/timing restrictions for the protection of ESA-listed species or species they forage upon in the Seattle action areas.

CM #	**Stormwater Pollution Prevention**
	Develop a CSECP
2	Each project shall have onsite a written Construction Stormwater and Erosion Control Plan (CSECP) that includes all information needed to reduce erosion and sedimentation on the project. All projects will require the contractor to assign an onsite Erosion Control Lead to oversee the work and ensure compliance with the CSECP.
	Ensure City crew/contractor has SPCP
3	The City crew/contractor shall have onsite a written Spill Prevention and Control Plan (SPCP) that describes materials to be used and measures to prevent or reduce impacts from potential spills (fuel, hydraulic fluid, etc).
4	Maintain a spill kit onsite to respond to accidental spills during construction. Ensure that spill kit is stocked with adequate containment material and other supplies to suit the specific job site and potential containment distances.
	Minimize site- preparation-related impacts
9	Ensure proper BMPs, such as covering, berming, matting, seeding, or mulching, are implemented to prevent erosion of any excavated material.
	Avoid heavy equipment fuel/oil leakage
15	Equipment used for work below the OHW or MHHW or in riparian zones or shoreline areas shall be cleaned of accumulated grease, oil, mud, etc. and leaks repaired before arriving at the project.
16	Equipment shall be fueled and serviced in an established staging area. Thereafter, all equipment shall be inspected daily for leaks or accumulation of grease, and any identified problems fixed before equipment enters areas typically covered with water.
17	Two oil absorbing floating booms appropriate for the size of the work shall be available onsite during all phases of work whenever heavy equipment is used below the OHW or MHHW. The booms shall be placed in a location that facilitates an immediate response to potential petroleum leakage and shall be deployed for all petroleum leaks.
18	Vegetable-based hydraulic fluid should be substituted when machines will operate in sensitive areas or their buffer for more than incidental work.
	General restoration in open waters
27	For in-water work at or below OHW or MHHW, appropriate and effective erosion control devices or other water quality control devices will be in place before project work begins. Control devices include sealed sand or gravel bags, silt curtains, silt fencing or other containment systems. Deploy and maintain curtain at sufficient depth to reach bottom and contain sediment
28	If mechanized equipment is used within the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters). This prevents material from entering the water during construction. It is recommended that a tarp be placed on the substrate of the work area. All debris removed shall be disposed of offsite in an approved upland disposal area.
29	Confine use of equipment operating below OHW or MHHW to designated access corridors.

CM #	**Piling Installation and Noise Abatement**
	Installation
45	Plastic, concrete, or timber piling is preferred over steel piling.
46	Use a containment boom for sawdust and debris work. If in marine water, a containment boom may rest on substrate rather than float at all times due to tidal action. Remove contained debris to prevent it from entering the waterway at construction completion.
47	If treated piling are fully extracted or cut below the mudline, cap the holes or piling with appropriate materials (e.g., clean sand or steel pile caps for cut piling). This practice ensures that chemicals from the existing piling do not leach into the adjacent sediments or water column.
48	Do **not** use piling treated with creosote or pentachlorophenol.
49	Do **not** use hydraulic water jets to remove or place piling.
50	Replace piling in same general location. Do **not** extend beyond footprint of existing structure.
51	All treated wood will be contained on land or barge during and after removal to preclude sediments and any contaminated material from re-entering the aquatic environment.
	Noise abatement
52	Use a vibratory hammer to the maximum extent possible for setting piling. Geotechnical engineering can determine if this will be sufficient based on the piling material and load capacity.
53	A bubble curtain or other noise attenuation method (e.g., wood blocks, nylon blocks etc.) shall be used during impact installation or proofing of steel piling. For piling with a 10-inch or smaller diameter, the sound attenuation device must include one of the methods listed above. For piling with a diameter greater than 10 inches, the sound attenuation device must include both the placement of a sound bock between the hammer and the piling during pile driving **and** use of a bubble curtain.
54	Hydroacoustic monitoring shall be used for driving large (>12-inch diameter) steel piling.
55	All reasonable measures shall be taken for the suppression of noise resulting from the work operations. All work shall be performed consistent with the applicable noise control levels set forth in SMC Chapter 25.08 and comply with noise pollution requirements.
	Shoreline and Aquatic Habitat Protection
	All projects/all structures
57	Perform the work in the dry whenever possible (80-90% of the time).
58	Minimize construction impacts by conducting work during minus tides or low water levels.
59	All fill materials will be of clean, washed, and commercially-obtained material.
62	If a construction barge is used, it shall not ground or rest on the substrate at anytime or anchor over vegetated shallows.
63	Take care to prevent spread of invasive plant species during their removal.
64	Plant the project shoreline with native riparian vegetation. City crew/contractor will ensure 80% survival of the planted material at 1, 3, and 5 years after installation. Riparian planting plans, including performance standards, monitoring schedule and contingency protocol (should performance standards not be met) will be submitted along with the project permit application.

65	Require City crew/contractor to retrieve any debris generated during construction that has entered the water and sunk to dispose of it at an upland facility.
	Beach nourishment/substrate addition
67	Use clean gravel (less than 3% fines by weight [material passing a number 200 sieve per U.S. standard sieve size]) to avoid turbidity during gravel placement.
	Boat launch
69	No wet concrete or epoxy shall be placed in the wetted perimeter. Concrete and epoxy must be cured before they come into contact with the water.
	Bulkhead repair/replacement
70	Move the bulkhead as far back as possible above OHW or MHHW.
71	Construct bulkhead to contain habitat complexity, such as coves, where recreational use allows.
72	Plant new bulkhead with native riparian vegetation where not in conflict with recreational use.
	Riprap addition
73	When installing riprap, include rootwads and/or large woody debris to increase habitat complexity.
74	Cover all newly placed riprap with habitat mix to fill voids and cover the rock to benefit benthic organisms. In locations where habitat mix will wash away rapidly, it may be deemed unnecessary to install.

3.7 Method 7: Habitat Addition and Maintenance

Habitat elements are organic or inorganic objects that—when placed in or near aquatic areas—increase fish and wildlife habitat and protect infrastructure. Habitat elements include large wood, root wad, baffles, boulders, rock, and weirs. When placed into waterbodies, these objects can slow or alter flow directions and provide complex habitat including riffles, pools and appropriate substrate that create food and hiding places for fish and wildlife. Habitat addition and maintenance also protect infrastructure and sewer lines.

Habitat addition or maintenance work may require using heavy or light equipment, hand labor or a combination of these methods. Many projects including those in parks require establishing a temporary construction access. The following is the construction technique for habitat addition or maintenance:

- Select design and installation of habitat elements in accordance with the WDFW *Integrated Streambank Protection Guidelines* (WDFW et al. 2003).
- Instream or floodplain restoration materials (e.g. large wood and boulders) shall mimic as much as possible those found in a natural environment. Such materials may be salvaged or reused from the project site or hauled in from offsite but cannot be taken from streams, wetlands, or other sensitive areas.

Various anchoring techniques are sometimes required to prevent the movement of structures when their movement could damage downstream infrastructure or channel integrity. If anchoring is required, bury the habitat element—such as woody debris or boulders—into the banks. Use cable or concrete blocks only sparingly in project design and only when conditions do not exist to anchor woody debris naturally between riparian trees or into the banks. Use concrete sparingly when necessary to anchor boulders to concrete weirs to create a more natural effect.

A. Large Woody Material[5]

Large wood includes whole trees with rootwads and limbs attached, pieces of trees with or without rootwads and limbs, and cut logs. This material is used to change flow direction, provide grade control, reduce erosion at toe of bank, and provide habitat elements. Large woody material creates hydraulic diversity when installed in contact with water over a range of flows. Rootwads should have as many roots attached as possible to provide habitat complexity. Large woody material should be installed so habitat is available at all times including when water levels are low. Large woody material should also be installed to provide cover under the rootwads or logs installed.

The design of these structures will follow guidance provided in WDFW *Stream Habitat Restoration Guidelines* (WDFW 2004). In general, coniferous tree species are preferred for this use. Deciduous species may be incorporated with coniferous species.

The most common method for anchoring large wood is bole burial and ballasting. Other methods include entanglement and/or bracing with other material such as rock or existing wood in streams or on the streambank. In some cases, logs may be pinned together using wood or rebar pins to increase structure stability.

This material can be installed using either hand or machine methods. Hand methods are generally limited to bracing, entanglement, and ballasting with other material. Burial or pushing this material into the banks by hand is limited. Machine installation methods

[5] Large woody material is also referred to as large woody debris or LWD in this document.

include entanglement, bracing, trenching, digging, installing mechanical anchor, and pushing into the streambed and/or bank.

See below *E, Biotechnical Stabilization,* for a description of biotechnical techniques that use vegetation and wood to reproduce the natural system and to provide structural and surface erosion protection.

B. Boulders or Boulder Clusters

Placement of boulders and boulder clusters within the stream channel creates a diversity of water depth, substrate, and velocity. These placements are used to change flow direction, provide grade control, reduce erosion at the toe of bank, and provide habitat elements.

Methods and design will follow guidance provided in *WDFW Stream Habitat Restoration Guidelines* (2004). Boulders and boulder clusters can be installed by hand and/or machine. This material is installed by direct placement on the streambed, digging and placing in and/or along the toe and face of streambank. Rock can occur as the sole element (e.g., bank protection, weir or groin) or in conjunction with other materials (e.g., large woody material)

C. Weirs or Groins

Low-elevation weirs usually span the entire width of the channel. These structures are used to spill and direct flow away from an eroding bank, dissipate and redistribute energy, and provide grade control stabilization. Other applications may include flow realignment, fish passage, or increased habitat diversity.

Groins are used to realign a channel or redirect flow away from a streambank to protect it from erosion. Groins can also be used to increase flow resistance at channel locations that lack resistance elements.

Both weirs and groins are typically constructed with rock and/or large woody material. Weirs have also been constructed using sheet piling and concrete. Groins can also be constructed using pilings that collect other woody debris. The design of these structures will follow guidance provided in the *Integrated Streambank Protection Guidelines* (WDFW et al. 2003).

Equipment Used
Backhoe/excavator, boat/barge combinations, bobcat, bull dozer, car, chain saw, concrete mixer, concrete pump, dump truck, front-end loader, hand tools, hydro-seeding truck, large and small compactor, pick-up truck, tractor, trailer, weed trimmer, wheelbarrow.

Conservation Measures	
• Approved work windows • Stormwater pollution prevention • Shoreline and aquatic habitat protection • Pesticides	
CM #	
	Approved Work Windows
1	All work shall comply with the approved work windows/timing restrictions for the protection of ESA-listed species or species they forage upon in the Seattle action areas.

CM #	**Stormwater Pollution Prevention**
	Develop a CSECP
2	Each project shall have onsite a written Construction Stormwater and Erosion Control Plan (CSECP) that includes all information needed to reduce erosion and sedimentation on the project. All projects will require the contractor to assign an onsite Erosion Control Lead to oversee the work and ensure compliance with the CSECP.
	Ensure City crew/contractor has SPCP
3	The City crew/contractor shall have onsite a written Spill Prevention and Control Plan (SPCP) that describes materials to be used and measures to prevent or reduce impacts from potential spills (fuel, hydraulic fluid, etc).
4	Maintain a spill kit onsite to respond to accidental spills during construction. Ensure that spill kit is stocked with adequate containment material and other supplies to suit the specific job site and potential containment distances.
	Minimize site-preparation-related impacts
5	Confine construction impacts to the minimum area necessary to complete the project and delineate impact areas on project plans. Flag boundaries of clearing limits associated with site access, construction, and staging areas as well as wetland and riparian corridor where work has been authorized.
6	Establish staging and site access areas along existing roadways or other disturbed areas to minimize erosion into or contamination of sensitive areas or their buffers. Confine work to the area noted using flagging or other barriers.
7	Limit clearing and grubbing area to minimum required. Retain vegetation to maximum extent possible. Minimize clearing and grubbing effects by cutting vegetative stems but not removing the root systems, which help to reduce erosion potential and allow native plants to regenerate.
9	Ensure proper BMPs, such as covering, berming, matting, seeding, or mulching, are implemented to prevent erosion of any excavated material.
10	Stockpile large wood, trees, riparian vegetation, other vegetation, sand, and topsoil removed for establishment of staging area and reuse for site restoration.
11	Salvaged debris such as roots and stumps may be used for habitat. Disposal of debris may include chipping, shredding, or grinding for reintroduction to the site as mulch.
12	Place sediment barriers (e.g., silt fences, coir logs, wood straw or other effective erosion control method) around disturbed sites to prevent erosion from sediment deposition from entering a waterbody.
13	Keep a supply of erosion control materials (e.g., silt fence or mulch) on hand to respond to sediment emergencies. For wetland areas with high likelihood of germination, use wood straw.
14	Use curb inlet sediment traps and geotextile filters, along with silt fencing, to capture sediment before it leaves the site.
	Avoid heavy equipment fuel/oil leakage
15	Equipment used for work below the OHW or MHHW or in riparian zones or shoreline areas shall be cleaned of accumulated grease, oil, mud, etc. and leaks repaired before arriving at the project.
16	Equipment shall be fueled and serviced in an established staging area. Thereafter, all equipment shall be inspected daily for leaks or accumulation of grease, and any identified problems fixed before equipment enters areas typically covered with water.

CM #	**Stormwater Pollution Prevention**
17	Two oil absorbing floating booms appropriate for the size of the work shall be available onsite during all phases of work whenever heavy equipment is used below the OHW or MHHW. The booms shall be placed in a location that facilitates an immediate response to potential petroleum leakage and shall be deployed for all petroleum leaks.
18	Vegetable-based hydraulic fluid should be substituted when machines will operate in sensitive areas or their buffer for more than incidental work.
	Minimize earthmoving-related erosion
19	Operate machinery from existing roads and paved areas where they exist in proximity to the site. In many cases, wood chippings and timber mats can provide a temporary surface where heavy equipment can access a work site.
20	Use temporary materials such as geotextile barriers, hog fuel or wood pellets to stabilize haul and access routes, staging areas and stockpile areas.
21	Stockpile native streambed or substrate materials above the OHW for later use in project restoration. To prevent contamination from fine soils, these materials shall be kept separate from other stockpiled material not native to streambed or substrate.
22	If equipment wash areas are required, they shall be located where washwater, sediment, and pollutants cannot enter waterbodies, including wetlands.
	Minimize stream crossing sedimentation
25	Minimize stream and riparian crossings. If possible, cross at right angles to the main channel.
26	Where temporary stream crossings are essential, crossings shall be managed to minimize the risk of creating erosion.
	General restoration in open waters
27	For in-water work at or below OHW or MHHW, appropriate and effective erosion or other water quality control devices will be in place before project work begins. Control devices include sealed sand or gravel bags, silt curtains, silt fencing, or other containment systems. Deploy and maintain curtain at sufficient depth to reach bottom and contain sediment.
28	If mechanized equipment is used within the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters). This prevents material from entering the water during construction. It is recommended that a tarp be placed on the substrate of the work area. All debris removed shall be disposed of offsite in an approved upland disposal area.
29	Confine use of equipment operating below OHW or MHHW to designated access corridors.
	Temporary Dewatering Plan requirements
30	Develop a Temporary Dewatering Plan (TDP) for any dewatering lasting more than 1 day or requiring the installation of a trench safety system.
	Shoreline and Aquatic Habitat Protection
	All projects / all structures
57	Perform the work in the dry whenever possible (80 – 90%).
58	Minimize construction impacts by conducting work during minus tides or low water levels.
59	All fill materials will be of clean, washed, and commercially-obtained material.

60	To avoid entraining fish, an excavated trench exposed to open water between tidal cycles should be sloped or filled with sand and gravel to optimize fish habitat.
61	Equipment and materials are mobilized to and from the site via upland access or construction barge. If the project area is not isolated and dewatered, a silt curtain will be installed.
62	If a construction barge is used, it shall not ground or rest on substrate at anytime or anchor over vegetated shallows.
63	Take care to prevent spread of invasive plant species during their removal.
64	Plant the project shoreline with native riparian vegetation. City crew/contractor will ensure 80% survival of the planted material at 1, 3, and 5 years after installation. Riparian planting plans, including monitoring and reporting, will be submitted along with the project permit application.
65	Require City crew/contractor to retrieve any debris generated during construction that has entered the water and sunk to dispose of it at an upland facility.
	Boat launch
68	Place appropriate habitat gravel mix as needed. The mix shall meet WDFW Hydraulic Permit Application requirements.
69	No wet concrete or epoxy shall be placed in the wetted perimeter. Concrete and epoxy must be cured before they come into contact with the water.
	Pesticides
75	Pesticides will be applied only under direct supervision (within line of sight) of a licensed applicator.
76	When native plants are being restored to a project site, pesticides can be used to control those weeds listed in the King County Noxious Weed List. Plants that are highly invasive and damaging to native riparian habitats include Himalayan Blackberry, clematis, morning glory, and Japanese knotweed.
77	Within the shoreline and riparian zone of all waterbodies, use only herbicide products containing glyphosate for general weed control and/or selected Washington State Department of Ecology-approved herbicides mandated for aquatic noxious weed control.

3.8 Method 8: Beach Nourishment and Substrate Addition

This method, also known as beach sand and gravel replacement, replenishes sand and/or gravel above and below the high waterline on City swimming or other beaches. It is used to improve or to restore the function of designated swimming beaches and, in other locations, to provide improved substrate for aquatic organisms and provide shallow water for shore protection. It is also used as part of the work in replacing or installing stormwater or combined sewer outfalls.

A. Beach Nourishment

Work is typically done while the water level is low so that most of the beach area is exposed. Clean sand/gravel is hauled to the beach by truck and deposited at or above the water line at low tide. Occasionally, some material is deposited directly in the water. The deposited material is then spread by front-end loader, tractor, or backhoe. An alternative to in-water spreading is to allow the material to naturally distribute with the movement of the water.

Besides small amounts of sand/gravel that may be brought to the site by truck, in certain situations beach nourishment is best effected by delivering the sand or gravel by barge. This would be the case when truck access is not possible or when larger amounts of material are involved. In these cases, the material will be barged to the site and offloaded by front-end loader or conveyor system. Material is then spread at low tide or lower water by a track excavator situated on a barge. Wave action further flattens any undulations left by the excavator.

B. Substrate Addition

Soil can be added to the shoreline as part of the pipe or outfall replacement or installation in order to restore the bank to a more natural topography with area-similar-grain-sized soils. Stream gravel can be imported to disturbed sites to restore the stream bed. The gravel size distribution should be selected during the design phase based on consideration of the stream geomorphology and anticipated fish species likely to utilize the site.

When new channel substrate is specified, the material shall be from a clean source and shall be washed to remove fines. A gradation analysis and evaluation of scour as well as stability of new material to resist stream forces based on native substrate shall be used to properly size the channel substrate mix.

Habitat mix is a specific substrate to benefit macroinvertebrates and fill in interstitial space in larger-sized substrate.

Equipment Used
Backhoe, barge, front-end loader, rake, shovel, small dump truck, track excavator, tractor

Conservation Measures

- Approved work windows
- Stormwater pollution prevention
- Shoreline and aquatic habitat protection

CM #	
	Approved Work Windows
1	All work shall comply with the approved work windows/timing restrictions for the protection of ESA-listed species or species they forage upon in the Seattle action areas.
	Stormwater Pollution Prevention
	Develop a CSECP
4	Maintain a spill kit onsite to respond to accidental spills during construction. Ensure that spill kit is stocked with adequate containment material and other supplies to suit the specific job site and potential containment distances.
	Avoid heavy equipment fuel/oil leakage
15	Equipment used for work below the OHW or MHHW or in riparian zones or shoreline areas shall be cleaned of accumulated grease, oil, mud, etc. and leaks repaired before arriving at the project.
16	Equipment shall be fueled and serviced in an established staging area. Thereafter, all equipment shall be inspected daily for leaks or accumulation of grease, and any identified problems fixed before equipment enters areas typically covered with water.
18	Vegetable-based hydraulic fluid should be substituted when machines will operate in sensitive areas or their buffer for more than incidental work.
	General restoration in open waters
27	For in-water work at or below OHW or MHHW, appropriate and effective erosion or other water quality control devices will be in place before project work begins. Control devices include sealed sand or gravel bags, silt curtains, silt fencing, or other containment systems. Deploy and maintain curtain at sufficient depth to reach bottom and contain sediment.
28	<u>If mechanized equipment is used within the OHW or MHHW,</u> only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters). This prevents material from entering the water during construction. It is recommended that a tarp be placed on the substrate of the work area. All debris removed shall be disposed of offsite in an approved upland disposal area.
29	Confine use of equipment operating below OHW or MHHW to designated access corridors.
	Shoreline and Aquatic Habitat Protection
	All projects/all structures
54	Perform the work in the dry whenever possible (80-90% of the time).
58	Minimize construction impacts by conducting work during minus tides or low water levels.
59	All fill materials will be of clean, washed, commercially-obtained material.
62	<u>If a construction barge is used</u>, it shall not ground or rest on the substrate at anytime or anchor over vegetated shallows.
	Beach nourishment/substrate addition
66	Beach material will typically be washed gravel whenever possible to minimize the amount of fill eroding into the waterbody. Sands may be applied above the OHW or MHHW depending on project purpose.

3.9 Method 9: Boat Launch Improvement, Repair and Maintenance

Boat ramp repair/maintenance is the resurfacing and restoration of material used to facilitate the public launching of boats from trailers. Efficient boat launching requires maintained parking and circulation areas as well as driving surfaces and armoring leading into the water. Repair and maintenance work at boat launches typically includes filling prop wash holes; replacement of ballast, edge armoring, and/or concrete panels; repair of holes/broken edges on concrete panels; and pressure washing to clean algae. This method includes the following routine activities:

- Filling prop wash holes
- Replacing ballasts, edge armoring and concrete panels
- Pressure washing boat ramps.

A. Fill Prop Wash Holes

This method allows for the return or replacement of substrate to holes created by prop wash. If the displaced material remains in a mound in the vicinity of the hole, it is simply returned to the wash hole (gravel return method). Otherwise, the hole is filled with imported gravel (gravel replacement method).

Gravel Return Method

Whenever practicable, hand tools and a bucket are used to scoop, return, and spread the displaced gravel back into the hole. At some locations, a backhoe or similar equipment may be required for this work. If heavy equipment is used, only the extension arm and bucket enter the wetted perimeter.

Gravel Replacement Method

Clean gravel is hauled to the boat ramp on existing roads and dumped above the water line. The rock is placed and spread by hand tools into the prop wash hole whenever practicable. If heavy equipment is used for placing and spreading the gravel, only the extension arm and bucket enter the wetted perimeter. Up to 30 cubic yards of gravel may be required to fill holes. Clean, washed, crushed gravel is used. The diameter of the gravel particles is typically 1 to 4 inches, depending on the depth of the prop wash holes.

Equipment Used
Backhoe, bucket, hand shovel, small dump truck, tractor

B. Replace Ballast, Edge Armoring and Concrete Panels; Repair Concrete Panels

This method allows for the replacement of pre-cast concrete panels, associated ballast, and edge armoring at boat launches. In addition, this method allows for the repair of concrete launch panels, such as patching a crack/hole or replacing a broken corner. Most of this work (80-90%) can be done in the dry and is timed to coincide with low water levels at the project site. Of necessity, all cast-in place work must be done in the dry.

Replacing Ballast and Edge Armoring

Whenever practicable, hand tools and a bucket are used to scoop, return, and spread displaced gravel back into the hole. At some locations, a backhoe or similar equipment may be required for this work. If heavy equipment is used, only the extension arm and bucket enter the wetted perimeter.

Replacing Cast-in-place Concrete Panels

For cast-in place concrete panels, the deteriorated panels of the ramp are demolished and a ballast placed and leveled. Temporary wood frames are placed along the edges of the ramp to delineate the footprint and rebar or metal wire fabric is secured with anchor bolts. High-early-strength concrete formulated specifically for pouring directly in water is used. An anti-washout admixture is used to greatly reduce or eliminate concrete washout during curing. These additives produce concrete that becomes fluid when sheared or mechanically agitated but reverts to dense, high viscous consistency when at rest. The mixtures reduce or eliminate the accumulation of fine particles on the surface of curing concrete. This type of concrete sets almost immediately. A tremie (tube) is used, which allows the concrete truck to remain as far as possible from water's edge. Pouring begins shortly after tidal water recedes on Puget Sound locations, so that maximum hardening time is available before inundation. During hardening, the cast-in-place concrete is covered with plastic to minimize the surface area that contacts with water.

Repairing Concrete Panels

Some repairs to a concrete boat launch can be undertaken if panel replacement is cost prohibitive. To replace an edge or corner piece that has broken off, the broken edge is smoothed or cleaned with a power wash, steel bars are embedded in the panel (if the original bars are damaged or destroyed), a sealed form is attached, and the form is filled with fast-curing concrete. Generally, the form is left in place and protected from use by boaters for 1 to 2 days while the concrete gains strength. To fill a thin crack, a quick-setting, high-strength grout (e.g., Portland cement) is used. For larger holes, a concrete saw or chisel is used to prepare the hole prior to filling with fast curing concrete.

Equipment Used
Backhoe, concrete mixer, concrete pump, crane, dump truck, excavator, front-end loader, hand shovel, power wash, tractor, wheelbarrow

Conservation Measures
- Approved work windows
- Stormwater pollution prevention
- Shoreline and aquatic habitat protection

CM #	
	Approved Work Windows
1	All work shall comply with the approved work windows/timing restrictions for the protection of ESA-listed species or species they forage upon in the Seattle action areas.
	Stormwater Pollution Prevention
	Develop a CSECP
2	Each project shall have onsite a written Construction Stormwater and Erosion Control Plan (CSECP) that includes all information needed to reduce erosion and sedimentation on the project. All projects will require the contractor to assign an onsite Erosion Control Lead to oversee the work and ensure compliance with the CSECP.

CM #	*Ensure City crew/contractor has SPCP*
3	The City crew/contractor shall have onsite a written Spill Prevention and Control Plan (SPCP) that describes materials to be used and measures to prevent or reduce impacts from potential spills (fuel, hydraulic fluid, etc).
	Avoid heavy equipment fuel/oil leakage
15	Equipment used for work below the OHW or MHHW or in riparian zones or shoreline areas shall be cleaned of accumulated grease, oil, mud, etc. and leaks repaired before arriving at the project.
16	Equipment shall be fueled and serviced in an established staging area. Thereafter, all equipment shall be inspected daily for leaks or accumulation of grease, and any identified problems fixed before equipment enters areas typically covered with water.
18	Vegetable-based hydraulic fluid should be substituted when machines will operate in sensitive areas or their buffer for more than incidental work.
	General restoration in open waters
27	For in-water work at or below OHW or MHHW, appropriate and effective erosion or other water quality control devices will be in place before project work begins. Control devices include sealed sand or gravel bags, silt curtains, silt fencing, or other containment systems. Deploy and maintain curtain at sufficient depth to reach bottom and contain sediment.
28	If mechanized equipment is used with the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters). This prevents material from entering the water during construction. It is recommended that a tarp be placed on the substrate of the work area. All debris removed shall be disposed of offsite in an approved upland disposal area.
29	Confine use of equipment operating below OHW or MHHW to designated access corridors.
	Shoreline and Aquatic Habitat Protection
	All projects/all structures
57	Perform the work in the dry whenever possible (80 – 90% of the time).
58	Minimize construction impacts by conducting work during minus tides or low water levels.
59	All fill materials will be of clean, washed, and commercially-obtained material.
63	Take care to prevent spread of invasive plant species during their removal.
69	No wet concrete or epoxy shall be placed in the wetted perimeter. Concrete and epoxy must be cured before they come into contact with water.

C. Pressure Washing Boat Ramps

Algae accumulates on boat ramps and needs to be removed for safety reasons. High pressure washers are used to clean boat ramps. No solvents are used during the cleaning.

Equipment Used
Hand shovel, scrapers, power washer, wheelbarrow.

Conservation Measures

- Approved work windows
- Stormwater pollution prevention
- Shoreline and aquatic habitat protection

CM #	
	Approved Work Windows
1	All work shall comply with the approved work windows/timing restrictions for the protection of ESA-listed species or species they forage upon in the Seattle action areas.
	Shoreline and Aquatic Habitat Protection
	All projects/all structures
57	Perform the work in the dry whenever possible (80 – 90% of the time).
58	Minimize construction impacts by conducting work during minus tides or low water levels.
61	Equipment and materials are mobilized to and from the site via upland access or construction barge. If the project area is not isolated and dewatered, a silt curtain will be installed.
63	Take care to prevent spread of invasive plant species during their removal.

3.10 Method 10: In-water/Overwater Structure Repair and Replacement

Several types of fixed and floating recreational structures are found in and above open waters and wetlands at City of Seattle parks. Fixed structures are those having a permanent horizontal and vertical alignment and include piers, docks, viewing platforms, pedestrian bridges and abutment wing walls. The in-water vertical support for these fixed structures is typically piling of timber, steel, or concrete but can be rubble or rock. Floating structures include connecting ramps, floats, floating breakwaters, floating log booms, buoys and rafts. Periodically, these structures require either repair or replacement. Temporary scaffolding or work platforms are sometimes constructed to help in repairing or replacing in-water of overwater structures. This method includes repairing and replacing the following:

- Piling
- Anchor and chain systems
- Superstructure decking, and utilities on fixed structures
- Floats and gangways
- Floating log booms
- Buoys
- Fixed breakwaters
- Highway or road bridge foundation or footing repair
- Removal of plants and animals from pilings for inspection or repair

This method also includes the installation of temporary scaffolding or work platforms to conduct the above activities.

A. Piling

The following 4 methods are typically used to replace piling:

- Full extraction of an existing pile.
- Cutting off the existing pile.
- Cut off damaged pile and splice in a new section onto existing pile.
- Driving a new pile.

Fully Extracting an Existing Pile

1. For full extraction, the pile is removed either by use of a choker chain and crane or with a vibratory pile hammer.

3. For the choker chain method, the chain is placed securely around the pile. Then by using a crane mounted on a barge, the crane operator pulls the pile directly up until it is completely out of the substrate.

4. For the vibratory method, the vibratory pile hammer is mounted on a barge and the vibratory hammer is clamped onto the top of the pile. The vibration of the pile hammer loosens the pile from the substrate. The vibratory hammer is raised

directly upward as the pile loosens until the pile is completely free from the substrate.

The vibratory method is the preferred method, especially when the pile is firmly secured in the substrate. There is less likelihood for the pile to break.

Once removed, the pile is placed on the barge and disposed of at an appropriate upland location (disposal depends on chemical treatment of piling). Upon removal of the piling, new or recycled (non-creosote, pentachlorophenol or coal tar) piling may be installed. The method for driving a new pile is described below. Where a piling is pulled, the hole is backfilled with clean sand to match the surrounding substrate.

Cutting Off the Existing Pile

A pile is cut off when it is so deteriorated or rotted that it would break during extraction. If the pile inadvertently breaks during extraction, it is also cut off and broken portions of the pile are removed from the water column. In most cases, the pile is cut off two feet below the mudline. The cutting may also be at or above the mudline. Cutting below the mudline is preferred. The piling is cut by a diver underwater using a pneumatic saw or knife. Depending on the height of the piling, they may be cut in sections. The pneumatic knife technique cuts the pile below the mudline without dredge material removal. The pneumatic saw is used once the area around the pile is excavated with a clamshell or hydraulic dredge. The dredged material and cut piling are placed, secured, and contained on the barge and disposed of at a Washington State Department of Ecology-approved upland disposal site.

If the pile being removed is treated wood (e.g., creosote), plastic or metal caps or covers may be placed on the cut piles, or the area surrounding the pile may be capped or covered with a layer of clean substrate to prevent leaching of contaminants in the water and sediment. Capping material depends on the substrate, current conditions, and boat activity (potential for propwash) at the site. The same equipment used to excavate around the pile is typically used to place the capping material: a clamshell dredge or tremie. Appropriate capping includes, but is not limited to, clean/washed sand or habitat mix. Adjacent material may be used unless it is contaminated.

Cut Off Damaged Pile and Splice in a New Section onto the Existing Pile

In cases where a pile is partially damaged or a section of the pile is deteriorating to a point where it needs to be replaced, it may be faster, cheaper, and easier to just replace the bad section of the pile versus removing the whole pile and installing a new pile. A pneumatic saw or knife is used to cut out the damaged section of the pile. A new timber, steel, or composite pile is spliced into the existing pile. The piles are held together by a variety of methods: collars, adhesives, screws or bolts.

Driving a New Pile

New or recycled piling are driven using a barge-mounted pneumatic pile driver, standard drop-hammer, or vibratory pile hammer. A pile is lowered through the piling-guide until it rests in place on the substrate and is then driven to an adequate depth. Should refusal come at an insufficient depth, the pile is pulled and moved to gain more depth. Setup time for each piling is generally 20 to 30 minutes while actual driving time is about the same, depending on tide and substrate conditions. Pneumatic pile drivers are most common today, but the older pile drivers that use a heavy weight dropped on top of the pile are still used. The weight drop technique is used when bearing capacity is geotechnically and structurally required. Vibratory hammers are the preferred method of installing piling in the water; however, impact hammers are sometimes needed based on the subsurface conditions. Impact hammers are used when vibrating a pile alone is not adequate to reach bearing capacity.

Equipment Used
Barge, containment boom, crane, excavation bucket, hydraulic dredge, piling and lagging, sheet driving, tremie

Conservation Measures

- Approved work windows
- Overwater structure size
- Piling installation and noise abatement
- Shoreline and aquatic habitat protection

CM #	
	Approved Work Windows
1	All work shall comply with the approved work windows/timing restrictions for the protection of ESA-listed species or species they forage upon in the Seattle action areas.
	Overwater Structure Size
	Floats, docks or piers
34	Minimize/reduce piling number and space piling further apart where possible to reduce shading impacts.
	Piling Installation and Noise Abatement
	Installation
45	Plastic, concrete, or timber piling is preferred over steel piling.
46	Use a containment boom for sawdust and debris work. If in marine water, a containment boom may rest on substrate rather than float at all times due to tidal action. Remove contained debris to prevent it from entering the waterway at construction completion.
47	If treated piling are fully extracted or cut below the mudline, cap the holes or piling with appropriate materials (e.g., clean sand or steel pile caps for cut piling). This practice ensures that chemicals from the existing piling do not leach into the adjacent sediments or water column.
48	Do **not** use piling treated with creosote, pentachlorophenol, or coal tar.
49	Do **not** use hydraulic water jets to remove or place piling.
50	Replace piling in same general location. Do **not** extend beyond footprint of existing structure.
51	All treated wood will be contained on land or barge during and after removal to preclude sediments and any contaminated material from re-entering the aquatic environment.
	Noise abatement
52	Use a vibratory hammer to the maximum extent possible for setting pile. Geotechnical engineering can determine if this will be sufficient based on the piling material and load capacity.

53	A bubble curtain or other noise attenuation method (wood blocks, nylon blocks etc.) shall be used during impact installation or proofing of steel piling. For piling with a 10-inch or smaller diameter, the sound attenuation device must include one of the methods listed above. For piling with a diameter greater than 10 inches, the sound attenuation device must include both the placement of a sound block between the hammer and the piling during pile driving **and** use of a bubble curtain.
54	Hydroacoustic monitoring shall be used for driving large (> 12-inch diameter) steel piling.
55	All reasonable measures shall be taken for the suppression of noise resulting from the work operations. All work shall be performed consistent with the applicable noise control levels set forth in SMC Chapter 25.08.
56	Projects using an impact hammer to drive or proof steel piling in marine/estuarine waters must deploy sound attenuation **and** have an observer onsite during all pile driving and proofing to scan open water within a certain radius around the work area. If a marine mammal or marbled murrelet is observed within radius, all pile driving must stop.
	Shoreline and Aquatic Habitat Protection
	All projects/all structures
62	If a construction barge is used, it shall not ground or rest on the substrate at anytime or anchor over vegetated shallows.
65	Require City crew/contractor to retrieve any debris generated during construction that has entered the water and sunk to dispose of it at an upland facility.

B. Anchor and Chain Systems

Anchor and chain systems are typically used as the lateral support for floats and mooring buoys. Both concrete and metal anchors are used. The anchor is attached to the float or buoy by chain, cable, rope or similar material. A midline float is attached to the chain to prevent it from dragging on the substrate when water levels are low. Concrete anchors are dropped in place from a work boat. Helical metal anchors are placed by divers. Periodically the anchor system is inspected by a diver and, if necessary, the anchor, chain, and/or hardware are replaced.

Equipment Used
Hand tools, work boat

Conservation Measures

- Approved work windows
- Stormwater pollution prevention
- Overwater structure size
- Shoreline and aquatic habitat protection

CM #	
	Approved Work Windows
1	All work shall comply with the approved work windows/timing restrictions for the protection of ESA-listed species or species they forage upon in the Seattle action areas.

CM #	**Stormwater Pollution Prevention**
	Avoid heavy equipment fuel/oil leakage
15	Equipment used for work below the OHW or MHHW or in riparian zones or shoreline areas shall be cleaned of accumulated grease, oil, mud, etc. and leaks repaired before arriving at the project.
16	Equipment shall be fueled and serviced in an established staging area. Thereafter, all equipment shall be inspected daily for leaks or accumulation of grease, and any identified problems fixed before equipment enters areas typically covered with water.
	General restoration in open waters
29	Confine use of equipment operating below OHW or MHHW to designated access corridors.
	Overwater structure size
	Anchoring buoys, floats and floating breakwaters
43	Ensure that anchor lines do not drag on the substrate or in aquatic vegetation during low water levels. Buoy cables or chains will be kept off of the bottom by the addition of a second float below the surface at the appropriate length and size to perform during all tidal and wind conditions.
44	Use mechanical anchors (e.g., helical screw) in lieu of concrete anchors unless substrate (e.g., bedrock) prevents installation of screw anchors.
	Shoreline and aquatic habitat
62	If a construction barge is used, it shall not ground or rest on the substrate at anytime or anchor over vegetated shallows.
65	Require City crew/contractor to retrieve any debris generated during construction that has entered the water and sunk to dispose of it at an upland facility.

C. Superstructure, Decking and Utilities on Fixed Structures

This method covers the repair, replacement or maintenance of piers, viewing platforms and pedestrian bridges. These structures provide controlled access to sensitive environments. Foot traffic is contained on platforms and bridges to reduce impacts to wetlands, shorelines and riparian areas. As the materials deteriorate over time, they require maintenance, repair, or replacement in kind, or to meet current standards.

Fixed Piers

Typical maintenance includes replacement of broken deck planks, hand rails, and utility lines. Decking planks are replaced with wood or composite material (e.g., Ironwood, Trex). Material is laid, screwed into place, and excess ends are cut off with a saw. If grating is installed, a frame is built on the stringers and rails before placing the grated panel. Rails and stringers are attached to the piling and are repaired using power tools, galvanized hardware, and epoxy. Waterproof conduits (galvanized steel or waterproof conduits) are attached to the rails and stringers for electricity and water service. Other utilities (lights, poles, etc.) are maintained as needed.

Viewing Platforms

Viewing platforms are structures that are built onshore but can extend over a waterbody from the shoreline. They are constructed either with in-water support piling, or with beams cantilevered from the shoreline. The structure, decking, and utilities are maintained or repaired in generally the same manner as described above for fixed piers.

Pedestrian Bridges

Pedestrian bridges span an open water or wetland. They are constructed with either in-water or upland supporting structures. End supports are typically piling, micro piling, or pin piling with wood lagging, modular blocks, and/or gravity concrete abutments. The structure, decking, and utilities are maintained or repaired in generally the same manner as described above for fixed piers.

Equipment Used Backhoe, barge, containment boom, crane, cutting torch, front-end loader, jack hammer, power tools (saws, drills), track hoe, work boat

Conservation Measures • Approved work windows • Stormwater pollution prevention • Overwater structure size • Piling installation and noise abatement • Shoreline and aquatic habitat protection	
CM #	
	Approved Work Windows
1	All work shall comply with the approved work windows/timing restrictions for the protection of ESA-listed species or species they forage upon in the Seattle action areas.
	Stormwater Pollution Prevention
	Ensure City crew/contractor has SPCP
3	The City crew/contractor shall be required to have onsite a written Spill Prevention and Control Plan (SPCP) that describes materials to be used and measures to prevent or reduce impacts from potential spills (fuel, hydraulic fluid, etc).
4	Maintain a spill kit onsite to respond to accidental spills during construction. Ensure that spill kit is stocked with adequate containment material and other supplies to suit the specific job site and potential containment distances.
	Minimize site preparation-related impacts
7	Limit clearing and grubbing area to minimum required. Retain vegetation to maximum extent possible. Minimize clearing and grubbing effects by cutting vegetative stems but not removing the root systems, which help to reduce erosion potential and allow native plants to regenerate.
12	Place sediment barriers (silt fences, coir logs, wood straw, or other effective erosion control method) around disturbed sites to prevent erosion from sediment entering a waterbody.
	Avoid heavy equipment fuel/oil leakage
15	Equipment used for work below the OHW or MHHW or in riparian zones or shoreline areas shall be cleaned of accumulated grease, oil, mud, etc. and leaks repaired before arriving at the project.
16	Equipment shall be fueled and serviced in an established staging area. Thereafter, all equipment shall be inspected daily for leaks or accumulation of grease, and any identified problems fixed before equipment enters areas typically covered with water.
18	Vegetable-based hydraulic fluid should be substituted when machines will operate in sensitive areas or their buffer for more than incidental work.

CM #	*Minimize earth-moving-related erosion*
19	Operate machinery from existing roads and paved areas where they exist in proximity to the site. In many cases, wood chippings and timber mats can provide a temporary surface where heavy equipment can access a work site.
	Minimize stream crossing sedimentation
25	Minimize stream and riparian crossings. If possible, cross at right angles to the main channel.
26	Where temporary stream crossings are essential, crossings shall be managed to minimize the risk of creating erosion.
	General restoration in open waters
27	For in-water work at or below OHW or MHHW, appropriate and effective erosion or other water quality control devices will be in place before project work begins. Control devices include sealed sand or gravel bags, silt curtains, silt fencing, other containment systems. Deploy and maintain curtain at sufficient depth to reach bottom and contain sediment.
28	If mechanized equipment is used within the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters). This prevents material from entering the water during construction. It is recommended that a tarp be placed on the substrate of the work area. All debris removed will be disposed of offsite or to an approved upland disposal area.
29	Confine use of equipment operating below OHW or MHHW to designated access corridors.
	Overwater Structure Size
	Floats, docks or piers
33	Overwater structures such as piers and floats should be no larger (length and width) than needed for the specified function (see Table 4-7). Minimize/reduce pier and overall footprint of structure to reduce shading impacts. In the SPIF, give rationale for project-specific pier and float size requirements.
35	To reduce shading impacts, grating shall be installed on fixed structure surfaces during replacement to provide light transmission to the maximum extent practicable and American Disabilities Act (ADA) requirements. If grating cannot be installed in pier/float decking, consider using transparent glass blocks, prisms, or floors to obtain more light under pier.
37	In marine waters, replacement floats shall be at least 4 feet above marine vegetation (*e.g.*, eelgrass) to avoid creating new shade over marine vegetation.
38	Any flotation material used shall be positioned so that they do not block any grating or other surface light treatment (i.e. prisms, blocks) and associated light transmission through the overwater structure.
39	Place new and replacement piers at least 2 feet above OHW or MHHW.
40	New or replacement skirting will not be installed.
	Piling Installation and Noise Abatement
	Installation
45	Plastic, concrete, or timber piling is preferred over steel piling.

46	Use a containment boom for sawdust and debris work. If in marine water, a containment boom may rest on substrate rather than float at all times due to tidal action. Remove contained debris to prevent it from entering the waterway at construction completion.
48	Do **not** use piling treated with creosote, pentachlorophenol, or coal tar.
	Noise abatement
55	All reasonable measures shall be taken for the suppression of noise resulting from the work operations. All work shall be performed consistent with the applicable noise control levels set forth in SMC Chapter 25.08.
	Shoreline and Aquatic Habitat Protection
	All project/all structures
57	Perform the work in the dry whenever possible (80 – 90% of the time).
58	Minimize construction impacts by conducting work during minus tides or low water levels.
59	All fill materials will be of clean, washed, and commercially-obtained material.
62	If a construction barge is used, it shall not ground or rest on the substrate at anytime or anchor over vegetated shallows.
63	Take care to prevent spread of invasive plant species during their removal.
64	Plant the project shoreline with native riparian vegetation. City crew/contractor will ensure 80% survival of the planted material at 1, 3, and 5 years after installation. Riparian planting plans, including monitoring and reporting, will be submitted along with the project permit application.
65	Require City crew/contractor to retrieve any debris generated during construction that has entered the water and sunk to dispose of it at an upland facility.

D. Floats and Gangways

Floats and gangways are fabricated at land-based facilities and transported to the site by barge, work boat, or truck. A crane or similar hoisting machine is used to lift and locate the float or gangway into position and/or a small boat is used for final location and connection. Float designs include in-water lateral support, flotation, superstructure, and decking. In-water lateral support is typically by piling or anchor and chain system. The construction method, equipment, and conservation measures are described above for pilings, *section A, Piling*, and anchor and chain systems, *section B, Anchor and Chain Systems*. Rings, hoops, blocked pockets or similarly designed hardware are used to connect floats to piling or anchors. For the chain and anchor system, concrete or metal anchors are attached to the float by a galvanized steel chain or similar material. Floats are generally pulled from the water by mechanical means and repaired on dry land. See Table 4-7 in **Section 4, Conservation Measures**.

Equipment Used
Barge, crane, power or hand tools, work boat

Conservation Measures

- Approved work windows
- Stormwater pollution prevention
- Overwater structure size
- Shoreline and aquatic habitat protection

CM #	
	Approved Work Windows
1	All work shall comply with the approved work windows/timing restrictions for the protection of ESA-listed species or species they forage upon in the Seattle action areas.
	Stormwater Pollution Prevention
	Develop a CSECP
2	Each project shall have onsite a written Construction Stormwater and Erosion Control Plan (CSECP) that includes all information needed to reduce erosion and sedimentation on the project. All projects will require the contractor to assign an onsite Erosion Control Lead to oversee the work and ensure compliance with the CSECP.
	Ensure City crew/contractor has SPCP
3	The City crew/contractor shall have onsite a written Spill Prevention and Control Plan (SPCP) that describes materials to be used and measures to prevent or reduce impacts from potential spills (fuel, hydraulic fluid, etc).
4	Maintain a spill kit onsite to respond to accidental spills during construction. Ensure that spill kit is stocked with adequate containment material and other supplies to suit the specific job site and potential containment distances.
	Minimize site-preparation-related impacts
6	Establish staging and site access areas along existing roadways or other disturbed areas to minimize erosion into or contamination of sensitive areas or their buffers. Confine work to the area noted using flagging or other barriers.
7	Limit clearing and grubbing area to minimum required. Retain vegetation to maximum extent possible. Minimize clearing and grubbing effects by cutting vegetative stems but not removing the root systems, which help to reduce erosion potential and allow native plants to regenerate.
9	Ensure proper BMPs, such as covering, berming, matting, seeding or mulching are implemented to prevent erosion of any excavated material.
12	Place sediment barriers (e.g., silt fences, coir logs, wood straw or other effective erosion control method) around disturbed sites to prevent erosion from sediment from entering a waterbody.
13	Keep a supply of erosion control materials (e.g., silt fence or mulch) on hand to respond to sediment emergencies. For wetland areas with high likelihood of germination, use wood straw.
14	Use curb inlet sediment traps and geotextile filters, along with silt fencing, to capture sediment before it leaves the site.
	Avoid heavy equipment fuel/oil leakage
15	Equipment used for work below the OHW or MHHW or in riparian zones or shoreline areas shall be cleaned of accumulated grease, oil, mud, etc. and leaks repaired before arriving at the project.
16	Equipment shall be fueled and serviced in an established staging area. Thereafter, all equipment shall be inspected daily for leaks or accumulation of grease, and any identified problems fixed before equipment enters areas typically covered with water.

17	Two oil absorbing floating booms appropriate for the size of the work shall be available onsite during all phases of construction whenever heavy equipment is used below the OHW or MHHW. Place booms in a location that facilitates an immediate response to potential petroleum leakage and shall be deployed for all petroleum leaks.
18	Vegetable-based hydraulic fluid should be substituted when machines will operate in sensitive areas or their buffer for more than incidental work.
19	Operate machinery from existing roads and paved areas where they exist in proximity to the site. In many cases, wood chippings and timber mats can provide a temporary surface where heavy equipment can access a work site.
	Minimize stream crossing sedimentation
25	Minimize stream and riparian crossings. <u>If possible</u>, cross at right angles to the main channel.
26	Where temporary stream crossings are essential, crossings shall be managed to minimize the risk of creating erosion.
	General restoration in open waters
27	For in-water work at or below OHW or MHHW, appropriate and effective erosion or other water quality control devices will be in place before project work begins. Control devices include sealed sand or gravel bags, silt curtains, silt fencing, other containment systems. Deploy and maintain curtain at sufficient depth to reach bottom and contain sediment.
28	<u>If mechanized equipment is used within the OHW or MHHW</u>, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters). This prevents material from entering the water during construction. It is recommended that a tarp be placed on the substrate of the work area. All debris removed will be disposed of offsite or to an approved upland disposal area.
29	Confine use of equipment operating below OHW or MHHW to designated access corridors.
	Overwater Structure Size
	Floats, docks or piers
33	Overwater structures such as piers and floats should be no larger (length and width) than needed for the specified function (see Table 4-7). Minimize/reduce pier and overall footprint of structure to reduce shading impacts. In the SPIF, give rationale for project-specific pier and float size requirements.
35	To reduce shading impacts, grating shall be installed on fixed structure surfaces during replacement to provide light transmission to the maximum extent practicable and American Disabilities Act (ADA) requirements. If grating cannot be installed in pier/float decking, consider using transparent glass blocks, prisms, or floors to obtain more light under pier.
36	Flotation for floats will be fully contained in a durable protective casing to prevent breakup of the flotation material and its release into the waterway.
37	In marine waters, replacement floats shall be at least 4 feet above marine vegetation (e.g., eelgrass) to avoid creating new shade over marine vegetation.
38	Any flotation material used shall be positioned so that they do not block any grating or other surface light treatment (i.e. prisms, blocks) and associated light transmission through the overwater structure.

CM #	**Shoreline and Aquatic Habitat Protection**
	All projects/all structures
63	Take care to prevent spread of invasive plant species during their removal.
64	Plant the project shoreline with native riparian vegetation. City crew/contractor will ensure 80% survival of the planted material at 1, 3, and 5 years after installation. Riparian planting plans, including monitoring and reporting, will be submitted along with the project permit application.
65	Require City crew/contractor to retrieve any debris generated during construction that has entered the water and sunk to dispose of it at an upland facility.

E. Floating Log Boom

A floating log boom is a chained or cabled series of floating timbers that serves to obstruct navigation. The in-water support for these structures is typically piling and/or anchor and chain system. The construction method, equipment, and conservation measures are described above for pilings, *section A, Piling*, and anchor and chain systems, *section B, Anchor and Chain Systems*. Log booms are fabricated at a land-based facility before delivery to the site by barge, work boat, or truck. If necessary, a crane or similar hoisting machine lifts the boom or breakwater into place and it is attached to the piling or chain and anchor system. Otherwise, the boom is floated as a raft to the site, extended open, and attached to the support piling or chain and anchor system.

Equipment Used
Barge, crane, delivery truck, hand tools, work boat

Conservation Measures

- Approved work windows
- Overwater structure size
- Shoreline and aquatic habitat protection

CM #	
	Approved Work Windows
1	All work shall comply with the approved work windows/timing restrictions for the protection of ESA-listed species or species they forage upon in the Seattle action areas.
	Overwater Structure Size
	Floats, docks and piers
41	Limit overall size, length, and width to minimum necessary for wave attenuation and safe public use/navigation.
	Anchoring buoys and floating breakwaters
43	Ensure that the anchor lines do not drag on the substrate or in aquatic vegetation during low water levels. Buoy cables or chains will be kept off of the bottom by the addition of a second float below the surface at the appropriate length and size to perform during all tidal and wind conditions.
44	Use mechanical anchors (e.g. helical screw) in lieu of concrete anchors unless substrate (e.g., bedrock) prevents installation of screw anchors.
	Shoreline and Aquatic Habitat Protection
	All projects/all structures
62	If a construction barge is used, it shall not ground or rest on the substrate at anytime or anchor over vegetated shallows.
65	Require City crew/contractor to retrieve any debris generated during construction that has entered the water and sunk to dispose of it at an upland facility.

F. Buoys

A buoy is a floating object used to moor boats, aid navigation, or mark an area. The size of the buoy depends on its purpose. Buoys may be set individually or attached together in a linear system.

Individual Buoys

The in-water vertical support is typically an anchor and chain system.

Attached Line of Buoys

The vertical support may be piling or an anchor and chain system. The construction method, equipment, and conservation methods for piling and for anchor and chain systems are described above in sections **12A, Piling** and **12B, Anchor and Chain Systems**. The buoy typically has a foam core, durable outer surface, a rod through its diameter, and eye bolts attached to the rod ends. Periodically buoys, anchors, chains, and their hardware are inspected by divers and, if necessary, replaced or repaired.

Equipment Used Hand tools, work boat

Conservation Measures • Approved work windows • Overwater structure size • Shoreline and aquatic habitat protection	
CM #	
	Approved Work Windows
1	All work shall comply with the approved work windows/timing restrictions for the protection of ESA-listed species or species they forage upon in the Seattle action areas.
	Overwater Structure Size
	Anchoring buoys and floating breakwaters
43	Ensure that the anchor lines do not drag on the substrate or in aquatic vegetation during low water levels. Buoy cables or chains will be kept off of the bottom by the addition of a second float below the surface at the appropriate length and size to perform during all tidal and wind conditions.
44	Use mechanical anchors (e.g., helical screw) in lieu of concrete anchors unless substrate (e.g., bedrock) prevents installation of screw anchors.
	Shoreline and Aquatic Habitat Protection
	All projects/all structures
62	If a construction barge is used, it shall not ground or rest on the substrate at anytime or anchor over vegetated shallows.
63	Take care to prevent spread of invasive plant species during their removal.
64	Plant the project shoreline with native riparian vegetation. City crew/contractor will ensure 80% survival of the planted material at 1, 3, and 5 years after installation. Riparian planting plans, including monitoring and reporting, will be submitted along with the project permit application.
65	Require City crew/contractor to retrieve any debris generated during construction that has entered the water and sunk to dispose of it at an upland facility.

G. Fixed Breakwaters

Breakwaters are structures that provide protection against wave actions and are used on their protected side for boat moorage or swimming. Pile breakwaters with lagging and/or revetments are constructed from land-based equipment and hand tools. The breakwaters are made from a combination of materials such as timber in the splash zone and revetment rock in the shoal area with concrete walks or access points. Damage to wood lagging and revetment lost to shore drift and/or prop scour in most cases are replaced by hand but mechanized equipment may be used. Access may be from shore or barge/work boat.

Equipment Used
Backhoe, hand tools (maintenance only), piling and lagging, work boat

Conservation Measures

- Approved work windows
- Stormwater pollution prevention
- Shoreline and aquatic habitat protection

CM #	
	Approved Work Windows
1	All work shall comply with the approved work windows/timing restrictions for the protection of ESA-listed species or species they forage upon in the Seattle action areas.
	Stormwater Pollution Prevention
	Develop a CSECP
2	Each project shall have onsite a written Construction Stormwater and Erosion Control Plan (CSECP) that includes all information needed to reduce erosion and sedimentation on the project. All projects will require the contractor to assign an onsite Erosion Control Lead to oversee the work and ensure compliance with the CSECP.
	Ensure City crew/contractor has SPCP
3	The City crew/contractor shall be required to have onsite a written Spill Prevention and Control Plan (SPCP) that describes materials to be used and measures to prevent or reduce impacts from potential spills (fuel, hydraulic fluid, etc).
4	Maintain a spill kit onsite to respond to accidental spills during construction. Ensure that spill kit is stocked with adequate containment material and other supplies to suit the specific job site and potential containment distances.
	Minimize site-preparation-related impacts
6	Establish staging and site access areas along existing roadways or other disturbed areas to minimize erosion into or contamination of sensitive areas or their buffers. Confine work to the area noted using flagging or other barriers.
12	Place sediment barriers (e.g., silt fences, coir logs, wood straw or other effective erosion control method) around disturbed sites to prevent erosion from sediment from entering a waterbody.
13	Keep a supply of erosion control materials (e.g., silt fence or mulch) on hand to respond to sediment emergencies. For wetland areas with high likelihood of germination, use wood straw.
14	Use curb inlet sediment traps and geotextile filters, along with silt fencing, to capture sediment before it leaves the site.

CM #	*Avoid heavy equipment fuel/oil leakage*
15	Equipment used for work below the OHW or MHHW or in riparian zones or shoreline areas shall be cleaned of accumulated grease, oil, mud, etc. and leaks repaired before arriving at the project.
16	Equipment shall be fueled and serviced in an established staging area. Thereafter, all equipment shall be inspected daily for leaks or accumulation of grease, and any identified problems fixed before equipment enters areas typically covered with water.
17	Two oil absorbing floating booms appropriate for the size of the work shall be available onsite during all phases of construction whenever heavy equipment is used below the OHW or MHHW. The booms shall be placed in a location that facilitates an immediate response to potential petroleum leakage and shall be deployed for all petroleum leaks.
18	Vegetable-based hydraulic fluid should be substituted when machines will operate in sensitive areas or their buffer for more than incidental work.
	Minimize earthmoving-related erosion
19	Operate machinery from existing roads and paved areas where they exist in proximity to the site. In many cases, wood chippings and timber mats can provide a temporary surface where heavy equipment can access a work site.
20	Use temporary materials such as geotextile barriers, hog fuel or wood pellets to stabilize haul and access routes, staging areas and stockpile areas.
	General restoration in open waters
27	For in-water work at or below OHW or MHHW, appropriate and effective erosion or other water quality control devices will be in place before project work begins. Control devices include sealed sand or gravel bags, silt curtains, silt fencing, other containment systems. Deploy and maintain curtain at sufficient depth to reach bottom and contain sediment.
28	If mechanized equipment is used within the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters). This prevents material from entering the water during construction. It is recommended that a tarp be placed on the substrate of the work area. All debris removed will be disposed of offsite or to an approved upland disposal area.
	Overwater Structure Size
	Floating breakwaters
42	Logs shall be clean and without bark.
	Shoreline and Aquatic Habitat Protection
	All projects/all structures
57	Perform the work in the dry whenever possible (80 – 90% of the time).
58	Minimize construction impacts by conducting work during minus tides or low water levels.
59	All fill materials will be of clean, washed, and commercially-obtained material.
62	If a construction barge is used, it shall not ground or rest on the substrate at anytime or anchor over vegetated shallows.
63	Take care to prevent spread of invasive plant species during their removal.

64	Plant the project shoreline with native riparian vegetation. City crew/contractor will ensure 80% survival of the planted material at 1, 3, and 5 years after installation. Riparian planting plans, including monitoring and reporting, will be submitted along with the project permit application.
65	Require City crew/contractor to retrieve any debris generated during construction that has entered the water and sunk to dispose of it at an upland facility.
	Beach nourishment/substrate addition
67	Use clean gravel (less than 3% fines by weight [material passing a number 200 sieve per U.S. standard sieve size]) to avoid turbidity during gravel placement.
	Riprap addition
73	When installing riprap, include rootwads and/or large woody material to increase habitat complexity
74	Cover all newly placed riprap with habitat mix to fill voids and cover the rock to benefit benthic organisms. In location where habitat mix will wash away rapidly, it may be deemed unnecessary to install.

H. Highway or Road Bridge Foundation or Footing Repair

Bridge foundations, footings, and abutments provide the main support for bridges. The foundations, footings, and abutments are constructed of rebar encased in concrete. Over time the concrete may deteriorate due to weathering, wave actions, stream current, or aging. Maintenance is required to repair deteriorated portions of the bridge foundations, footings, and abutments.

Concrete spalling on bridge foundations, footings, and abutments is repaired by removing loose and deteriorating concrete. Rebar or additional steel bracing is welded or replaced. New concrete is added by constructing a form around the damaged area and injecting concrete or epoxy into the form.

In some cases, riprap is placed around the foundations and footings for protection. High flows can cause riprap to erode, scour, or wash away. The replacement of the riprap will follow actions described in Method 7F – Repair Bulkheads.

Equipment Used
Barge, crane, hand tools, work boat

Conservation Measures • Approved work windows • Stormwater Pollution Prevention • Shoreline and aquatic habitat protection • Riprap Addition	
CM #	
	Approved Work Windows
1	All work shall comply with the approved work windows/timing restrictions for the protection of ESA-listed species or species they forage upon in the Seattle action areas.
	Stormwater Pollution Prevention
	Avoid Heavy Equipment Fuel/Oil Leakage
15	Equipment used for work below the OHW or MHHW or in riparian zones or shoreline areas shall be cleaned of accumulated grease, oil, mud, etc. and leaks repaired before arriving at the project.

16	Equipment shall be fueled and serviced in an established staging area. Thereafter, all equipment shall be inspected daily for leaks or accumulation of grease, and any identified problems fixed before equipment enters areas typically covered with water.
17	Two oil absorbing floating booms appropriate for the size of the work shall be available onsite during all phases of work whenever heavy equipment is used below the OHW or MHHW. The boom shall be placed in a location that facilitates an immediate response to potential petroleum leakage and shall be deployed for all petroleum leaks.
18	Vegetable-based hydraulic fluid should be substituted when machines will operate in sensitive areas or their buffer for more than incidental work.
	Shoreline and Aquatic Habitat Protection
	All projects/all structures
57	Perform the work in the dry whenever possible (80 – 90%).
58	Minimize construction impacts by conducting work during minus tides or low water levels.
59	All fill materials will be of clean, washed, and commercially-obtained material.
61	Equipment and materials are mobilized to and from the site via upland access or construction barge. If the project area is not isolated and dewatered, a silt curtain will be installed.
62	If a construction barge is used, it shall not ground or rest on substrate at anytime or anchor over vegetated shallows.
65	Require City crew/contractor to retrieve any debris generated during construction that has entered the water and sunk to dispose of it at an upland facility.
	Riprap addition
74	Cover all newly placed riprap with habitat mix to fill voids and cover the rock to benefit benthic organisms. In locations where habitat mix will wash away rapidly, it may be deemed unnecessary to install.

I. Removal of Plants and Animals from Pilings for Inspection or Repair

Plants and animals, such as mussels and barnacles, need to be removed to inspect and repair some pilings or seawalls. Methods used to remove plants and animals include: scraping with knives, pressure washing, or hand removal. Work can occur underwater by divers, or in the dry during low tides.

Equipment Used
Barge, crane, hand tools, work boat

Conservation Measures

- Approved work windows
- Shoreline and aquatic habitat protection

CM #	
	Approved Work Windows
1	All work shall comply with the approved work windows/timing restrictions for the protection of ESA-listed species or species they forage upon in the Seattle action areas.
	Shoreline and Aquatic Habitat Protection
	All projects/all structures
57	Perform the work in the dry whenever possible (80 – 90%).

58	Minimize construction impacts by conducting work during minus tides or low water levels.
61	Equipment and materials are mobilized to and from the site via upland access or construction barge. If the project area is not isolated and dewatered, a silt curtain will be installed.
62	If a construction barge is used, it shall not ground or rest on substrate at anytime or anchor over vegetated shallows.
63	Take care to prevent spread of invasive plant species during their removal.
65	Require City crew/contractor to retrieve any debris generated during construction that has entered the water and sunk to dispose of it at an upland facility.

3.11 Method 11: Seawall Repair and Maintenance

Various types of seawalls exist around Elliott Bay. The seawalls form the shoreline of Elliott Bay and many were constructed between 1916 through 1934. Different construction methods were used to build the seawalls:

Seawalls along Alaska Way Viaduct:

- Pre-cast concrete face panels resting on steel piles that have been driven into the underlying sediment. The seawall is held in place by a relieving platform of timber beams and wood piles that resist the forces of the fill behind the seawall.
- Pre-cast concrete face panels resting on steel sheet piles that extend up through the intertidal water column. The seawall is held in place by a relieving platform of timber beams and wood piles that resist the forces of the fill behind the seawall.
- A timber-pile-supported, unreinforced concrete gravity wall.
- Concrete-pile-supported reinforced concrete sidewalk frame wall.

Seawalls along Harbor Ave SW:

- Concrete face panels and support columns.

The face of the seawalls can be concrete, steel, or wood. Ekki wood is used because of its extremely hard characteristics ideal for the marine environment. Ekki wood does not need to be treated prior to use in water.

A cathodic protection (CP) device is also attached to portions of certain seawalls. The CP system counteracts the electrochemical process of corrosion that would otherwise occur at the surface of the seawall. The CP system consists of a sacrificial device (anode) placed 20 to 40 feet in front of the seawall. A very small electrical current runs between the steel seawall (cathode) and the anode.

An electronic monitoring system was installed along the portions of the seawall to provide real time data on potential movement along the seawall because of seismic activity. The equipment is mounted on the seawall above MHHW under the overhanging sidewalk of the seawall. Monitors are placed at approximately 60-feet intervals.

Because of its age and environmental forces acting up it, the seawall needs regular maintenance to keep it structurally sound.

A. Remove and Replace Damaged Concrete, Wood or Steel

As concrete, wood, and steel associated with the seawalls deteriorates, it must be removed and replaced so structural integrity of the seawalls can be maintained. The following methods can be used.

1. Removal of concrete through the use of jack-hammers or air driven chipping guns.
2. Cleaning of rebar with air driven needle guns, hooked up to shop vacuum with a Hepa filter
3. Wooden forms used to construct columns. Forms will be made water tight by sealing with caulk or foam.

4. Removal of wood panels along the seawall by shaking or vibrating out the panels. New panels are inserted into slot in the seawall that hold them in place.

B. Backfilling of Voids in Seawall

The top of the seawall has numerous six inch access holes to fill the voids behind the wood and steel plates. A tube is inserted into the access holes and washed gravel is gravity fed from a hopper located above the seawall.

C. Cathodic Protection and Electronic Monitoring System Maintenance

Steel conduit with electrical wiring runs from the anodes to the seawall, and then along the seawall to the monitoring system. The steel conduit corrodes due to the marine environment and needs to be replaced. The anodes also need to be periodically replaced as their use causes them to deteriorate. Divers are used to hook a crane to the anodes for removal and replace underwater conduit. Workers can replace conduit that is not underwater from boats.

D. Riprap Repair

The base of the seawall has riprap to protect the seawall from erosion. Over time some of the riprap may wash away and needs to be replaced. The replacement of the riprap will follow actions described in Method 7F – Repair Bulkheads.

Equipment Used
Backhoe/excavator, cars, barge, scaffolding, jackhammer, air driven chipping guns, air driven needle guns, chain saw, concrete mixer, concrete pump, crane, drilling rig, dump truck, front-end loader, hand tools, pick-up truck, tractor, trailer, wheelbarrow

Conservation Measures • Approved work windows • Stormwater pollution prevention • Piling installation and noise abatement • Shoreline and aquatic habitat protection	
CM #	
	Approved Work Windows
1	All work shall comply with the approved work windows/timing restrictions for the protection of ESA-listed species or species they forage upon in the Seattle action areas.
	Stormwater Pollution Prevention
	Ensure City crew/contractor has SPCP
3	The City crew/contractor shall have onsite a written Spill Prevention and Control Plan (SPCP) that describes materials to be used and measures to prevent or reduce impacts from potential spills (fuel, hydraulic fluid, etc).
4	Maintain a spill kit onsite to respond to accidental spills during construction. Ensure that spill kit is stocked with adequate containment material and other supplies to suit the specific job site and potential containment distances.
	Avoid heavy equipment fuel/oil leakage
15	Equipment used for work below the OHW or MHHW or in riparian zones or shoreline areas shall be cleaned of accumulated grease, oil, mud, etc. and leaks repaired before arriving at the project.

16	Equipment shall be fueled and serviced in an established staging area. Thereafter, all equipment shall be inspected daily for leaks or accumulation of grease, and any identified problems fixed before equipment enters areas typically covered with water.
17	Two oil absorbing floating booms appropriate for the size of the work shall be available onsite during all phases of work whenever heavy equipment is used below the OHW or MHHW. The booms shall be placed in a location that facilitates an immediate response to potential petroleum leakage and shall be deployed for all petroleum leaks.
18	Vegetable-based hydraulic fluid should be substituted when machines will operate in sensitive areas or their buffer for more than incidental work.
	General restoration in open waters
27	For in-water work at or below OHW or MHHW, appropriate and effective erosion control devices or other water quality control devices will be in place before project work begins. Control devices include sealed sand or gravel bags, silt curtains, silt fencing or other containment systems. Deploy and maintain curtain at sufficient depth to reach bottom and contain sediment
28	If mechanized equipment is used within the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters. This prevents material from entering the water during construction. It is recommended that a tarp be placed on the substrate of the work area. All debris removed shall be disposed of offsite in an approved upland disposal area.
29	Confine use of equipment operating below OHW or MHHW to designated access corridors.
	Shoreline and Aquatic Habitat Protection
	All projects/all structures
57	Perform the work in the dry whenever possible (80-90% of the time).
58	Minimize construction impacts by conducting work during minus tides or low water levels.
59	All fill materials will be of clean, washed, and commercially-obtained material.
61	Equipment and materials are mobilized to and from the site via upland access or construction barge. If the project area is not isolated and dewatered, a silt curtain will be installed.
62	If a construction barge is used, it shall not ground or rest on the substrate at anytime or anchor over vegetated shallows.
65	Require City crew/contractor to retrieve any debris generated during construction that has entered the water and sunk to dispose of it at an upland facility.
	Riprap addition
74	Cover all newly placed riprap with habitat mix to fill voids and cover the rock to benefit benthic organisms. In locations where habitat mix will wash away rapidly, it may be deemed unnecessary to install.

3.12 Method 12: Site Restoration

Site restoration stabilizes the site after construction is complete, the staging and access areas are vacated, and the Construction Stormwater and Erosion Control Plan (CSECP) measures are modified to ensure effective stabilization. These measures prepare the site for replanting, return to pre-construction use, and protect disturbed soil from erosion and invasive weeds.

Inspect rough grading to ensure final slopes will not generate erosive energy affecting sensitive areas. When necessary, loosen compacted access roads, staging, and stockpile areas and use the CSECP measures. Scatter and place stockpiled woody debris.

Upon project completion, spread or remove stockpiled materials. All imported soil or rock must be removed, and the covered surface regraded and replanted to original conditions at project completion.

If final site restoration activities cannot be completed within **5 days** of the last construction phase, install interim measures (erosion control) until conditions permit installation of the restoration plan.

Equipment Used
Cars, chain saw, dump truck, front-end loader, hand tools, pick-up truck, spray equipment, tractor, trailer, weed trimmer, wheelbarrow

Conservation Measures

- Approved work windows
- Stormwater pollution prevention
- Piling installation and noise abatement
- Shoreline and aquatic habitat protection

CM #	
	Approved Work Windows
1	All work shall comply with the approved work windows/timing restrictions for the protection of ESA-listed species or species they forage upon in the Seattle action areas.
	Stormwater Pollution Prevention
	Develop a CSECP
4	Maintain a spill kit onsite to respond to accidental spills during construction. Ensure that spill kit is stocked with adequate containment material and other supplies to suit the specific job site and potential containment distances.
	Minimize site preparation-related impacts
11	Salvaged debris such as roots and stumps may be used for habitat. Disposal of debris may include chipping, shredding, or grinding for reintroduction to the site as mulch.
12	Place sediment barriers (e.g., silt fences, coir logs, wood straw or other effective erosion control method) around disturbed sites to prevent erosion from sediment from entering a waterbody.
	Avoid heavy equipment fuel/oil leakage
15	Equipment used for work below the OHW or MHHW or in riparian zones or shoreline areas shall be cleaned of accumulated grease, oil, mud, etc. and leaks repaired before arriving at the project.

16	Equipment shall be fueled and serviced in an established staging area. Thereafter, all equipment shall be inspected daily for leaks or accumulation of grease, and any identified problems fixed before equipment enters area typically covered with water.
18	Vegetable-based hydraulic fluid should be substituted when machines will operate in sensitive areas or their buffer for more than incidental work.
	Minimize earthmoving-related erosion
19	Operate machinery from existing roads and paved areas where they exist in proximity to the site. In many cases, wood chippings and timber mats can provide a temporary surface where heavy equipment can access a work site.
24	Remove equipment and excess supplies, clean work storage areas, and remove temporary erosion control materials and temporary fill after construction when soils have stabilized.
	Shoreline and Aquatic Habitat Protection
	All projects/all structures
57	Perform the work in the dry whenever possible (80 – 90% of the time).
58	Minimize construction impacts by conducting work during minus tides or low water levels.
65	Require contractor to retrieve any debris generated during construction that has entered the water and sunk to dispose of it at an upland facility.

3.13 Method 13: Landscaping and Planting

This method creates new or repairs existing landscapes after sensitive area disturbance. New native plantings may be installed to replace lawns, high maintenance landscapes, or impervious surfaces. Success will be measured with percent survival, site cover, invasive plant cover or target species diversity monitoring. Replanting of native plant communities increases wildlife and fish habitat. Before spreading topsoil, check stockpile for weed contamination or soil compaction due to settling during storage. Check subgrade for proper compaction, particularly over trenches. If soil is added, till to the specified depth at the specified ratio. Avoid overcompaction and ensure even distribution of topsoil.

Install specified native plants. Typically, planting does not occur until late October to January to ensure greater success and reduce initial watering requirements. Add mulch to the site to suppress weeds and enhance soil moisture. Schedule the monitoring and maintenance program according to the planting plan and permit requirements. Maintenance may be required for up to 5 years.

No fertilizers are used to establish restoration. Soil amendments are allowed if approved for riparian application.

'Pesticide' is a generic term for any licensed or registered product or material including herbicides, insecticides, and fungicides, or biological agents applied to a target pest as control measure**.** Pesticide use, when necessary, is part of an Integrated Pest Management (IPM) approach. Permits are required from the departments of Ecology and Agriculture if a pesticide (i.e., herbicide) is used to control invasive/noxious aquatic weeds.

City of Seattle departmental IPM coordinators approve specific pesticide applications. The Office of Sustainability and Environment approves certain chemicals such as a Tier 1 Exemption.

Equipment Used
Backhoe/excavator, bull dozer, cars, dump truck, front-end loader, hand tools/wheel barrow, hydro-seeding truck, pick-up truck, tiller, trailer, watering truck for irrigation during plant establishment

Conservation Measures • Approved work windows • Stormwater pollution prevention • Shoreline and aquatic habitat protection • Pesticides	
CM #	
	Approved Work Windows
1	All work shall comply with the approved work windows/timing restrictions for the protection of ESA-listed species or species they forage upon in the Seattle action areas.
	Stormwater Pollution Prevention
	Develop a CSECP
2	Each project shall have onsite a written Construction Stormwater and Erosion Control Plan (CSECP) that includes all information needed to reduce erosion and sedimentation on the project. All projects will require the contractor to assign an onsite Erosion Control Lead to oversee the work and ensure compliance with the CSECP.

CM #	*Ensure City crew/contractor has SPCP*
3	The City crew/contractor shall have onsite a written Spill Prevention and Control Plan (SPCP) that describes materials to be used and measures to prevent or reduce impacts from potential spills (fuel, hydraulic fluid, etc)
4	Maintain a spill kit onsite to respond to accidental spills during construction. Ensure that spill kit is stocked with adequate containment material and other supplies to suit the specific job site and potential containment distances.
	Minimize site-preparation-related impacts
5	Confine construction impacts to the minimum area necessary to complete the project and delineate impact areas on project plans. Flag boundaries of clearing limits associated with site access, construction, and staging areas as well as wetland and riparian corridor where work has been authorized.
6	Establish staging and site access areas along existing roadways or other disturbed areas to minimize erosion into or contamination of sensitive areas or their buffers. Confine work to the area noted using flagging or other barriers.
7	Limit clearing and grubbing area to minimum required. Retain vegetation to maximum extent possible. Minimize clearing and grubbing effects by cutting vegetative stems but not removing the root systems, which help to reduce erosion potential and allow native plants to regenerate.
9	Ensure proper BMPs, such as covering, berming, matting, seeding, or mulching are implemented to prevent erosion of any excavated material.
10	Stockpile large wood, trees, riparian vegetation, other vegetation, sand, and topsoil removed for establishment of staging area and reuse for site restoration.
11	Salvaged debris such as roots and stumps may be used for habitat. Disposal of debris may include chipping, shredding, or grinding for reintroduction to the site as mulch.
12	Place sediment barriers (e.g., silt fences, coir logs, wood straw or other effective erosion control method) around disturbed sites to prevent erosion from sediment from entering a waterbody.
13	Keep a supply of erosion control materials (e.g., silt fence or mulch) on hand to respond to sediment emergencies. For wetland areas with high likelihood of germination, use wood straw.
14	Use curb inlet sediment traps and geotextile filters, along with silt fencing, to capture sediment before it leaves the site.
	Avoid heavy equipment fuel/oil leakage
15	Equipment used for work below the OHW or MHHW or in riparian zones or shoreline areas shall be cleaned of accumulated grease, oil, mud, etc. and leaks repaired before arriving at the project.
16	Equipment shall be fueled and serviced in an established staging area. Thereafter, all equipment shall be inspected daily for leaks or accumulation of grease, and any identified problems fixed before equipment enters areas typically covered with water.
18	Vegetable-based hydraulic fluid should be substituted when machines will operate in sensitive areas or their buffer for more than incidental work.
	Minimize earthmoving-related erosion
19	Operate machinery from existing roads and paved areas where they exist in proximity to the site. In many cases, wood chippings and timber mats can provide a temporary surface where heavy equipment can access a work site.
20	Use temporary materials such as geotextile barriers, hog fuel or wood pellets to stabilize haul and access routes, staging areas and stockpile areas.

22	<u>If equipment wash areas are required</u>, they shall be located where washwater, sediment, and pollutants cannot enter waterbodies, including wetlands.
	Minimize stream crossing sedimentation
25	Minimize stream and riparian crossings. <u>If possible</u>, cross at right angles to the main channel.
26	Where temporary stream crossings are essential, crossings shall be managed to minimize the risk of creating erosion.
	Shoreline and Aquatic Habitat Protection
57	Perform the work in the dry whenever possible (80 – 90% of the time).
63	Take care to prevent spread of invasive plant species during their removal.
64	Plant the project shoreline with native riparian vegetation. City crew/contractor will ensure 80% survival of the planted material at 1, 3, and 5 years after installation. Riparian planting plans, including monitoring and reporting, will be submitted along with the project permit application.
65	Require City crew/contractor to retrieve any debris generated during construction that has entered water and sunk to dispose of it at an upland facility.
	Beach nourishment/substrate addition
67	Use clean gravel (less than 3% fines by weight [material passing a number 200 sieve per U.S. standard sieve size]) to avoid turbidity during gravel placement.
	Bulkhead repair/replacement
72	Plant new bulkhead with native riparian vegetation where not in direct conflict with recreational use.
	Riprap addition
73	When installing riprap, include rootwads and/or large woody material to increase habitat complexity
74	Cover all newly placed riprap with habitat mix to fill voids and cover the rock to benefit benthic organisms. In location where habitat mix will wash away rapidly, it may be deemed unnecessary to install.
	Pesticides
75	Pesticides will be applied only under direct supervision (within line of sight) of a licensed applicator.
76	When native plants are being restored to a project site, pesticides can be used to control those weeds listed in the King County Noxious Weed List. Plants that are highly invasive and damaging to native riparian habitats include Himalayan blackberry, clematis, morning glory, and Japanese knotweed.
78	Other chemicals, such as foaming agents used to kill roots growing into utility pipes, will be subject to Tier 1 chemical application exemptions that will require approval from the Parks IPM coordinator <u>**and**</u> the Office of Sustainability and Environment.

Section 4

Conservation Measures

Conservation measures are best management practices (BMPs) used to ensure that activities avoid and minimize impacts to ESA-listed species and their habitat. This section describes 8 general categories of conservation measures, listed below, that apply to each of the 13 construction methods described in Section 3. Four of these 8 general conservation measures have subcategories outlined below in italics.

4.1 Approved Work Windows, CM 1

4.2 Stormwater Pollution Prevention, CM 2 - 30

- *A. Develop Construction Stormwater & Erosion Control Plan (CSECP),* CM 2
- *B. Ensure Contractor/City Crew has SPCP,* CM 3 & 4
- *C. Minimize Site-Preparation-Related Impacts,* CM 5 - 14
- *D. Avoid Heavy Equipment Fuel/Oil Leakage,* CM 15 - 18
- *E. Minimize Earthmoving-Related Erosion,* CM 19 - 24
- *F. Minimize Stream Crossing Sedimentation,* CM 25 & 26
- *G. General Restoration in Open Waters,* CM 27 - 29
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4.3 Work Area Isolation, CM 31

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E. Riprap Addition, CM 73 & 74

4.8 Pesticides, CM 75 - 78

Across the 8 general categories, there are a total of 78 specific conservation measures. These are detailed below, sequentially numbered starting at 1, shown just below conservation measure 4.1 (Approved Work Windows) and running through to the end of general category 8.

City of Seattle staff will indicate on the **Specific Project Information Forms** (SPIFs), given in Appendix A, those conservation measures that will be applied to a specific activity or suite of activities. There may be additional conservation measures other than those presented here. If additional conservation measures or BMPs will be used, these must be identified and described in the SPIFs.

4.1 Approved Work Windows

CM 1. All work shall be conducted during the approved work windows/timing restrictions for the protection of ESA-listed species or the species they forage upon in the Seattle action areas. If work cannot be completed during the approved work, a request for modification or an extension to the work window should be made to the Corps and Services. These windows can overlap for various species and locations. The work window for bald eagles, protected under the Bald and Golden Eagle Act, is in Appendix C.

A. Fish Windows

Freshwater Fish Window. Follow the approved freshwater work window for ESA-listed species in the Seattle action areas (Table 4-1).

Table 4-1. Approved Freshwater Work Windows for ESA-Listed Fish Species in the Seattle Action Areas*

Waterbody	Location	Window
Lake Washington Ship Canal	Upstream of Locks to east end of Montlake Cut	Oct 1 – Apr 15
Lake Washington south of I-90	>1 mile from the Cedar River	Jul 16 – Dec 31
	Within 1 mile of the Cedar River	Jul 16 – Jul 31 Nov 16 – Dec 31
Lake Washington	Between I-90 and SR 520	Jul 16 – Apr 30
Lake Washington north of SR 520	Between SR 520 and line due west from Arrowhead Point	Jul 16 – Mar 15
	North of line due west from Arrowhead Point	Jul 16 – Jul 31 Nov 16 – Feb 1
Tributaries to Lake Washington in Seattle		Jul 1 – Aug 31
Duwamish River - mouth to upper turning basin		Oct 1 – Feb 15
Tributaries to the Duwamish River		Jul 1 - Sept 30
Tributaries to Puget Sound		Jul 1 – Sept 30
Source**:** Corps 2010		

*Work window for a stream applies to all its tributaries, unless otherwise indicated

Marine Fish Window. Follow the approved marine and estuarine work window for ESA-listed fish species (Coastal-Puget Sound bull trout, Puget Sound Chinook salmon, steelhead and rockfish) and forage fish in the Seattle action areas. (see Figure 1).

- Have City crew or contractor make use of tide tables to select the lowest tides for work.
- Where a river, stream, or tributary enters marine or estuarine water, work windows listed in Table 4-2 apply to all tidally influenced portions of a river, stream or tributary.
- If forage fish spawning habitat is documented in the project area, then the work window for that species applies. For the Seattle Biological Evaluation, 'forage fish' means surf smelt, Pacific sand lance, and Pacific herring. Chinook salmon are forage fish for bull trout as are other small salmonids.

Table 4-2. Approved Marine/Estuarine Work Windows for Puget Sound Chinook Salmon, Bull Trout, Steelhead, Rockfish, and Forage Fish in Seattle Action Areas

Species	Location	Window
Salmon (Puget Sound Chinook)		Jul 2 – Mar 2
Bull trout (Coastal-Puget Sound bull trout)		Jul 16 – Feb 15
	Duwamish Waterway mouth to upper turning basin (SE ¼ of NW ¼ section 4, T23N, R4E)	Oct 1 – Feb 15
Steelhead		Jul 2 – Mar 2
Rockfish*	Puget Sound – kelp beds, eel grass, large rocks	Oct. 1 – Feb. 15
Forage fish:		
Surf smelt		Apr 1 – Aug 31
Pacific herring		May 1 – Jan 14
Pacific sand lance		Mar 2 – Oct 14
Source**:** Corps 2010		

* This work window is for projects that are in or near kelp, eel grass, or large rocks. Rockfish may be present in the nearshore during the summer portion of the Chinook salmon, bull trout, and steelhead (July 2 – October 1). If a project is not located near kelp, eel grass, or large rocks, then the marine work window for listed salmonids should be followed.

Several Work Windows. If several work windows for different species apply (such as for both Chinook and bald eagles) for a specific project, the work windows must be combined.

For example, if the project is in north Puget Sound, Pacific sand lance spawning habitat is present and work windows would be:

Salmon	July 2 – March 2
Bull trout	July 16 – February 15
Pacific sand lance	March 2 – October 14

Taking the days that the approved work windows have in common, the time the project could be constructed is **July 16 – October 14**.

4.2 Stormwater Pollution Prevention

A. Develop Temporary Erosion and Sediment Control Plan

CM 2. Each project shall have onsite a written a Construction Stormwater Erosion Control Plan (CSECP) that includes all information needed to reduce erosion and sedimentation on the project. All projects will require the contractor/City crew to assign an onsite Erosion Control Lead to oversee the work and ensure compliance with the CSECP.

B. Ensure Contractor/City Crew has SPCP

CM 3. The City crew/contractor shall have onsite a written Spill Prevention and Control Plan (SPCP) that describes materials to be used and measures to prevent or reduce impacts from potential spills (fuel, hydraulic fluid, *etc.*).

CM 4. Maintain a spill kit onsite to respond to accidental spills during construction. Ensure that spill kit is stocked with adequate containment material and other supplies to suit the specific job site and potential containment distances.

C. Minimize Site-Preparation-Related Impacts

CM 5. Confine construction impacts to the minimum area necessary to complete the project and delineate impact areas on project plans. Flag boundaries of clearing limits associated with site access, construction, and staging areas as well as wetland and riparian corridor where work has been authorized.

CM 6. Establish staging and site access areas along existing roadways or other disturbed areas to minimize erosion into or contamination of sensitive areas or their buffers. Confine work to the area noted using flagging or other barriers.

CM 7. Limit clearing and grubbing area to minimum required. Retain vegetation to maximum extent possible. Minimize clearing and grubbing effects by cutting vegetative stems but not removing the root systems, which help to reduce erosion potential and allow native plants to regenerate.

CM 8. Divert run-off from entering the project (disturbed) area.

CM 9. Ensure proper BMPs, such as covering, berming, matting, seeding, or mulching, are implemented to prevent erosion of any excavated material.

CM 10. Stockpile large wood, trees, riparian vegetation, other vegetation, sand, and topsoil removed for establishment of staging area and reuse for site restoration.

CM 11. Salvaged debris such as roots and stumps may be used for habitat. Disposal of debris may include chipping, shredding, or grinding for reintroduction to the site as mulch (Std Specs 1-05.13(3), 1-07.5, 2-01.2, 2-10.3(2) and 8-01).

CM 12. Place sediment barriers (*e.g.*, silt fences, coir logs, wood straw, or other effective erosion control method) around disturbed sites to prevent erosion from sediment deposition from entering a waterbody.

CM 13. Keep a supply of erosion control materials (*e.g.*, silt fence or mulch) on hand to respond to sediment emergencies. For wetland areas with high likelihood of germination, use wood straw.

CM 14. Use curb inlet sediment traps and geotextile filters, along with silt fencing, to capture sediment before it leaves the site.

D. Avoid Heavy Equipment Fuel/Oil Leakage

CM 15. Equipment used for work below the OHW[1] or MHHW[2] or in riparian zones or shoreline areas shall be cleaned of accumulated grease, oil, mud, *etc*, and leaks repaired before arriving at the project.

CM 16. Equipment shall be fueled and serviced in an established staging area. Thereafter, all equipment shall be inspected daily for leaks or accumulation of grease, and any identified problems fixed before equipment enters areas typically covered with water.

CM 17. Two oil-absorbing floating booms appropriate for the size of the work shall be available onsite during all phases of work whenever heavy equipment is used below the OHW or MHHW. The booms shall be placed in a location that facilitates an immediate response to potential petroleum leakage and shall be deployed for all petroleum leaks.

CM 18. Vegetable-based hydraulic fluid should be substituted when machines will operate in sensitive areas or their buffer for more than incidental work.

E. Minimize Earthmoving-Related Erosion

CM 19. Operate machinery from existing roads and paved areas where they exist in proximity to the site. In many cases, wood chippings and timber mats can provide a temporary surface where heavy equipment can access a work site.

CM 20. Use temporary materials such as geotextile barriers, hog fuel or wood pellets to stabilize haul and access routes, staging areas and stockpile areas.

CM 21. Stockpile native streambed or substrate materials above the OHW for later use in project restoration. To prevent contamination from fine soils, these materials shall be kept separate from other stockpiled material not native to streambed or substrate.

CM 22. If equipment wash areas are required, they shall be located where washwater, sediment, and pollutants cannot enter waterbodies, including wetlands.

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[1] Ordinary high water (OHW): A non-tidal (freshwater) visible line on a bank where the presence and action of waters are so common as to leave a mark on soil or vegetation.
[2] Mean higher high water (MHHW): A tidal (marine water) datum that is the average high water height.

CM 23. No sediment shall be tracked onto paved streets or roadways. Sediment shall be removed from trucks and equipment before leaving the site.

CM 24. Remove equipment and excess supplies, clean work storage areas, and remove temporary erosion control materials and temporary fill after construction and when soils have stabilized (Std Spec 1-04.11).

F. Minimize Stream Crossing Sedimentation

CM 25. Minimize stream and riparian crossings. If possible, cross at right angles to the main channel.

CM 26. Where temporary stream crossings are essential, crossings shall be managed to minimize the risk of creating erosion.

G. General Restoration in Open Waters

CM 27. For in-water work at or below OHW or MHHW, appropriate and effective erosion or other water quality control devices will be in place before project work begins. Control devices include sealed sand or gravel bags, silt curtains, silt fencing, or other containment systems. Deploy and maintain curtain at sufficient depth to reach bottom and contain sediment.

CM 28. If mechanized equipment is used within the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters). This prevents material from entering the water during construction. It is recommended that a tarp be placed on the substrate of the work area. All debris removed shall be disposed of offsite in an approved upland disposal area.

CM 29. Confine use of equipment operating below OHW or MHHW to designated access corridors.

H. Temporary Dewatering Plan Requirements

CM 30. Develop a Temporary Dewatering Plan (TDP) for any dewatering lasting **more than one day** or requiring the installation of **a trench safety system**. The City crew/contractor shall submit the TDP to the City project manager. The TDP shall contain the following minimum information:

- Contact information for preparer and implementation of TDP
- Location of point of discharge and construction schedule
- Existing site conditions and proposed construction activities
- Water quantity (if applicable) and discharge volume monitoring plan
- Impacts of temporary dewatering activities to adjacent public places or streams, wetlands, or their buffers
- *Dewatering Suspension Plan* to secure site if both water quality and quantity requirements are not met. The plan requires the City/contractor to focus efforts on CSECP and dewatering treatment for the site. For sites discharging subsurface flows, the City shall require that site operations cease under the plan. All discharges from dewatering treatment systems must meet Washington state water quality

requirements. If temporarily dewatering dredged material, the returned water should be cleaned to the level acceptable by regulation.

- Emergency termination of dewatering discharges if any of the water quality and/or quantity treatment requirements are not being met. Routing flows to the sewer system is a last-resort option that must receive Seattle Public Utilities and King County consent prior to instigation. All reasonable treatment options (as determined by Seattle Public Utilities) must be exhausted before this is allowed.
- Other information deemed necessary to temporary dewatering activities during the review of the TDP and/or during construction.

4.3 Work Area Isolation

CM 31. Follow proper work area isolation measures (Table 4-3)

Table 4-3. Work Area Isolation

	Measure
1	Determine if a cofferdam or other waterproof barrier is necessary and install it in the dry, if possible.
2	If water infiltrates into the work site, either through the barrier or groundwater, and must be removed, pump it to a tank or other method of treatment so that it meets water quality standards before introducing it back into the waterbody.
3	Where work will occur completely within the water or where isolating the work area is not practical, install a silt curtain or similar measure to minimize environmental impacts to the surrounding area.
4	Do not remove deployed silt curtains until turbidity within the work area has returned to background levels.
5	The temporary bypass system must consist of non-erosive techniques, such as a pipe or a plastic-lined channel, both of which must be sized large enough to accommodate the predicted flow rates during construction. For projects that last longer than 1 day, a contingency plan must be developed to address unexpected storm flows. If storm flows occur and the diversion is overtopped, equipment shall be removed and the project stopped. After the flows return to normal, fish bypass and removal shall occur again to remove any fish that entered the construction area during the storm event.
6	Dissipate flow at the outfall of the bypass system to diffuse erosive energy of the flow. Size the dissipater for the volume and velocity of the bypassed flow. Place the outflow in an area that minimizes or prevents damage to riparian vegetation.
7	Except for gravity diversions that have gradual and small outfall drops directly into water, all water intake structures must have a fish screen installed, operated, and maintained in accordance with the NMFS Juvenile Fish Screen Criteria and the NMFS Addendum NMFS Pump Intake Screen Guidelines. If the diversion

	inlet is a gravity diversion and is not screened to allow for downstream passage of fish, place diversion outlet in a location that facilitates gradual and safe reentry of fish into the stream channel.
8	All stream diversion devices, equipment, pipe, and conduits will be removed and disturbed soil will be restored after the diversion is no longer needed.

4.4 Fish Handling

CM 32. Follow proper fish capture and handling measures (Tables 4-4 through 4-6).

Table 4-4. Fish Capture and Handling General Procedures

	Measure
1	Fish capture operations will be conducted by a trained individual experienced in this type of work. Key staff working with fish removal must have the necessary knowledge, skills, and abilities to ensure the safe handling of all aquatic species.
2	The applicant must obtain any other federal, state and local permits and authorizations necessary for the conduct of fish capture activities.
3	Before conducting activities that may involve fish handling, individuals shall ensure that hands are free of sunscreen, lotion, or insect repellent.
4	Fish will be handled with extreme care and kept in water to the extent possible during transfer procedures based on Tables 4-5 and 4-6.
5	If water remains within the work area and fish are potentially present after isolation of the work area and stream diversion, electrofish, seine, and dip net the work area until catch rates reach zero fish for 3 consecutive passes.

Table 4-5. Fish Capture Methods

Method	Required or Optional	Details
Minnow traps	Optional	Traps may be left in place overnight and may be used in conjunction with seining. This method has limited success in areas of flowing water (most streams), but may be beneficial in calm waters.
Seining	Required	Use seine with mesh of such a size to ensure entrapment of residing fish and age classes. This method is difficult (if not impractical) in streams with many obstacles (wood, rock or undercut banks and insufficient area to beach nets to collect fish).
Dip nets	Required	Use in conjunction with other methods as area is dewatered.

Electrofishing	Required	Use electrofishing in addition to other means of fish capture to ensure the effective capture of fish. Applicants shall adhere to NMFS Backpack Electrofishing Guidelines or SPU-approved fish electroshocking methods. If fish are observed spawning during the in-water work period (a condition likely to occur only in an emergency situation because permitted work/timing windows do not allow this), electrofishing shall not contact spawning adult fish or active redds. **NFMS Backpack Electrofishing Guidelines** 1. Only Direct Current (DC) or Pulsed Direct Current (PDC) shall be used. 2. For conductivity <100 μΩ/cm, use voltage ranges from 900 to 1100. For conductivity from 100 to 300 μΩ/cm, use voltage ranges from 500 to 800. For conductivity greater than 300 μΩ/cm, use voltage to 400. 3. Begin electrofishing with minimum pulse width. Gradually increase to the point where fish are immobilized and captured. 4. Do not allow fish to come into contact with anode. Do not electrofish an area for an extended period of time. Upon capture, remove fish immediately from water. 5. Dark bands on the fish indicate injury, suggesting a reduction in voltage and longer recovery time. **SPU Backpack Electrofishing Guidelines Using Smith Root Backpack Electroshocker** 1. Program the unit for automatic setup (instructions are with unit). 2. Find an unobstructed section of water where fish can be observed. 3. Herd any fish out of the area before initiating automatic setup. 4. Initiate automatic setup. Within Seattle urban creeks initial settings often fall within the following ranges: • Hertz = 30 • Duty Cycle = > 10 but < 15 • Volts = > 180 but < 210 5. Before initiating first sweep, drop duty cycle by 2 units and voltage by 30V. Lowering these units will ensure larger fish (which conduct more voltage) will not be harmed. 6. Conduct the first sweep at this level to remove larger fish. Smaller fish will not react at this voltage, but it may herd them from the area. 7. On the second sweep reset to the original units from the automatic setup. This should now begin to bring in the smaller

	fish. If smaller fish are still avoiding the electroshocking device, increase voltage in 10-unit increments until they are drawn in to the electrode. Under normal urban creek conditions in Seattle voltage should be effective below 250V.

Table 4-6. Fish Handling Methods

	Method
1	In areas where ESA-listed fish have been recorded, it is recommended that the transfer of fish be conducted using a sanctuary net that holds water during transfer to prevent the added stress of an out-of-water transfer.
2	If using MS 222 to anesthetize fish, use the minimal amount required. Only anesthetize a few fish at a time to minimize the time fish are in MS 222 solution. Anesthetized fish must be fully recovered before being released into a stream.
3	Release captured fish as soon as possible.
4	If fish are held, provide a healthy environment for the stressed fish and minimize the holding time. Water-to-water transfers, the use of dark-shaded containers, and supplemental oxygen should all be considered in designing fish handling operations.
5	Provide a healthy environment for the stressed fish by using large buckets (5-gallon minimum) to prevent overcrowding and minimal handling of fish.
6	Place large fish in buckets separate from smaller prey-sized fish.
7	Monitor water temperature in buckets and well-being of captured fish.
8	After fish have recovered, it is recommended they be released upstream from the project area in suitable habitat, such as a pool or area that provides cover and flow refuge. Because this action is site specific, apply these principles. Release fish: • As close to point of capture as possible • Based on the life-history stage. Juvenile fish are released downstream of the site to aid migration out of the system. Adult fish are released upstream to aid migration to spawning or resting locations. • Into best available habitat to reduce or decrease predation and aid recovery. Or release where good habitat exists and fish can reoccupy the work area after the project is completed. • At multiple release points. If a large number of fish are caught, release fish at different areas so that fish are not concentrated at one location.

4.5 Overwater Structure Size

A. Floats, Docks, or Piers

CM 33. Overwater structures such as piers and floats should be no larger (length and width) than needed for the specified function (Table 4-7). Minimize/reduce pier and overall footprint of structure to reduce shading impacts. In the SPIF, give rationale for project-specific pier and float size requirements.

Table 4-7. Typical Seattle Parks and Recreation Marine Structure Size

Structure	Size
Swim docks	20-by-40 ft to 32-by-40 ft
Small craft floats	maximum 70 ft long 16 to 20 ft wide for stability
Boat launch floats	maximum 8 ft wide for stability (Must accommodate 20 users at a time)

CM 34. Minimize/reduce piling number and space piling further apart where possible to reduce shading impacts.

CM 35. To reduce shading impacts, grating shall be installed on fixed structure surfaces during replacement to provide light transmission to the maximum extent practicable and meet the American Disabilities Act (ADA) requirements. If grating cannot be installed in pier/float decking, consider using transparent glass blocks, prisms, or floors to obtain more light under pier.

CM 36. Flotation for floats will be fully contained in a durable protective casing to prevent breakup of the flotation material and its release into the waterway.

CM 37. In marine waters, replacement floats shall be at least 4 feet above marine vegetation (*e.g.*, eelgrass) to avoid creating new shade over marine vegetation.

CM 38. Any floatation material used shall be positioned so that they do not block any grating or other surface light treatment (i.e. prisms, blocks) and associated light transmission through the overwater structure.

CM 39. Place new and replacement piers at least two feet above OHW or MHHW.

CM 40. New or replacement skirting will not be installed.

B. Floating Breakwaters

CM 41. Limit overall size, length and width to minimum necessary for wave attenuation and safe public use/navigation.

CM 42. Logs shall be clean and without bark.

C. Anchoring Buoys, Floats and Floating Breakwaters

CM 43. Ensure that anchor lines do not drag on the substrate or in aquatic vegetation during low water levels. Buoy cables or chains will be kept off of the bottom by the addition of a second float below the surface at the appropriate length and size to perform during all tidal and wind conditions.

CM 44. Use mechanical anchors (*e.g.*, helical screw) in lieu of concrete anchors unless substrate (*e.g.*, bedrock) prevents installation of screw anchors.

4.6 Piling Installation and Noise Abatement

A. Piling Installation

CM 45. Plastic, concrete, or timber piling is preferred over steel piling.

CM 46. Use a containment boom for sawdust and debris work. If in marine water, a containment boom may rest on substrate rather than float at all times due to tidal action. Remove contained debris to prevent it from entering the waterway at construction completion.

CM 47. If treated piling is fully extracted or cut below the mudline, cap the holes or piling with appropriate materials (*e.g.*, clean sand or steel pile caps for cut piling). This practice ensures that chemicals from existing piling do not leach into the adjacent sediments or water column.

CM 48. Do **not** use piling treated with creosote, pentachloraphenol, or coal tar.

CM 49. Do **not** use hydraulic water jets to remove or place piling.

CM 50. Replace piling in same general location. Do **not** extend beyond footprint of existing structure.

CM 51. All treated wood will be contained on land or barge during and after removal to preclude sediments and any contaminated material from re-entering the aquatic environment.

B. Piling Installation Noise Abatement

CM 52. Use a vibratory hammer to the maximum extent possible for setting piling. Geotechnical engineering can determine if this will be sufficient based on the piling material and load capacity.

CM 53. A bubble curtain or other noise attenuation method (*e.g.*, wood blocks, nylon blocks, *etc.*) shall be used during impact installation or proofing of steel piling. For piling with a 10-inch or smaller diameter, the sound attenuation device must include one of the methods listed above. For piling with a diameter greater than 10 inches the sound attenuation device must include both the placement of a sound block between the hammer and the piling during pile driving **and** use of a bubble curtain.

CM 54. Hydroacoustic monitoring shall be used for driving large (>12-inch-diameter) steel piling.

CM 55. All reasonable measures shall be taken for the suppression of noise resulting from the work operations. All work shall be performed consistent with the applicable noise control levels set forth in SMC Chapter 25.08 and comply with Std Spec 1-07.5(4) Noise Pollution.

CM 56. Projects using either a vibratory or an impact pile driver to install or remove piling in marine/estuarine waters must deploy sound attenuation and have a qualified observer(s) onsite during all pile driving to scan open water within a certain radius around the work area for marine mammals or marbled murrelets. The radius is based on use of the Practical Spreading Loss model and sound pressure levels from broad band sounds that may cause death, injury, or behavioral disturbance to marine mammals or marbled murrelets. The distance is based on the following thresholds:

- Marine mammals
  - 120 dB_{rms} behavioral threshold for continuous sound (e.g. vibrating)
  - 160 dB_{rms} behavioral threshold for impulse sound threshold (e.g. impact driving)
  - 180 dB_{rms} injury threshold for whales
  - 190 dB_{rms} injury threshold for pinnipeds
- Marbled murrelet
  - 183 dB_{SEL} non-injurious threshold shift
  - 202 dB_{SEL} auditory injury threshold
  - 208 dB_{SEL} barotrauma threshold

Should a marine mammal (e.g. killer whale, humpback whale, or Steller sea lion) or marbled murrelet be observed within this radius, then the observer must immediately notify the pile driver operator and the operator must cease all pile driving activities immediately and only resume pile driving when all marine mammals or marbled murrelets have left the radius around the work area.

While no monitoring is required for impacts to listed fish species, the practical spreading model can be used to determine the distance for injury or behavioral impacts. The distance is based on the following thresholds:

- Chinook salmon, steelhead, bull trout, rock fish
  - 150 dB_{rms} behavioral threshold
  - 183 dB_{SEL} injury threshold for fish $\leq$ 2 g
  - 187 dB_{SEL} injury threshold for fish > 2 g
  - 206 dB_{peak} instantaneous injury threshold

4.7 Shoreline and Aquatic Habitat Protection

A. All Projects/All Structures

CM 57. Perform the work in the dry whenever possible (80-90% of the time).

CM 58. Minimize construction impacts by conducting work during minus tides or low water levels.

CM 59. All fill materials will be of clean, washed, and commercially-obtained material.

CM 60. To avoid entraining fish, an excavated trench exposed to open water between tidal cycles should be sloped or filled with sand and gravel to optimize fish habitat.

CM 61. Equipment and materials are mobilized to and from the site via upland access or construction barge. If the project area is not isolated and dewatered, a silt curtain will be installed.

CM 62. If a construction barge is used, it shall not ground or rest on the substrate at anytime or anchor over vegetated shallows.

CM 63. Take care to prevent spread of invasive plant species during their removal.

CM 64. Plant the project shoreline with native riparian vegetation. City crews and or their contractors will ensure 80% survival of the planted material at one, three, and five years after installation. Riparian planting plans will be submitted along with the project permit application.

CM 65. Require City crews and or their contractors to retrieve any debris generated during construction that has entered the water and sunk to dispose of it at an upland facility.

B. Beach Nourishment/Substrate Addition

CM 66. Beach material will typically be washed gravel whenever possible to minimize the amount of fill eroding into the waterbody. Sands may be applied above the OHW or MHHW depending on the project purpose.

CM 67. Use clean gravel (less than 3% fines by weight [material passing a number 200 sieve per U.S. standard sieve size]) to avoid turbidity during gravel placement.

C. Boat Launch

CM 68. Place appropriate habitat gravel mix as needed. The mix shall meet WDFW Hydraulic Permit Application requirements.

CM 69. No wet concrete or epoxy shall be placed in the wetted perimeter. Concrete and epoxy must be cured before they come into contact with the water.

D. Bulkhead Repair/Replacement

CM 70. Move the bulkhead as far back as possible above the OHW mark or the MHHW level.

CM 71. Construct bulkhead to contain habitat complexity, such as coves, where recreational use allows.

CM 72. Plant new bulkhead with native riparian vegetation where not in direct conflict with recreational use.

E. Riprap Addition

CM 73. When installing riprap, include rootwads and/or large woody debris to increase habitat complexity.

CM 74. Cover all newly placed riprap with habitat mix to fill voids and cover the rock to benefit benthic organisms. In locations where habitat mix will wash away rapidly, it may be deemed unnecessary to install.

4.8 Pesticides

CM 75. Pesticides will be applied only under direct supervision (within line of sight) of a licensed applicator. Only pesticides approved by the City Of Seattle may be used. Contact your departmental integrated pest management (IPM) coordinator for information and guidance on pesticide use.

CM 76. When native plants are being restored to a project site, pesticides can be used to control those weeds listed in the King County Noxious Weed List. Plants that are highly invasive and damaging to native riparian habitats include Himalayan blackberry, clematis, morning glory, and Japanese knotweed. These noxious weeds are highly invasive and are particularly damaging to native plant habitat. Increased effort to reduce and/or eradicate these plants should be exercised.

CM 77. Within the shoreline and riparian zone of all waterbodies, pesticide use within 100 feet of the shoreline is regulated under the City of Seattle Environmental Critical Areas Ordinance. Aquatic and emergent noxious weed control is also regulated by the Washington State Department of Ecology (WDOE). A permit from WDOE is required to control aquatic and emergent weeds with herbicides that are approved by WDOE. Contact your departmental IPM Coordinator for information on how to acquire noxious aquatic and emergent weed control permits.

CM 78. Other chemicals, such as foaming agents used to kill roots growing into utility pipes, will be subject to Tier 1 chemical applications exemptions that will require approval from the the Interdepartmental IPM Committee and the Office of Sustainability and Environment. Contact your departmental IPM Coordinator for more information.

Section 5

Status of the Species

This section describes the biology and distribution of the proposed, threatened, and endangered species occurring within the Seattle action areas (see Figure 1):

- Puget Sound Chinook salmon — Threatened
- Coastal-Puget Sound bull trout — Threatened
- Killer whale: Southern Resident — Endangered
- Steller sea lion: North Pacific population — Threatened
- Humpback whale — Endangered
- Marbled murrelet — Threatened
- Puget Sound steelhead — Threatened
- Eulachon – Threatened
- Bocaccio – Endangered
- Canary rockfish – Threatened
- Yelloweye rockfish – Threatened

The action areas for this Seattle Biological Evaluation are the 7 major drainage basins within Seattle (see Figure 1):

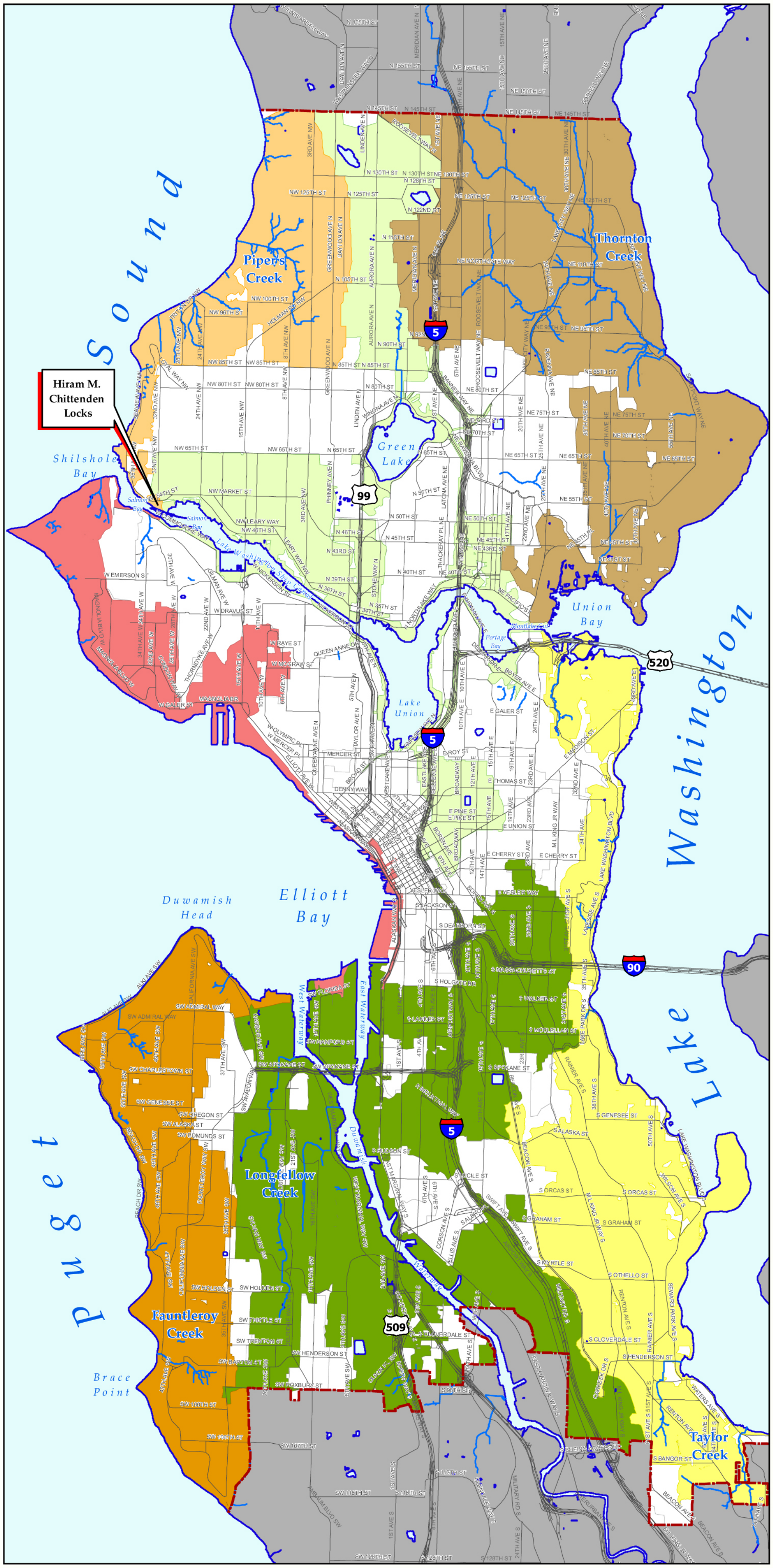
1. Elliott Bay
2. Lake Washington Ship Canal
3. Lower Green/Duwamish
4. North Seattle/Puget Sound
5. North Lake Washington
6. South Seattle/Puget Sound
7. South Lake Washington

The action areas are based on which waterbody surface waters will drain. Figure 2 shows the receiving waterbodies within the City of Seattle. The areas shown in white drain only to a sewage treatment plant. During high rain events within the white areas, discharges may occur from several combined sewer outfalls (CSOs) throughout the different action areas.

Before the potential effects of the proposed actions can be analyzed, it is important to understand how the species currently use the action areas. 'Action area' refers to the area affected by the actions covered in the Seattle Biological Evaluation. There are 7 action areas for the Seattle Biological Evaluation, and they are termed the 'Seattle action areas' in this document (see Figure 1). Of the listed species, the Chinook salmon, bull trout, steelhead, and killer whale reside in the Seattle action areas. The humpback whale, Steller sea lion, and marbled murrelet do not inhabit the Seattle action areas, but an occasional migratory animal may be observed. The use of the action areas by the eulachon, bocaccio, canary rockfish, and yelloweye rockfish, is rare or infrequent with some migratory use through the area. Table 5-1 summarizes the status of the listed species within the Seattle action areas.

Fig 2. Seattle Biological Evaluation Receiving Surface Waterbodies

11x17 inches



Seattle Biological Evaluation

City of Seattle

FIGURE 2

Seattle Biological Evaluation Receiving Surface Waterbodies

- Elliott Bay
- Lake Washington Ship Canal
- Lower Green/Duwamish
- North Seattle/Puget Sound
- North Lake Washington
- South Seattle/Puget Sound
- South Lake Washington
- Areas Draining to Sewage Treatment Plant*

* Unless an overflow occurs in the combined sewer outfall system.

- Stream
- City Limit
- Freeway
- Arterial

This map shows where surface water drains:

(1) to a sewage treatment plant, or
(2) to a major creek system and/or waterbody.

N S W E

0 0.25 0.5 1

Miles

March 30, 2007

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Coordinate System: State Plane, NAD83-91, WA North Zone

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Table 5-1
Summary status of the species for Seattle action areas (Consult a scientist for the latest information.)

Species	Action areas	Species in system	Critical Habitat
Puget Sound **Chinook salmon** ***Oncorhynchus tshawytscha*** **Threatened** 	Ship Canal, North Lake Washington, and South Lake Washington	2 populations: • Sammamish River • Cedar River	Lake Washington and Ship Canal
	Lower Green/Duwamish	1 population: Duwamish/Green River	Duwamish River
	Estuarine and marine waters of Puget Sound including action areas of Elliott Bay, North Seattle/Puget Sound and South Seattle/Puget Sound	Puget Sound Chinook salmon from throughout ESU may be present in marine and estuarine waters	Inshore marine nearshore: MHHW, including tidally influenced freshwater heads of estuaries. Offshore marine nearshore extends from extreme high water out to a depth no greater than 98 ft (30 m) relative to MLLW
Coastal-Puget Sound bull trout *Salvelinus confluentus* Threatened 	Ship Canal, North Lake Washington, and South Lake Washington	Bull trout from throughout DPS may be present in Lake Washington and Ship Canal action area	Lake Washington and Ship Canal
	Lower Green/Duwamish	Bull trout from throughout DPS may be present in Lower Green/Duwamish action area.	Duwamish River
	Estuarine/marine waters of Puget Sound including action areas: Elliot Bay, North Seattle/Puget Sound and South Seattle/Puget Sound	Bull trout from throughout DPS may be present in marine and estuarine waters	Inshore marine nearshore: MHHW line, including tidally influenced freshwater heads of estuaries Offshore marine nearshore: extent of photic zone 33 ft (10 m)
Killer whale ***Orcinus orca*** **Endangered** 	North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound	Southern Resident: particularly J Pod, but all pods use Puget Sound.	Designated habitat includes all waters in Puget Sound deeper than 20 ft (6.1 m)

Table 5-1
Summary status of the species for Seattle action areas (Consult a scientist for the latest information.)

Species	Action areas	Species in system	Critical Habitat
Steller sea lion ***Eumetopias jubatus*** **Threatened** 	North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound	North Pacific population	No critical habitat is designated in Washington
Humpback whale ***Megaptera novaeangliae*** **Endangered** 	North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound	Occurrence is rare, but species may migrate through action area.	No critical habitat has been designated for the humpback whale
Marbled murrelet ***Brachyramphus marmoratus*** **Threatened** 	North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound	Occurrence is rare, but species may be present foraging in area.	No critical habitat has been designated within the Seattle action areas. 99.8% of designated critical habitat is located on federal lands in upper portions of watersheds. Marine environments were not designated
Puget Sound steelhead ***Oncorhynchus mykiss*** **Threatened** 	Ship Canal, North Lake Washington, South Lake Washington	4 spawning populations: Lake Washington, Cedar River, Lake Sammamish, Sammamish River	None proposed at this time
	Lower Green/Duwamish	2 stocks: Summer run, winter run	None proposed at this time
	Estuarine and marine waters of Puget Sound	Steelhead throughout DPS may be present in marine and estuarine waters	None proposed at this time

Table 5-1
Summary status of the species for Seattle action areas (Consult a scientist for the latest information.)

Species	Action areas	Species in system	Critical Habitat
Eulachon ***Thaleichthys pacificus*** **Threatened** 	North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound	Occurrence is rare, but species may migrate through action area.	Proposed critical habitat does not include any of the Seattle action areas.
Bocaccio ***Sebastes paucispinis*** **Endangered** 	North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound	Adults, juveniles, and larvae could be present.	None proposed at this time
Canary Rockfish ***Sebastes pinniger*** **Threatened** 	North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound	Adults, juveniles, and larvae could be present.	None proposed at this time
Yelloweye Rockfish ***Sebastes ruberrimus*** **Threatened** 	North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound	Adults and larvae could be present	None proposed at this time

5.1 Puget Sound Chinook Salmon

5.1.1 Listing and Critical Habitat Designation

Chinook salmon (*Oncorhynchus tshawytscha*) were designated threatened on March 24, 1999 (64 FR 14307). The threatened status was reaffirmed on June 28, 2005 (70 FR 37160). Chinook salmon are Pacific salmon and belong to the scientific family Salmonidae. The ESA allows listing of 'distinct population segments' (DPS) of vertebrates. For a group of salmon populations to be a DSP they must be an evolutionarily significant unit (ESU). Scientists have established 2 criteria for ESUs:

1. The population must show substantial reproductive isolation
2. There must be an important component of the evolutionary legacy of the species as whole.

The Puget Sound ESU is comprised of 31 historically quasi-independent populations of Chinook salmon, of which 22 are believed to be existing (PSTRT 2001, 2002, Good et al. 2005). The populations presumed to be extinct were mostly early-returning fish. Most of these were in the mid- to southern parts of Puget Sound, Hood Canal and the Straits of Juan de Fuca.

The Puget Sound ESU encompasses all runs of Chinook salmon in the Puget Sound region from the North Fork Nooksack River to the Elwha River on the Olympic Peninsula. Chinook salmon are found in most rivers in this region. The boundaries of the Puget Sound ESU correspond generally with the boundaries of the Puget Lowland Ecoregion. Despite being in the rain-shadow of the Olympic Mountains, the river systems in this area maintain high flow rates due to melting snowpack in the Cascade Mountains. The Elwha River, which is in the Coastal Ecoregion, is the only system in this ESU that lies outside the Puget Sound Ecoregion. Previous assessments of stocks within the Puget Sound ESU have identified several stocks as being 'at risk' or 'of concern.' Long-term trends (~1952 to 2002) in abundance and median population growth rates for naturally spawning populations of Chinook salmon in Puget Sound indicate that about half of the populations are declining, and half are increasing in abundance (Good et al. 2005). Four of 22 populations have declining abundance over the short term (1990 to 2002), but 11 populations show declining population growth rates when strays from hatchery salmon are incorporated into the analysis.

NMFS designated critical habitat for this ESU on September 2, 2005 (70 FR 52630). Critical habitat is defined in section 3 of the ESA as the following:

> *"(i) the specific areas within the geographical area occupied by a species, at the time it is listed in accordance with the ESA, on which are found those physical or biological features (I) essential to the conservation of the species, and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographic area occupied by a species at the time it is listed, upon a determination that such areas are essential for the conservation of the species."*

'Conservation' is defined by the ESA as the use of all methods and procedures necessary to bring any endangered or a threatened species to the point at which the measures provided under the ESA are no longer necessary.

To be included in a critical habitat designation, habitat must be ‘essential to the conservation of the species.’ Critical habitat designations identify, to the extent known and using the best scientific data available, habitat areas that provide at least 1 physical or biological feature essential to the conservation of the species. These physical or biological features are known as ‘primary constituent elements’ (PCEs) as defined by 50 CFR 424.12(b).

Critical habitat boundaries for Puget Sound Chinook salmon include stream channels within the designated stream reaches, and include a lateral extent as defined by the OHW (33 CFR 319.11).

Figure 3 shows the designated critical habitat areas for Puget Sound Chinook salmon, Coastal- Puget Sound bull trout and Southern Resident killer whale within City of Seattle boundaries.

In areas where OHW has not been defined, the lateral extent of critical habitat will be defined by the bankfull elevation. Bankfull elevation is the level at which water begins to leave the channel and move into the floodplain. The bankfull level is reached at a discharge that generally recurs at an interval of 1 to 2 years on the annual flood series. Critical habitat in lake areas is defined by the perimeter of the waterbody as displayed on standard 1:24,000 scale topographic maps or the elevation of OHW, whichever is greater. In estuarine and nearshore marine areas, critical habitat includes areas contiguous with the shoreline from the line of extreme high water out to a depth no greater than 98 feet (30 m) relative to MLLW.

The following are the 6 primary constituent elements (PCEs) for **Puget Sound Chinook salmon ESU critical habitat**:

- **Puget Sound Chinook Salmon PCE #1**: Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development. There are no freshwater spawning sites within the Seattle action areas.

Figure 3. Critical Habitat for Puget Sound Chinook salmon, Coastal-Puget Sound bull trout and Southern Resident killer whale around the City of Seattle

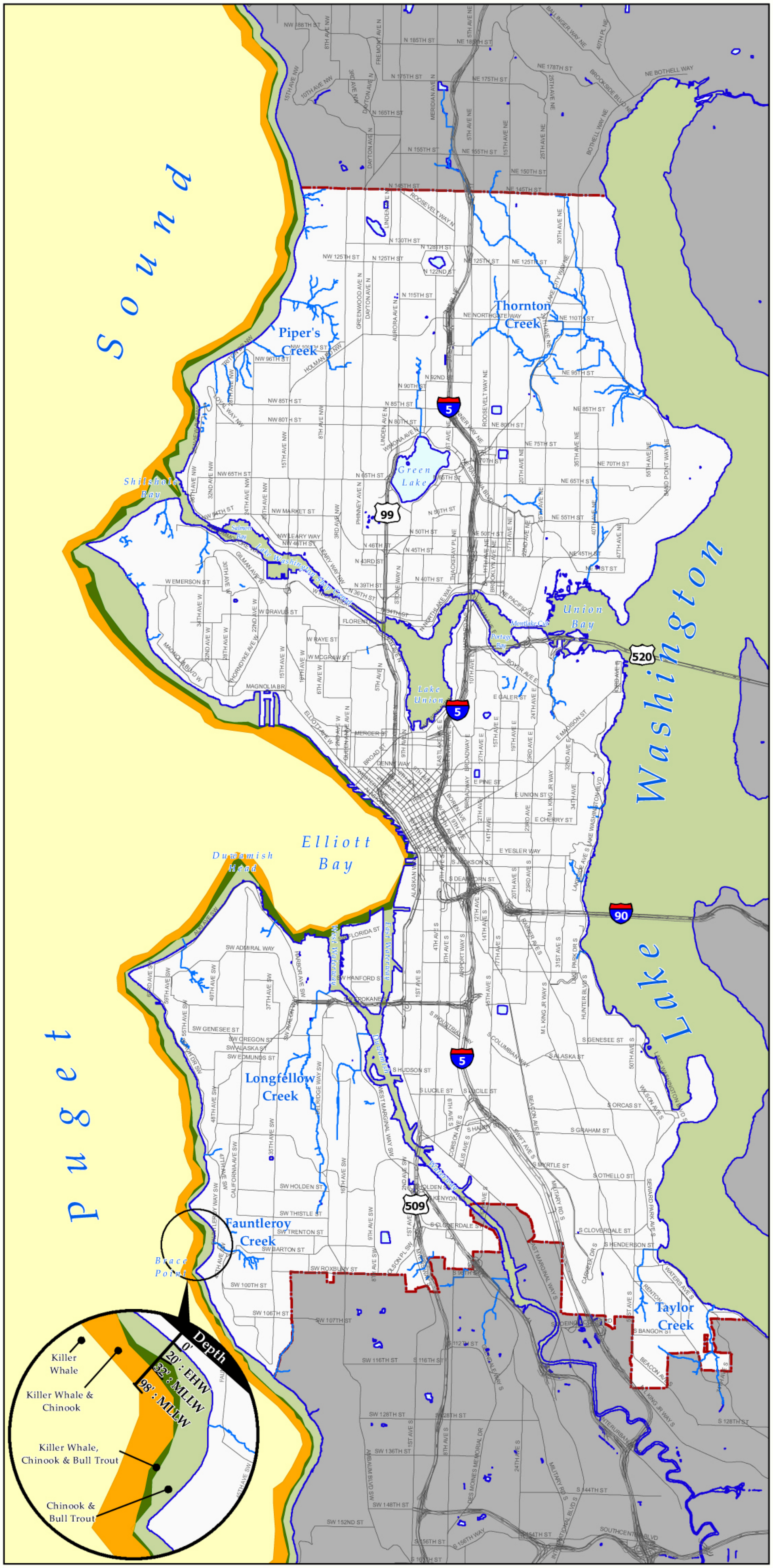
11x17 inches

Seattle Biological Evaluation

City of Seattle

FIGURE 3

Critical Habitat for Southern Resident Killer Whale, Chinook Salmon and Bull Trout around the City of Seattle



Critical Habitat *

Individual critical habitat for each species may overlap. The colors below can indicate critical habitat for more than one species.

- Southern Resident Killer Whale
- Killer Whale & Chinook
- Killer Whale, Chinook & Bull Trout
- Chinook & Bull Trout

For marine waters only, critical habitat extends to a depth of 98 feet (30 m) for chinook salmon, and 32 feet (10 m) for bull trout relative to mean lower low water (MLLW), and from a minimum depth of 20 feet (6.1 m) relative to extreme high water (EHW) for killer whales.

- Land within City Limits
- City Limit
- Stream
- Arterial
- Freeway

* All areas were derived from existing bathymetry data. In places where collection data were not available, data were interpolated and may contain some degree of error.

N / W / E / S

0 0.25 0.5 1
Miles

March 22, 2007

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- **Puget Sound Chinook Salmon PCE #2**: Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; 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.
- **Puget Sound Chinook Salmon 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.
- **Puget Sound Chinook Salmon PCE #4**: Estuarine areas free of obstruction and excessive predation with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fish, supporting growth and maturation.
- **Puget Sound Chinook Salmon PCE #5**: Nearshore marine areas free of obstruction with water quality and quantity conditions and forage, including aquatic invertebrates and fish, supporting growth and maturation; and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels.
- **Puget Sound Chinook Salmon PCE #6**: Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fish, supporting growth and maturation.

NMFS has analyzed habitat areas within 61 occupied watersheds in 15 associated subbasins, as well as the nearshore marine areas in Puget Sound (Table 5-2).

Table 5-2

Designated critical habitat subbasins for Puget Sound Chinook salmon

Nooksack	Upper Skagit	Sauk
Lower Skagit	Stillaguamish	Skykomish
Snoqualmie	Snohomish	Lake Washington
Duwamish	Puyallup	Nisqually
Skokomish	Hood Canal	Dungeness/Elwha
Nearshore marine areas		

5.1.2 Species Information

5.1.2.1 Life History

Chinook salmon have a complex lifecycle that spans a variety of fresh and saltwater habitats. They are anadromous fish, which means that they migrate up rivers from the ocean to breed in freshwater. Pacific salmon are in the scientific genus *Oncorhynchus*, which includes pink, sockeye, chum, Chinook and coho salmon, steelhead, and rainbow trout. Salmon fry emerge from spawning gravels in inland streams and rivers, migrate to coastal estuaries, and then disperse into ocean waters to grow. Once mature, they reverse their course, returning through the estuaries, fighting their way back upriver to the very streams where they emerged, to reproduce, die, and begin the cycle again.

The largest of any salmon (Netboy 1958), Chinook salmon exhibit the most complex life history strategies of all salmonids. Healey (1986) described 16 age categories for Chinook salmon, 7 total ages with 3 possible freshwater ages. Two generalized freshwater life-history types were initially described by Gilbert (1912):

- **Stream-type** Chinook salmon that reside in freshwater for a year or more following emergence
- **Ocean-type** Chinook salmon that migrate to the ocean within their first year.

Healey (1983, 1991) has promoted the use of broader definitions for ocean-type and stream-type to describe 2 distinct races of Chinook salmon. This approach incorporates life-history traits, geographic distribution, genetic differentiation, and gives a frame of reference for comparisons of Chinook salmon populations. The generalized life history of Chinook salmon involves incubation, hatching, and emergence in freshwater, migration to the ocean, and subsequent initiation of maturation and return to freshwater for completion of maturation and spawning.

Spring-run Chinook salmon in the Puget Sound ESU typically have a high proportion of yearling smolt emigrants. Summer- and fall-run Chinook salmon typically smolt as subyearlings, but some systems produce yearling smolts. Year-to-year variations in smolt age are likely determined by variations in environmental conditions, whereas mean age of smolts is likely determined by genetic factors. Summer and fall runs tend to mature at ages 3 and 4 and exhibit similar, coastally-oriented, ocean migration patterns.

The most recent 5-year geometric mean natural spawner numbers in populations of Puget Sound Chinook salmon range from 222 to 9,489 fish (Good et al. 2005). Most populations contain hundreds of natural spawners (median recent natural escapement = 766). Of the 10 Puget Sound Chinook salmon populations with more than 1,000 natural spawners, only 2 are thought to have a low fraction of hatchery fish. Estimates of historical equilibrium abundance, from pre-settlement habitat conditions, range from 1,700 to 51,000 potential Chinook salmon spawners per population.[1] The historical estimates of spawner capacity are several orders of magnitude higher than realized spawner abundances currently observed throughout the Puget Sound ESU (Good et al. 2005).

[1] Equilibrium abundance is the abundance on a recruitment curve where recruitment of adults equals the number of parents that produced them. Continual spawning levels that achieve equilibrium abundances are high and by definition cannot support salmon fisheries (lower spawning escapements lead to less competition, higher survival rates, and a potential to support fisheries).

5.1.2.2 Factors for Decline

Factors for decline include human activities that have blocked or reduced access to historical spawning grounds and altered downstream flow and thermal conditions. In general, upper tributaries have been impacted by forest practices while lower tributaries and mainstem rivers have been influenced by agriculture and urbanization. Diking for flood control, draining and filling of freshwater and estuarine wetlands, and sedimentation due to forest practices and urban development are cited as problems throughout the ESU (WDF et al. 1993). Blockages by dams, water diversions, and shifts in flow regime due to hydroelectric development and flood control projects are major habitat problems in several basins. Bishop and Morgan (1996) identified a variety of critical habitat issues for streams in the Puget Sound ESU range:

1. Changes in flow regime (all basins)
2. Sedimentation (all basins)
3. High temperatures in some streams
4. Streambed instability
5. Estuarine loss
6. Loss of large woody debris in some streams
7. Loss of pool habitat in some streams
8. Blockage or passage problems associated with dams or other structures
9. Decreased gravel recruitment.

These impacts on the spawning and rearing environment may also have had an effect on the expression of many life-history traits and masked or exaggerated the distinctiveness of many stocks. The Puget Sound Salmon Stock Review Group (PFMC 1997) concluded that reductions in habitat capacity and quality have contributed to low survival and abundance of Puget Sound Chinook salmon. It cited evidence of direct losses of tributary and mainstem habitat due to the following:

- Dams
- Loss of slough and side-channel habitat caused by diking, dredging, and hydromodification
- Reductions in habitat quality due to land management activities.

The artificial propagation of fall-run stocks is widespread throughout this region. Summer/fall Chinook salmon transfers between watersheds within and outside the region were commonplace during the early to mid-1900s. Chinook salmon originating from the Green River hatchery were commonly planted in many watersheds in Puget Sound, especially in south Puget Sound streams. Nearly 2 billion Chinook salmon have been released into Puget Sound tributaries since the 1950s. Most of these have been from local returning fall-run adults. Returns to hatcheries have accounted for 57% of the total spawning escapement. However, the hatchery contribution to spawner escapement is probably much higher due to hatchery-derived strays on the spawning grounds. The electrophoretic (physical-chemical) similarity between Green River fall-run Chinook salmon and several other fall-run stocks in Puget Sound suggests a significant and lasting effect from some hatchery transplants (Marshall et al. 1995). Overall, the pervasive use of

Green River stock throughout much of the extensive hatchery network in this ESU may reduce the genetic diversity and fitness of naturally spawning populations.

Nehlsen et al. (1991) identified 4 stocks as extinct, 4 stocks as possibly extinct, 6 stocks as at high risk of extinction, 1 stock as at moderate risk, and 1 stock of special concern. Harvest rates on Puget Sound Chinook salmon populations averaged 75% (median = 85%; range 31-92%) in the earliest 5 years of data availability and have dropped to an average of 44% (median = 45%; range 26-63%) in the most recent 5-year period (Good et al. 2005).[2]

Abundance of natural-spawning Chinook salmon in this ESU has declined substantially from historical levels. Many populations are small enough that genetic and demographic risks are likely to be relatively high. Both long- and short-term trends in abundance are mainly downward, and several populations are exhibiting severe short-term declines. Spring-run Chinook salmon populations throughout the Puget Sound ESU are all depressed.

Other concerns noted by NMFS's Biological Review Team, who drafted the status of the Chinook salmon populations, are the following:

- Concentration of most natural production of Chinook salmon are in just 2 basins (Skagit River and Snoqualmie River, including the Skykomish River)
- High levels of hatchery production in many areas of the ESU
- Widespread loss of estuary and lower floodplain habitat diversity and, likely, associated life-history types.

Populations in this ESU have not experienced the sharp increases in the late 1990s seen in many other ESUs, though more populations have increased than decreased since the last Biological Review Team assessment. Marine conditions are known to have a strong effect on survival of Puget Sound Chinook salmon (Mahnken et al. 1998, Ruggerone and Goetz 2004). After adjusting for changes in harvest rates, however, trends in productivity are less favorable. Most populations are relatively small. Recent abundance within the ESU is only a small fraction of estimated historic size.

5.1.2.3 Habitat Requirements

Chinook salmon require varied habitats during different phases of their lifecycle. Spawning habitat typically consists of riffles and the tailouts of pools with clean substrates dominated by gravel located in the mainstem of rivers and large tributaries (Cramer et al. 1999, Schuett-Hames and Pleus 1996). Chinook salmon are most frequently observed spawning in water with a daily average temperature ranging from 39º to 57º F (4-14º C). Juvenile Chinook salmon usually rear in water with temperatures ranging from 50º to 63º F (10-17º C) (USEPA 2003). Chinook salmon typically spend 1 to 5 months rearing in freshwater before migrating to the ocean, where they typically spend 1 to 6 years maturing. Chinook salmon may spend up to 1 year in freshwater when environmental conditions are not favorable for migration (Myers et al. 1998a).

Juvenile Chinook salmon require estuarine and nearshore marine habitat for migration, foraging, refuge, and osmoregulation processes (physiological transition to saltwater).

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[2] The earliest 5 years of data vary with the 22 populations. The earliest data begin in 1969 (7 populations), 1971 (1 population), 1972 (3 populations), 1977 (1 population), 1979 (2 populations), 1981 (1 population), 1982 (3 populations), 1984 (2 populations), and 1985 (2 populations). The 5-year most recent period is 1994 – 1998 for all populations.

Juveniles spend from 1 to 6 weeks in estuarine habitat before migrating into marine waters (Williams et al. 2001, Ruggerone and Volk 2004). Juveniles rely on shallow nearshore habitats such as eelgrass meadows, intertidal flats, tidal marshes, and subtidal channels near estuaries (Steelquist 1992). Once juvenile Chinook salmon are large enough to eat small fish and have grown larger than most prey, they move away from shore into deeper marine waters.

Chinook salmon are opportunistic feeders. Juveniles prey on a wide variety of food such as benthic, epibenthic, and pelagic crustaceans, as well as insects, fish larva, and juvenile fish. While in the estuarine and marine environment, adult salmon feed on forage fish such as surf smelt, longfin smelt, Pacific sandlance and herring.

5.1.3 Species Occurrence in Action Areas

5.1.3.1 Lake Washington Ship Canal, North Lake Washington, South Lake Washington

The Lake Washington Ship Canal (Ship Canal), North Lake Washington, and South Lake Washington action areas are combined because they comprise the western portion of the Lake Washington basin. Designated critical habitat for these action areas includes Lake Washington and the Ship Canal. As defined by the Puget Sound Technical Recovery Team, 2 populations of the Puget Sound Chinook salmon ESU are present in the Lake Washington basin (Ruckelshaus et al. 2006):

1. Sammamish River population includes Issaquah Creek, a composite population at least partially sustained by production from the Issaquah hatchery, and north Lake Washington tributaries.
2. Cedar River population.

Current Range

Chinook salmon are found throughout Lake Washington and the Ship Canal. Within the tributaries of the Ship Canal, North Lake Washington, and South Lake Washington action areas, Chinook salmon are found only within Thornton Creek. Chinook salmon have been observed in the delta and lower reach of Taylor Creek. These fish may be juveniles migrating from the Cedar River and are using the shoreline habitat along the south end of Lake Washington (Tabor et al. 2006).

Migration

Several engineered changes within the Seattle action areas have had a profound impact on migration of the species. The City of Seattle has conducted recent detailed studies on the migration patterns of juvenile Chinook salmon. The following discussion reflects this wealth of information.

Engineered Changes within the Watershed

The Cedar River Chinook salmon population has been greatly affected by the construction of the Ship Canal. Built between 1911 and 1917, the Ship Canal rerouted the rivers that fed and drained Lake Washington forcing the Cedar River Chinook salmon juveniles to move into Lake Washington where they spend time rearing, then migrate through the Ship Canal, through the Hiram M. Chittenden Locks in Ballard (the Locks) and into Puget Sound (reverse order for spawning adults).

Before construction of the Ship Canal, Cedar River Chinook salmon migrated through the Cedar-Black-Green-Duwamish rivers for hundreds of generations, adapting to those circumstances. Cedar River Chinook salmon were forced into the new system almost instantly. Most Chinook salmon populations do not move through large lakes between freshwater spawning grounds and saltwater rearing habitat. As a result of the migration pathway reorientation and a lake in the new migratory pathway, Cedar River Chinook salmon stocks have remained at low levels for many generations.

Another consequence of the drainage system revision on Cedar River Chinook salmon survival is the lack of a brackish water transition zone. For most Chinook salmon stocks, the estuary is an especially important transition zone in the migration from fresh- to saltwater. The estuary provides essential resources such as food and salinity gradients that aid in the transition from fresh to saltwater habitats. In the Lake Washington basin, the estuary is extremely limited in Salmon Bay. Historically, Cedar River summer/fall Chinook salmon smolts migrated out through the Duwamish estuary. With the rerouting of the Cedar River into the Lake Washington in 1916, these smolts must migrate through Salmon Bay, an area where a much more rapid transition to saltwater occurs than that which these fish evolved under (Kerwin 2001). Both juvenile and adult individuals are forced to move abruptly from one salinity regime to another. The normal state of affairs would be for migrants (juveniles or adults) to spend time in the brackish water interface between salinity regimes (acclimation period) before moving from one salinity regime into another. This may well contribute to an increase in mortality.

Adult Migration

Adult Chinook salmon hold in Salmon Bay, west of the Locks, for an unknown period of time while acclimating to changes in salinity and temperatures (Taylor Associates 2010), or their success ascending the fish ladder (City of Seattle 2003). On average, adult Chinook salmon hold 19 days below the Locks, ranging from 1.0 to 45.0 days (Taylor Associates 2010) or 15 to 23.5 days (City of Seattle 2003). Approximately 30% of tagged adults that passed through the fish ladder moved back downstream below the Locks to return to cooler more saline waters (Taylor Associates 2010).

Adults first arrive at the Locks in mid-June. The peak time of entry through the Locks and into the Lake Washington basin occurs in mid-to late August and is generally complete by early November. These fish spend only 1 to 2 days migrating from the Locks to Lake Washington and take up temporary residence (days to 2 months) in Lake Washington before entering upstream spawning areas. Lake Washington basin summer/fall Chinook salmon stocks range in spawn timing from mid-September through November (Kerwin 2001).

Juvenile Migration

Juvenile Chinook salmon outmigration to Lake Washington and the estuary occurs over a broad time period. Typical juvenile summer/fall Chinook salmon outmigrate from January through early July. Two rearing strategies have been seen (Celedonia et al 2009). Fry enter Lake Washington from Jan through March and rear in the south end of Lake Washington for several months or fry rear in the river and then migrate to the lake in May or June as pre-smolts. Typically, the Lake Washington basin summer/fall Chinook salmon migrate within their first year of life. Some juveniles remain in the lake for an additional year. There are no data to indicate that there is a large component of Lake Washington basin stock summer/fall Chinook salmon juveniles remain in freshwater for that additional year after emerging from the redds. However, other Puget Sound Chinook salmon stocks (e.g., Snohomish summer Chinook salmon and Snohomish fall Chinook salmon) produce a significant number of juveniles that do remain in the freshwater environment for an additional year (Kerwin 2001).

Lake Washington and the Ship Canal provide rearing and foraging habitat for juvenile salmon in a variety of ways. Many Chinook salmon young-of-year use the lake for 1 to 5 months as rearing habitat before outmigration. Some (a small percentage) appear to stay for another year or 2 (DeVries 2005, Seiler et al. 2005). In years with larger winter and early spring flows, a large percentage of Chinook salmon fry may enter the lake from late January through April, followed by smolts. While rearing, juvenile Chinook salmon are shoreline oriented, using shallow water areas (< 3.2 feet or < 1m). When these fry reach a larger size, they disperse to deeper water (3.2 to 19.6 feet or 1 to 6 m) (Fresh 2000, Piaskowski and Tabor 2001, Tabor et al. 2006) and begin migration towards the Locks (Martz et al. 1996). Juvenile Chinook salmon spend between 2 to 4 weeks migrating through the Ship Canal (DeVries 2005). Most of the Ship Canal appears to function as a migratory corridor with Lake Union being a long-term holding area. Juveniles can spend days to weeks in Lake Union, utilizing the entire lake (Celedonia et al. 2009). Juveniles migrate past the Locks from May to September with peak migration occurring in June.

Seiler (1999) found that Chinook salmon preferred nighttime migration in the Cedar River and Bear Creek. For the first 4 weeks of trap operation, beginning January 23, weekly day/night ratios for Chinook salmon varied from 17% to 59% and declined as the season progressed. Juvenile migration is different in the river than it is in the lake. Juveniles rear in Lake Washington for 3 or more months. A comparison of the passage timing data with lunar data for Lake Washington and the Locks suggests a strong correlation between moon location relative to the earth and emigration timing, particularly for Chinook and coho salmon. This correlation appeared stronger than the correlation between emigration and moon phase (illumination). Migration through the Locks increased markedly within 1 or 2 days of the moon being at apogee (i.e., when the moon is farthest from the earth). Emigration decreased by the time of the next apogee (R2 Resource Consultants 2002). Peak Chinook salmon smolt outmigration occurs in June (Tabor et al. 2006).

Once through the Locks, juvenile Chinook salmon reside within Salmon Bay for a very short period of time compared to other estuaries (Taylor Associates 2010). Residence time varies from an hour to 31 days. This is compared to other estuaries where residence times can be up to 90 days. The difference may be to the larger size smolts that are leaving the Ship Canal and the Lake Washington system (Taylor Associates 2010).

Habitat Use

Tabor and Piaskowski (2002) and Tabor et al. (2003; 2004a, b; 2006) investigated nearshore habitat use of juvenile Chinook salmon, primarily in the littoral (intertidal) zone. They sampled locations on the west shore of Lake Washington between the Cedar River and Ship Canal, on Mercer Island and the eastern lake shoreline (12 sites total). Snorkel surveys were conducted between January and June when use by juvenile Chinook salmon typically occurs. Surveys found that numbers of juvenile Chinook salmon in the nearshore areas of south Lake Washington increased substantially in early March. During this time, fish concentrate in the south end of the lake near the mouth of the Cedar River and their numbers decline with increasing distance from the Cedar River (Tabor et al. 2004a, b; 2006). Behavior varies between night and day, with few fish observed during daytime surveys in April and May (Tabor and Piaskowski 2002). During the day, juvenile Chinook salmon were observed in aggregations (sometimes with sockeye), actively feeding at the surface. At night, Chinook salmon were no longer in an aggregation, were inactive, and were usually on the bottom in shallow water, close to shore (Tabor and Piaskowski 2002, Tabor et al. 2003; 2004a, b; 2006).

Habitat use by juvenile Chinook salmon varies somewhat between when they are fry (March-April) and larger smolts (May-June). The studies found that juvenile Chinook salmon fry preferred shallow depths, generally less than 1.6 feet (0.5m) deep, and areas with gradual slopes (Piaskowski and Tabor 2001, Tabor and Piaskowski 2002, Tabor et al. 2003; 2004a, b; 2006). By mid-May when fish are larger, they appear to move into deeper water. Sampling by Fresh (2000) found juvenile Chinook salmon expanding into the limnetic (open water of freshwater zone) of the lake. Water depth and migratory observations by Tabor et al. (2006) identified fish often feeding in water 6.5 to 13 feet (2-4 m) deep and migrating adjacent to the shoreline in these similar water depths 6.8 to 14.7 feet (2.1-4.5 m). Chinook salmon fry primarily selected sand, while later in May and June juveniles preferred both sand and gravel substrates. Coarser substrates such as cobble and boulders are used by very few fish and appear to be avoided.

More juvenile Chinook salmon are found along unretained shorelines than are found along armored shorelines (Paron and Nelson 2001, Piaskowski and Tabor 2001, Tabor and Piaskowski 2002, Tabor et al. 2004b, 2006). The fish used armored sites that were riprapped more than they used shorelines with a vertical bulkhead. Use of engineered overwater structures—such as docks and piers—seems to vary with fish size. Chinook salmon fry can use docks and piers during the daytime when the fry are small (February-March) (Tabor et al. 2003, 2004a). However, when fish grow larger, they avoid docks and piers and even alter migrational direction to move into deeper water as they approach docks and piers (Tabor and Piaskowski 2002; Tabor et al. 2004a; 2006).

Woody debris is generally more associated with higher overall densities of juvenile Chinook salmon than openwater sites during the daytime, with a reverse trend observed at night. In particular, a variety of different surveys from lakes Washington, Sammamish, and Quinault indicate that overhead cover is an important habitat feature for small Chinook salmon (Paron and Nelson 2001, Tabor et al. 2006). Results from overhead vegetation and in-water small woody debris studies conducted between late March and early April showed a significantly higher abundance of juvenile Chinook salmon during the daytime in sections with both overhead vegetation and small woody debris than sections with small woody debris or open sections (Tabor and Piaskowski 2002, Tabor et al. 2004b, 2006). However, at night, 46% of all the Chinook salmon were in open water. Of those, 65% were within areas with overhead vegetation/small woody debris and small woody debris located in the open. Previous work in Lake Washington also indicated Chinook salmon do not appear to extensively use cover as they increase in size (Tabor and Piaskowski 2002, Tabor et al. 2004a, 2006).

Studies in May, when Chinook salmon were larger, found that few Chinook salmon used overhead and small woody debris during either daytime or nighttime (Tabor and Piaskowski 2002, Tabor et al. 2004a, 2006). Field observations indicate that woody debris and overhanging vegetation can be used by juveniles as cover when predators are present (Tabor et al. 2006). Coho salmon exhibited similar use patterns in Lake Sammamish, and were more strongly affiliated with woody debris than were Chinook salmon.

As juvenile Chinook salmon migrate into the Ship Canal, they are no longer shoreline oriented and are broadly distributed throughout off-shore, deep water areas (Celedonia et al. 2009). This may be related to differences in predator populations and prey availability between Lake Washington and the Ship Canal. Fewer predators (northern pikeminnow and cutthroat trout) are found within the Ship Canal. Therefore, Chinook salmon can forage offshore where greater zooplankton abundance occurs.

Juvenile Chinook salmon in the Ship Canal also use edges of overwater structures in deep water, especially when water clarity is high. This may be due to increased offshore forage. However, this behavior may also result in increased predation from smallmouth bass that are oriented to overwater structures. Juvenile Chinook salmon were not found under the overwater structures (Celedonia et al. 2009).

Diet

Diet studies of Chinook salmon in Lake Washington and Lake Sammamish illustrate that juveniles are opportunistic feeders. Juvenile Chinook salmon consume a wide variety of prey items and appear to quickly switch to a locally abundant prey source (Tabor et al. 2006). Two major prey resources within Lake Washington are chironomids and a zooplankton, Daphnia. While Daphnia typically do not become abundant in the lake until June, chironomids are extremely abundant in the nearshore areas of Lake Washington most of the year (Koehler 2002). Tabor et al. (2006) examined the diet of juvenile Chinook salmon using lake shoreline reference sites and nearby lake tributaries to determine if there were differences in the prey consumed between these habitats. The studies found that there were not significant differences between Chinook salmon diets at the 2 types of sites and that chironomid pupae and adults were the most important prey item. This lack of a large difference between diets at lakeshores and tributary mouths is likely due to a prevalence of chironomid pupae and adults in the system, making them an important food source regardless of location. Benthic insects (chironomid larvae and mayfly nymphs) and terrestrial insects were more prevalent in Chinook salmon diets at tributary mouths than at lakeshore sites. In addition, occasionally some prey types (i.e., springtails, larval black flies and rhyacophilid caddisflies) were consumed at tributary mouth sites. In general, Chinook salmon diets at the tributary mouths had a wider variety than those at lakeshore sites (Tabor et al. 2006). In addition, Chinook salmon eating larval longfin smelt was documented at 1 tributary mouth (May Creek).

Thornton Creek

Thornton Creek within the North Lake Washington action area contains small numbers of Chinook salmon. Historically, Thornton Creek probably had Chinook in the mainstem, and perhaps the lower reaches of the forks (Trotter 2002). Washington Department of Fisheries (WDFW) salmon spawning ground surveys data had counts of 2 to 10 adults in 1976 and 1981. In addition, Thornton Creek received state releases of hatchery reared Chinook salmon on and off from 1977 to 1994, mostly from the University of Washington hatchery in Portage Bay (WDFW fish stocking records). The City of Seattle conducted salmon surveys in Thornton Creek from 1999 through 2008. During this time, 13 live Chinook salmon and 12 carcasses have been found in Thornton Creek (McMillan 2006, SPU 2009 unpublished data). Over half of these were identified as hatchery strays because of clipped adipose fins (McMillan 2006, SPU 2009 unpublished data).

Spawning within Thornton Creek occurs mainly downstream of the confluence of the North and South branches to Lake Washington. About 40 total Chinook salmon redds have been observed in Thornton Creek from 1999 to 2008 (McMillan 2006, SPU 2009, unpublished data). Of these, about one-third were located in the mainstem between the confluence and the outlet of the Meadowbrook Pond forebay (38th Avenue NE). Only a few were found in the forks, and more were found in the North Branch than found in the South Branch (McMillan 2006). In 2007, 16 Chinook redds were found within Thornton Creek, 9 within the mainstem, 6 in the North Branch, and one in the South Branch. In 2008, only 4 Chinooks were found in Thornton Creek, all in the mainstem.

The most upstream extent where Seattle Public Utilities spawning surveys have sighted Chinook salmon redds in Thornton Creek were downstream of the confluence of Kramer Creek at 30th Avenue NE on the South Branch, and upstream of NE 115th Street at 35th Ave NE on the North Branch (McMillan 2006, SPU 2009 unpublished data).

In 2002, a fish ladder was constructed to remove a 3-foot (0.9-m) fish barrier in South Branch Thornton Creek at Lake City Way. Since construction of the fish ladder, citizens have reported 2 sightings of Chinook salmon upstream of the fish ladder. One was on October 19, 2003, and another citizen photographed a live Chinook salmon just downstream of 20th Avenue NE on October 22, 2003. These sightings may have been the same fish. In addition, a King County/Salmon Watch member observed a Chinook salmon on October 25, 2004, at the juncture of 20th Avenue NE and NE 100th Street.

No information is available on emergent juvenile abundance (K. Lynch, SPU, pers. comm. 2004). However, starting in spring 2000, the City of Seattle, in cooperation with WDFW, conducted annual smolt trapping on Thornton Creek. The trapping survey is not comprehensive, and samples only part of the season. Typically, these surveys occurred during the first 2 weeks of May in an attempt to overlap with the peak outmigration period of coho smolts. The trapping period lasted 5 to 15 days per year, except in 2004 when the trapping period was 25 days. Between 2001 and 2003, coho smolts averaged about 5 to 10 per day. Since 2004, the average has dropped to less than 1 coho smolt per day. In most years, Chinook smolt captures are generally very low (0 to 2). However, in 2004, over 300 fish were captured (SPU smolt trapping data, K. Lynch, SPU, pers. comm. 2004). In 2004, the smolt trap results showed a different pattern: a higher number of Chinook salmon smolts (average of 12/day and 309 total), and very few coho (<1/day, 14 total) (SPU smolt trapping data). The trap was removed on May 25, 2004 to allow peamouth adults to move upstream to spawn. It is not known why 2004 results differed from the 2001 and 2003 data. One possibility was a warm spring in 2004, which might have caused Chinook salmon to emerge sooner than usual. The numbers were low for salmon smolts in 2005 and 2006: <1 coho /day, and only 1 Chinook in 2005 (none in 2006) (SPU smolt trapping data). Although the Salmon in the Classroom Program discontinued releasing hatchery salmon fry in 1999, other hatchery salmon releases may be occurring, which could affect the smolt trapping results.

Use of Non-Natal Tributaries

Studies indicate that juvenile Chinook salmon are attracted to non-natal tributaries in Lake Washington, using either the creek mouth or the lowest reaches of the tributary itself (Tabor et al. 2006). The use of non-natal tributaries is based on distance from the natal river and size, with larger creeks (e.g., Taylor Creek) likely avoided because of larger predatory fish in the area. Creek deltas offer preferred habitat, specifically shallow water, gradual slopes, and sand substrates (Tabor et al. 2004b). Creek deltas may also provide better foraging opportunities than adjacent lake shorelines. For example, Tabor et al. (2006) found that the abundance of Chinook salmon increased during a high flow event at May Creek, a tributary to Lake Washington. During storms, an increase in prey availability as well as flow may attract Chinook salmon and other salmonids such as cutthroat trout to lake tributaries.

In cases where Chinook salmon are using habitat within the tributary, use appears related to the ability to access the creek and find refuge and forage (Tabor et al. 2006). Habitat use studies within Johns Creeks, a tributary to Lake Washington close to the Cedar River mouth, found that Chinook salmon mostly used glides and scour pools (Tabor et al. 2004b, 2006). Fry density was greatest in glides during February and early March, but as the fish grew, the density of fish in glides dramatically declined. When fish were found in glides during late March and early April, they were almost always under overhanging vegetation. Scour pools were used throughout the February to May study period, with fish using shallow areas in February (edges and tailouts) and progressively moving into the deepest areas of the pools by the end of March. Scour pool densities were greatest April to May (Tabor et al. 2004b, 2006).

Drainages Outside of City Limits

The Sammamish and Cedar River populations all have declined since peak returns during the mid-1980s (Weitkamp et al. 2000). Adult returns have declined more than 8% per year for each run, with the Cedar River run declining at 10.1% per year, the Issaquah Creek run at 8% per year, and the North Lake Washington tributary run at 16.6% per year. Of the 23 populations of Chinook salmon in Puget Sound, the Lake Washington populations were among the 5 populations showing the steepest declines (>5%/yr) (Myers et al. 1998a; Good et al. 2005). Spawning escapements of natural Lake Washington Chinook salmon were exceptionally low in 1993 (approximately 150 fish) and in 2000 (approximately 100 fish) (White et al. 2008). The escapement goal for the Cedar River Basin is 1,200 fish.

5.1.3.2 Lower Green/Duwamish

Chinook salmon migrating through the Duwamish River estuary were initially divided into 2 main stocks (WDFW and WWTIT 1994): 1) the Duwamish/Green River summer/fall stock, and 2) the Duwamish/Green River-Newaukum Creek summer/fall stock. However, NMFS (70 FR 52630) considered these stocks to be a single independent population (Ruckelshaus et al. 2006).

Critical habitat extends from the estuary to the headwaters of the watershed, including tributaries known to support Chinook salmon. Critical habitat for this action area includes the Duwamish Waterway and the Duwamish River up to the city limit near river mile (RM) 4.6. The City of Seattle has been conducting salmon surveys in Longfellow Creek since 1999. Only 1 pair of Chinook salmon was recorded in Longfellow Creek in 2001, along with 1 possible Chinook salmon redd (McMillan 2006). The City of Seattle identified one live Chinook salmon in Longfellow Creek in 2003 (City of Seattle 2007).

Current Range

Spring Chinook salmon were historically present in the Green/Duwamish River basin. However, little information is available to evaluate the distribution of spring Chinook salmon in the watershed. It is possible the spring run was totally extirpated by the original construction effects of the Tacoma Headworks Dam in 1911, or became isolated from the basin by the diversion of the White River in 1906 (Kerwin and Nelson 2000).

Chinook salmon are presently distributed up to the Tacoma Headworks Dam (RM 61) and in several tributaries such as Soos and Newaukum creeks. The Muckleshoot Indian tribe release hatchery Chinook salmon fry into streams upstream of Howard Hanson Dam. Plans are being developed to transport adult salmon around the 2 dams and to enable juvenile fish passage through the dams.

Abundance and Productivity

The number of adult Chinook salmon spawning in the Green/Duwamish watershed averaged 9,286 fish during 1998 to 2002 (Good et al. 2005). The total number of adult Chinook salmon spawning ranged from 6,170 to 13,950 during the same period. However, a multi-year mark-recapture study indicated the spawning ground counts were biased low and the average number of spawners was 13,815 fish during 1998 to 2002. The estimated percentage of hatchery salmon on spawning grounds was 83% during 1997-2001 (Good et al. 2005), indicating only a small fraction of fish on the spawning grounds had originated from naturally spawning salmon.

Abundance of Chinook salmon includes fish returning to spawning areas plus those caught in fisheries. During the most recent 5-year period, about 57% of returning salmon were harvested in fisheries (Good et al. 2005). Thus, approximately 24,200 fish, on average, were destined for spawning areas of the Green River if fisheries had not occurred. Also, approximately 16,300 fish per year were destined for the hatchery. However, only a small portion of these fish were produced by naturally spawning salmon.

Good et al. (2005) estimated that the long- and short-term trends of naturally spawning Chinook salmon in the Green River are slightly positive. However, if the presence of numerous hatchery strays on the spawning grounds is included in the analysis, then the population growth rate is estimated to be in sharp decline. The effect of hatchery strays on wild Chinook salmon production in systems such as the Green/Duwamish River was identified in NMFS's review as a key concern leading to the listing of Chinook salmon (BRT 2003).

Adult Migration and Spawning

Adult Chinook salmon enter the Duwamish River from approximately mid-June through October. After entering the river, many early migrating Chinook salmon hold in the lower river areas (Duwamish to Kent area) until approximately mid-September, depending on temperature and flow (Ruggerone et al. 2004). Holding occurs in low velocity areas of the river, which are upstream of the action area. Water temperature, which is influenced by air temperature and long water residence time (related to flow), may reach stressful levels (72-77ºF or 22-25ºC) during this holding period (Kerwin and Nelson 2000). Initial movement of most fish on to the spawning grounds typically coincides with a freshet (autumn rain storms). Mainstem spawning in the Green River occurs between RM 24 and RM 61.

Juvenile Migration and Habitat Use

Juvenile Chinook salmon typically begin emerging from gravels in January. Seaward migration timing of subyearling Chinook salmon from the spawning reaches of Puget Sound watersheds tends to be bimodal. Some Chinook salmon fry begin moving downstream soon after emergence (typically the majority), whereas others remain upriver to rear in areas closer to the spawning grounds (Nelson et al. 2004). During 2000, approximately 68% of the juvenile Chinook salmon sampled at RM 34.5 migrated during January 1 to April 15 ('fry migrants'), whereas 32% migrated during April 16 to July 13 ('fingerling migrants'). Peak migration of fry typically occurs in early March, followed by few fish migrating during late March through April, and then fingerlings migrating May through early July. Size of 'fry migrants' was approximately 1.4 to 1.8 inches (35-45) mm, whereas size of the later migrating 'fingerling migrants' increased over time from 1.5 to 3.7 inches (46 mm to 93 mm).

Brackish marine water typically extends up to RM 6.5, although extreme high tides may carry saltwater further upriver. Chinook salmon fry begin entering marine areas of the Duwamish in January, typically following a significant rain event. In 2005, salmon fry were readily captured in nearshore areas of the lower Duwamish, but none were captured in mid-channel areas using a 700-foot (213-m) long purse seine (SAIC et al. 2005).

Data collected in recent years indicate juvenile Chinook salmon (and other salmonids) aggregate in the transition zone area where freshwater first mixes with marine waters (Warner and Fritz 1995, Nelson et al. 2004). An intensive study in 2005 indicated the area of relatively high densities of Chinook salmon extended from RM 4.7 to RM 6.5 (Ruggerone et al. 2006). Relatively low densities were observed in downstream areas, such as Kellogg Island. Downstream of the transition zone, juvenile Chinook salmon typically reared in off-channel habitats for only 1 tide cycle (Ruggerone and Jeanes 2004). These data support the hypothesis that juvenile Chinook salmon acclimate and rear in the transition zone, then migrate relatively rapidly through the lower Duwamish.

Juvenile Chinook salmon may be present in marine areas of the Duwamish during all months of the year, as some juvenile salmon re-enter the waterway from Puget Sound during summer through winter. During 2002, residence time of juvenile natural Chinook salmon in marine areas of the Duwamish declined steadily from approximately 28 ± 7 days in late May to 20 ± 7 days in early June to 15 ± 3 days in late June, then increased from 16 ± 4 days in early July to 23 days in late July/mid-August to 58 ± 13 days in early September (Ruggerone and Volk 2004). These data indicate the tendency for late migrating Chinook salmon to spend relatively little time in the estuary, followed by re-entry of Chinook salmon into the lower Duwamish from Puget Sound. Analyses of coded-wire-tagged Chinook salmon indicated non-local Chinook salmon did not extend upstream of Kellogg Island (Nelson et al. 2004).

Juvenile Diet and Growth

Analyses of Chinook salmon stomach contents indicate juveniles captured in mainstem areas of the Duwamish estuary frequently consumed atypical prey compared with those in less disturbed estuaries, whereas those captured in off-channel restoration areas consumed more typical prey, including terrestrial insects (Ruggerone et al. 2004). Additional data collected in 2005 support these observations (Ruggerone et al. 2006).

Growth rates of juvenile Chinook salmon, based on change in mean size each week, suggest growth of Green/Duwamish Chinook salmon is typical of other Chinook salmon populations where data have been collected. However, there was some evidence in 2003 that the release of 3 million hatchery Chinook salmon may have temporarily reduced their growth (Nelson et al. 2004). Examination of daily otolith growth patterns indicated growth in the marine areas of the Duwamish was positively correlated with the last 10 days of growth in freshwater (Ruggerone and Volk 2004). This finding provides evidence that conditions in freshwater can have a lingering effect upon salmon after entering the estuary.

5.1.3.3 North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound

The North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound action areas are combined because they border Puget Sound. In Puget Sound, nearshore marine waters are important for juvenile salmon rearing, growth and migration (Brennan et al. 2004, Mavros and Brennan 2001, Williams et al. 2001, Nelson et al. 2004). Nearshore areas also provide spawning habitat for forage fishes, which are important prey for older salmon. The nearshore environment in these action areas is used by various Puget Sound Chinook salmon stocks including the Snohomish River, Cedar River/Lake Washington, Green/Duwamish River, and Puyallup River stocks. Critical habitat has been designated for the nearshore extending along the entire City of Seattle Puget Sound nearshore from extreme high water to a depth of 98.4 feet (30 m) relative to MLLW.

Current Range

No adult Chinook salmon have been documented during spawning surveys initiated by Seattle Public Utilities in 1999 in Piper's and Fauntleroy creeks, which flow directly into Puget Sound (McMillan 2006). Six young-of-the-year Chinook salmon juveniles were found in Lower Piper's Creek during a stream-typing survey in July 1999 (Washington Trout 2000).

Collections with beach seines suggest that juvenile Chinook salmon are oriented to shallow water habitat located close to shore. They are most abundant in intertidal flats and shallow subtidal channels near estuarine and tidal marshes and eelgrass meadows (Toft et al. 2004, Williams et al. 2001).

Migration

Studies on Chinook salmon use of Puget Sound have found that juveniles begin entering into estuaries and the nearshore in late January and early February (Williams et al. 2001). Peak migration into Puget Sound occurs in June and July (KCDNR 2001, Toft et al. 2003, Nelson et al. 2004). Juvenile Chinook salmon are found along the nearshore through October. Current evidence suggests that Chinook salmon may use the nearshore year-round. Mavros and Brennan (2001) sampled from the beginning of June through mid-August and captured Chinook salmon throughout the sampling period. Toft et al. (2004) sampled from mid-May through the first of August and captured Chinook salmon throughout. Beamish et al. (1998) sampled offshore water and captured Chinook salmon into September. Brennan et al. (2004) used beach seines to sample the nearshore of King County, and they caught Chinook salmon in October of 2001 and 2002, but densities were low.

King County sampled juvenile Chinook salmon in a variety of nearshore habitats ranging from Vashon Island to Picnic Point during May to October, 2001 and 2002. About 88% of 58 Chinook salmon originating from Soos Creek Hatchery migrated south after entering Puget Sound; few individuals were captured in nearshore waters of WRIA 8 (Brennan and Higgins 2004). In the Elliott Bay area, most juvenile Chinook salmon captured after June were from Puget Sound watersheds other than the Duwamish (Ruggerone et al. 2004). Nelson et al. (2004) reported that catch rates of juvenile Chinook salmon in Elliott Bay were considerably smaller than catch rates in the Duwamish estuary (RM 0 to RM 7), reflecting rapid dispersal along marine habitats.

Diet, Growth, and Survival

Juvenile Chinook salmon are opportunistic foragers in Puget Sound, feeding on epibenthic and pelagic invertebrates, insects (possibly from drift out of streams, marine riparian vegetation, or recent feeding in freshwater), and small fishes. Ruggerone et al. (2004) noted that many Chinook salmon captured off the Snohomish estuary had consumed insects, which may imply that fish recently left the river, availability of marine prey was somewhat low, or that marine riparian vegetation supplied insects to the nearshore environment. Based on recent work by Brennan and Higgins (2004), Chinook salmon under 6 inches (150 mm) ate a highly varied diet along the shores of King County and Seattle, while Chinook salmon larger than 6 inches (150 mm) ate mostly juvenile fish. Chinook salmon under 6 inches (150 mm) consumed high amounts of polychaetes early in their marine residence and high levels of insects later in the summer. The polychaetes found in the diet were composed mostly of 1 species, which was typically associated with shallow vegetated habitats (i.e., kelp and eelgrass). Anecdotal evidence and studies in other regions indicate that marine riparian areas are important areas for insect prey production.

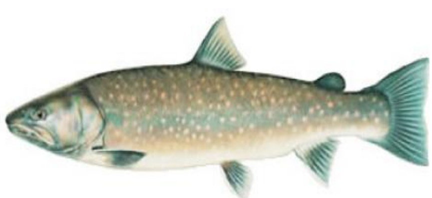
The importance of Puget Sound to juvenile Chinook salmon was highlighted in a recent study that examined the release of 53 million coded-wire tagged Chinook salmon in the Puget Sound region. This study found that that growth and survival of Puget Sound Chinook salmon declined and age-at maturation was delayed when juvenile Chinook salmon entered Puget Sound during even-numbered years along with numerous juvenile pink salmon (produced by the dominant odd-year return of adult pink salmon) (Ruggerone and Goetz 2004). Survival of even-year Chinook salmon migrants was 62% less than that of odd-year migrants during 1984 to 1997. Analyses indicated that the growth and survival impacts occurred within Puget Sound and Georgia Strait and that survival was influenced by the 1982/83 El Nino and subsequent climate events that influenced prey production in marine waters. These findings suggest that the capacity of Puget Sound to support Chinook salmon (i.e., food availability) may be reduced in some years, but few data are available that examine food availability and/or growth of salmon in Puget Sound over a series of years. The trophic interactions that influenced this significant effect are poorly understood.

5.2 Coastal-Puget Sound Bull Trout

5.2.1 Listing and Critical Habitat Designation

On November 1, 1999, the USFWS (USDI 1999a) listed 5 DPSs of bull trout within the coterminous United States as threatened:

1. Coastal-Puget Sound DPS
2. Columbia River DPS
3. Jarbridge River DPS
4. St. Mary-Belly River DPS
5. Klamath River DPS.



On September 26, 2005, critical habitat was designated for the Coastal-Puget Sound DPS of bull trout (*Salvelinus confluentus*) (70 FR 56212) (see Figure 3). On October 18, 2010, the USFWS revised the 2005 critical habitat designation (75 FR 63898) based on extensive review of the previous critical habitat process. The lateral extent of the critical habitat boundaries for bull trout is the width of the stream channel as defined by the OHW. In areas where the OHW has not been defined, the width of the channel is defined by bankfull elevation. In lakes and reservoirs, critical habitat is delineated by the perimeter of the waterbody as mapped on standard 1:24,000 scale maps. The inshore extent of critical habitat for marine nearshore areas is the MHHW, including tidally influenced freshwater heads of estuaries. The offshore extent of critical habitat for marine nearshore areas is based on the extent of the photic zone (depth to which sunlight can penetrate to permit photosynthesis), which is about 33 feet (10 m). See Figure 3 for a map of this area.

The areas designated as critical habitat for the Coastal-Puget Sound DPS of bull trout are designed to incorporate what is essential for their conservation. An area need not include all 9 of the PCEs listed below to qualify for designation as critical habitat. All lands identified as essential and designated as critical habitat contain 1 or more of the primary constituent elements for bull trout.

The following are the 9 PCEs for the **Coastal-Puget Sound DPS for bull trout critical habitat**:

- **Coastal-Puget Sound Bull Trout Critical Habitat PCE #1**: Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.
- **Coastal-Puget Sound Bull Trout Critical Habitat 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.
- **Coastal-Puget Sound Bull Trout Critical Habitat PCE #3**: An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.
- **Coastal-Puget Sound Bull Trout Critical Habitat 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 structures.
- **Coastal-Puget Sound Bull Trout Critical Habitat PCE #5**: Water temperatures ranging from 2 to 15 ºC (36 to 59 ºF), 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.
- **Coastal-Puget Sound Bull Trout Critical Habitat PCE #6**: In spawning and rearing areas, substrate 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 of fine sediment, generally ranging in size from silt to coarse sand, embedded in larger substrates, is characteristic of these conditions. The size and amounts of fine sediment suitable to bull trout will likely vary from system to system.
- **Coastal-Puget Sound Bull Trout Critical Habitat PCE #7**: A natural hydrograph, including peak, high, low, and base flows within historic and season ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.
- **Coastal-Puget Sound Bull Trout Critical Habitat PCE #8**: Sufficient water quality and quantity such that normal reproduction, growth and survival are not inhibited.
- **Coastal-Puget Sound Bull Trout Critical Habitat PCE #9**: Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass); interbreeding (e.g., brook trout); or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

Critical habitat units are patterned after recovery units identified in the Draft Recovery Plan (USFWS 2004) for the Coastal-Puget Sound DPS. The designated critical habitat within the action areas are within the Puget Sound critical habitat unit (Unit 28). To be included as critical habitat for bull trout, a critical habitat unit had to be occupied by the species and contain sufficient PCEs to provide 1 or more of the following functions:

- Spawning, rearing, foraging, or overwintering habitat to support existing bull trout local populations
- Movement corridors necessary for maintaining migratory life-history forms
- Suitable occupied habitat that is essential for recovering the species.

The Puget Sound critical habitat unit includes both marine and freshwater habitats. It is bordered by the Cascade Crest to the East, Puget Sound to the West, the Lower Columbia and Olympic Peninsula Recovery Units to the South, and the United States-Canada border to the North. The Draft Recovery Plan (USFWS 2004) identifies the need to maintain the 57 local populations and 5 potential local populations. Freshwater and marine foraging, migration, and overwintering habitats within the Puget Sound critical habitat unit are essential for the recovery of bull trout distribution, abundance, and productivity. These habitats are especially important for the amphidromous life-history form in which bull trout migrate to and from marine and freshwater areas.

5.2.2 Species Information

5.2.2.1 Life History

Bull trout are a member of the char family and closely resemble another member of the char family, Dolly Varden (*S. malma*). Genetics indicate, however, that bull trout are more closely related to an Asian char (*S. leucomaenis*) than to Dolly Varden (Pleyte et al. 1992). Bull trout are sympatric (originate and occupy the area) with Dolly Varden over part of their range, most notably in British Columbia and the Coastal-Puget Sound region of Washington.

Within the Coastal-Puget Sound DPS, current bull trout distribution is similar to the historic distribution, but population abundance has significantly decreased in portions of this range (USDI 1999a). Bull trout populations exhibit 4 distinct life-history types: resident, fluvial, adfluvial, and anadromous. Resident, fluvial, and adfluvial forms exist throughout the range of the bull trout (Rieman and McIntyre 1993) and spend their entire life in freshwater. The only known anadromous form within the coterminous United States occurs in the Coastal-Puget Sound region (Volk 2000, Kraemer 1994, Mongillo 1993). Highly migratory populations have been eliminated from many of the largest, most productive river systems across their range. Many ‘resident’ bull trout presently exist as isolated remnant populations in the headwaters of rivers that once supported larger, more fecund migratory forms. These isolated remnant populations—which lack connectivity to migratory populations—have a low likelihood of persistence (Rieman and Allendorf 2001, Rieman and McIntyre 1993).

Most growth and maturation occurs in estuarine and marine waters for anadromous bull trout, in lakes or reservoirs for adfluvial bull trout, and in large river systems for fluvial bull trout. Resident bull trout populations are generally found in small headwater streams where the fish spend their entire lives. These diverse life-history types are important to the stability and viability of bull trout populations (Rieman and McIntyre 1993).

For all life-history types, juveniles rear in tributary streams for 1 to 3 years before migrating downstream into a larger river, lake, or estuary and/or nearshore marine area to mature (Rieman and McIntyre 1993). In some lake systems, juveniles may migrate directly to lakes (Riehle et al. 1997). Juvenile and adult bull trout frequently inhabit side channels, stream margins and pools with suitable cover (Sexauer and James 1993) and areas with cold hyporheic zones or groundwater upwellings (Baxter and Hauer 2000).

Bull trout become sexually mature between 4 and 9 years of age and may spawn in consecutive or alternate years (Pratt 1992, Shepard et al. 1984). Size of sexually maturity varies with life-history type. Resident life-history forms typically mature at a length of about 7.9 to 9.8 inches (20.6- 24.9 cm). Fluvial bull trout mature at an average length of 13.8 inches (35 cm) and anadromous bull trout at 16.7 inches (16.7 cm) (Kraemer 2003). Spawning typically occurs from August through December in cold, low-gradient 1st- to 5th-order tributary streams, over loosely compacted gravel and cobble having groundwater inflow (Shepard et al. 1984, Brown 1992, Rieman and McIntyre 1996, Swanberg 1997, MBTSG 1998, Baxter and Hauer 2000). Spawning sites frequently occur near cover (Brown 1992). Migratory bull trout may begin their spawning migrations as early as April and have been known to migrate upstream as far as 155 miles (250 km) to spawning grounds (Fraley and Shepard 1989). Hatching occurs in winter or early spring, and alevins may stay in the gravel for up to 3 weeks before emerging from the gravel. The total time from egg deposition to fry emergence from the gravel may exceed 220 days. Post-spawning mortality, longevity, and repeat-spawning frequency are not well known (Rieman and McIntyre 1996), but lifespans may exceed 10 to 13 years (McPhail and Murray 1979, Pratt 1992, Rieman and McIntyre 1993).

Bull trout are apex predators and require a large prey base and home range. Adult and subadult migratory bull trout are primarily piscivorous, feeding on various trout and salmon species, whitefish (*Prosopium* spp.), yellow perch (*Perca flavescens*), and sculpin (*Cottus* spp.). Subadult and adult migratory bull trout move throughout and between basins in search of prey. Anadromous bull trout in the Coastal-Puget Sound DPS also feed on ocean fish, such as surf smelt (*Hypomesus pretiosus*) and sandlance (*Ammodytes hexapterus*). Resident and juvenile bull trout prey on terrestrial and aquatic insects, macrozooplankton, amphipods, mysids, crayfish, and small fish (Wyman 1975, Boag 1987, Donald and Alger 1993, Goetz 1989, Rieman and Lukens 1979 in Rieman and McIntyre 1993). A recent study in the Cedar River Watershed of western Washington found bull trout diets also consist of aquatic insects, crayfish, and salamanders (Connor et al. 1997).

5.2.2.2 Factors for Decline

The following factors have contributed to the decline of bull trout populations identified in the listing rule (Bond 1992, Thomas 1992, Donald and Alger 1993, Rieman and McIntyre 1993, WDFW 1997):

- Restriction of migratory routes by dams and other unnatural barriers
- Forest management, grazing, and agricultural practices
- Road construction
- Mining
- Introduction of nonnative species
- Residential development resulting in adverse habitat modification, overharvest, and poaching.

In May, 2004, the USFWS issued a Draft Recovery Plan for the Coastal-Puget Sound DPS (USFWS 2004). The Puget Sound Draft Recovery Plan identifies Lake Washington, the Ship Canal, Lake Union, and the lower Duwamish River as foraging, migration and overwintering habitat. Foraging, migration, and overwintering habitat is defined as relatively large streams and mainstem rivers, including lakes or reservoirs, estuaries, and nearshore environments, where subadult and adult migratory bull trout forage, migrate, mature, or overwinter (USFWS 2004). This habitat is typically downstream from spawning and rearing habitat and contains all the physical elements to meet critical overwintering, spawning migration, and subadult and adult rearing needs. Although use of foraging, migration and overwintering habitat by bull trout may be seasonal or very brief (as in some migratory corridors), it is a critical habitat component.

The Coastal-Puget Sound DPS is significant to the species as a whole because it contains the only anadromous forms of bull trout in the coterminous United States. Consequently, this DPS supports bull trout in a unique ecological setting. Also unique to this population segment is the overlap in distribution with Dolly Varden.

On October 18, 2010, the USFWS revised its September 26, 2005, critical habitat designation for bull trout in the conterminous United States (75 FR 63898). The final rule designated habitat in 32 critical habitat units which have an appropriate quantity and spatial arrangement of physical or biological features present that supports bull trout metapopulations, life processes, and overall species conservation. For the Puget Sound critical habitat unit, the designated critical habitat totals about 1,144 miles (1,840 km) of streams, 40,182 acres (16,261 ha) of lakes, and 443 miles (684 km) of marine shoreline in Washington. Within the action areas, critical habitat includes Lake Washington, the Ship Canal, Lake Union, the Duwamish Waterway, Duwamish River, and the estuarine and marine waters of Puget Sound (see Figure 3).

5.2.2.3 Habitat Requirements

Bull trout have more specific habitat requirements than other salmonids (Rieman and McIntyre 1993). Growth, survival, and long-term persistence depend on the following habitat characteristics:

- Cold water
- Complex instream habitat
- Stable substrate with a low percentage of fine sediments
- High channel stability
- Stream/population connectivity.

Stream temperature and substrate type, in particular, are critical factors for the sustained long-term persistence of bull trout. Spawning is often associated with the coldest, cleanest, and most complex stream reaches within basins. However, bull trout exhibit a patchy distribution even in pristine habitats (Rieman and McIntyre 1995). They should not be expected to occupy all available habitats at the same time (Rieman et al. 1997).

While bull trout clearly prefer cold waters and nearly pristine habitat, it cannot be assumed that they do not occur in streams where habitat is degraded. Given the depressed status of some subpopulations, it is likely that individuals in degraded rivers are using less than optimal habitat because that may be all that is available. In basins with high productivity, such as the Skagit River basin, bull trout may be using marginal areas when optimal habitat becomes fully occupied (Kraemer 2003). Bull trout have been documented using habitats that may be atypical or characterized as likely to be unsuitable (USFWS 2000).

Temperature

For long-term persistence, bull trout populations need a stream temperature regime that ensures sufficient amounts of cold water are present at the locations and during the times needed to complete their lifecycle. Temperature is most frequently recognized as the factor limiting bull trout distribution (Rieman and McIntyre 1993, Dunham and Chandler 2001). Probability of occurrence for juvenile bull trout in Washington is relatively high (7%) when maximum daily temperatures did not exceed about 52° to 54° F (11-12° C) (Dunham et al. 2001). Water temperature also seems to be an important factor in determining early survival, with cold water temperatures resulting in higher egg survival and faster growth rates for fry and juveniles (Pratt 1992). Optimum incubation temperatures range from 36° to 43° F (2-6° C). At 46° to 50° F (8-10° C), survival ranged from 0 to 20% (McPhail and Murray 1979). Tributary stream temperature requirements for rearing juvenile bull trout are also quite low, ranging from 43° to 50° F (6-10° C) (McPhail and Murray 1979, Goetz 1989, Pratt 1992, Buchanan and Gregory 1997).

Increases in stream temperatures can cause direct mortality, increased susceptibility to disease or other sublethal effects and displacement by avoidance (Bonneau and Scarnecchia 1996, McCullough et al. 2001). Temperature increases also increase competition with species more tolerant of warm stream temperatures (MBTSG 1998, Rieman and McIntyre 1993). Brook trout (*S. fontinalis*), which can hybridize with bull trout, may be more competitive than bull trout and displace them, especially in degraded drainages containing fine sediment and higher water temperatures (Clancy 1993, Leary et al. 1993). Recent laboratory studies suggest bull trout are at a particular competitive disadvantage in competition with brook trout at temperatures greater than 54° F (12° C) (McMahon et al. 2001).

Although bull trout require a narrow range of cold water temperatures to rear, migrate, and reproduce, they are known to occur in larger, warmer river systems that may cool seasonally, and that provide important migratory corridors and forage bases. For migratory corridors, bull trout typically prefer water temperatures ranging between 50° to 54° F (10-12° C) (Buchanan and Gregory 1997, McPhail and Murray 1979). When bull trout migrate through stream segments with higher water temperatures, they tend to seek areas offering thermal refuge such as confluences with cold tributaries (Swanberg 1997), deep pools, or locations with surface and groundwater exchanges in alluvial hyporheic zones (Frissell 1999). Water temperatures above 59º F (15° C) are believed to limit bull trout distribution, which partially explains their generally patchy distribution within a watershed (Fraley and Shepard 1989, Rieman and McIntyre 1995).

Substrate

Bull trout show a strong affinity for stream bottoms and a preference for deep pools in cold water streams (Goetz 1989, Pratt 1992). Stream bottom and substrate composition are highly important for juvenile rearing and spawning site selection (McPhail and Murray 1979, Graham et al. 1981, Rieman and McIntyre 1993). Fine sediments can influence incubation survival and emergence success (Weaver and White 1985, Pratt 1992) but might also limit access to substrate interstices that are important cover during rearing and overwintering (Goetz 1994, Jakober 1995). Rearing densities of juvenile bull trout have been shown to be lower when there are higher percentages of fine sediment in the substrate (Shepard et al. 1984). Due to this close connection to substrate, bed load movements and channel instability can negatively influence the survival of young bull trout.

Cover and Stream Complexity

Bull trout of all age classes are closely associated with cover, especially during the day (Fraley and Shepard 1989, Baxter and McPhail 1997). Cover may be in the form of overhanging banks, deep pools, turbulence, large wood, or debris jams. Young bull trout use interstitial spaces in the substrate for cover and are closely associated with the stream bed. This association appears to be more important for bull trout than for other salmonids (Pratt 1992, Rieman and McIntyre 1993).

Bull trout distribution and abundance is positively correlated with pools and complex forms of cover, such as large or complex woody debris and undercut banks, but may also include coarse substrates (cobble and boulder) (Rieman and McIntyre 1993, Jakober 1995, MBTSG 1998). Studies of Dolly Varden showed that population density declined with the loss of woody debris after clearcutting or the removal of logging debris from streams (Bryant 1983, Dolloff 1986, Elliott 1986, Murphy et al. 1986).

Large pools consisting of a wide range of water depths, velocities, substrates, and cover are characteristic of high-quality aquatic habitat and an important component of channel complexity. Reduction of wood in stream channels, either from present or past activities, generally reduces pool frequency, quality, and channel complexity (Bisson et al. 1987, House and Boehne 1987, Spence et al. 1996). Large wood in streams enhances the quality of habitat for salmonids and contributes to channel stability (Bisson et al. 1987). It creates pools and undercut banks, deflects streamflow, retains sediment, stabilizes the stream channel, increases hydraulic complexity, and improves feeding opportunities (Murphy 1995). By forming pools and retaining sediment, large wood also helps maintain water levels in small streams during periods of low streamflow (Lisle 1986).

Channel and Hydrologic Stability

Due to the bull trout's close association with the substrate, bed load movements and channel instability can reduce the survival of young bull trout. Maintaining bull trout habitat requires stream channel and flow stability (Rieman and McIntyre 1993). Bull trout are exceptionally sensitive to activities that directly or indirectly affect stream channel integrity. Juvenile and adult bull trout frequently inhabit areas of reduced water velocity, such as side channels, stream margins, and pools that are easily eliminated or degraded by management activities (Rieman and McIntyre 1993). Channel dewatering caused by low flows and bed aggradation (raising grade or level by deposition) has blocked access for spawning fish resulting in year-class failures (Weaver 1992). Timber harvest and the associated roads may cause landslides that affect many miles of stream through aggradation of the streambed.

Patterns of streamflow and frequency of extreme flow events that influence substrates may be important factors in population dynamics (Rieman and McIntyre 1993). With lengthy overwinter incubation and a close tie to the substrate, embryos and juveniles may be particularly vulnerable to flooding and channel scour associated with the rain-on-snow events common in parts of the range (Rieman and McIntyre 1993). Surface/groundwater interaction zones—which bull trout typically select for redd construction—are increasingly recognized as having high dissolved oxygen, constant cold water temperatures, and increased macro-invertebrate production.

5.2.2.4 Migration

The persistence of migratory bull trout populations requires maintaining migration corridors. Stream habitat alterations that either restrict or eliminate bull trout migration corridors include the following:

- Degradation of water quality (especially increasing temperatures and increased amounts of fine sediments)
- Alteration of natural streamflow patterns
- Impassable barriers (e.g., dams and culverts)
- Structural modification of stream habitat (e.g., channeling or removing cover).

In the Coastal-Puget Sound DPS, migratory corridors may link seasonal marine and freshwater habitats, as well as linking lake, river, and tributary complexes necessary for bull trout life-history requirements.

The importance of maintaining the migratory life-history form of bull trout, as well as migratory runs of other salmonids that may provide a forage base for bull trout, is repeatedly emphasized in the scientific literature (Rieman and McIntyre 1993, MBTSG 1998, Dunham and Rieman 1999, Nelson et al. 2002). Isolation and habitat fragmentation resulting from migratory barriers have negatively affected bull trout by the following:

1. Reducing geographical distribution (Rieman and McIntyre 1993, MBTSG 1998)
2. Increasing the probability of losing individual local populations (Rieman and McIntyre 1993, Dunham and Rieman 1999, MBTSG 1998, Nelson et al. 2002)
3. Increasing the probability of hybridization with introduced brook trout (Rieman and McIntyre 1993)
4. Reducing the potential for movements in response to developmental, foraging, and seasonal habitat requirements (Rieman and McIntyre 1993, MBTSG 1998).
5. Reducing reproductive capability by eliminating the larger, more fecund migratory form from many subpopulations (Rieman and McIntyre 1993, MBTSG 1998).

Therefore, restoring connectivity and restoring the frequency of occurrence of the migratory form will be an important factor in the recovery of bull trout.

Unfortunately, migratory bull trout have been restricted or eliminated in parts of their range due to stream habitat alterations, including seasonal or permanent obstructions, detrimental changes in water quality, increased temperatures, and the alteration of natural streamflow patterns. Dam and reservoir construction and operations have altered major portions of bull trout habitat in the Skokomish, Elwha, Skagit, Nooksack, and Puyallup river core areas. Dams without fish passage create barriers to fluvial and adfluvial bull trout that isolate populations. The operations of dams and reservoirs alter the natural hydrograph, thereby affecting forage, water temperature, and water quality (USDI 1997).

5.2.2.5 Marine Habitat Use

Estuaries and shoreline areas comprise what is known as the ‘nearshore’ marine habitat. The nearshore environment provides habitat critical to both bull trout and salmon. This habitat provides food production and foraging areas, refuge (from predation, seasonal high flows, winter storms), and migratory corridors.

Bull trout first migrate to tidal areas between ages 1 and 3. These juvenile fish may rear in the tidally influenced delta within intertidal marsh, distributary channels, or they may pass through into nearshore marine areas. Although no studies describe the salinity tolerance of bull trout, both subadult and adult bull trout can survive a wide range of salinities, varying from fresh to brackish to marine waters and can move between these areas with little or no delay for acclimation.

Additional information provided by bull trout acoustic radio telemetry and habitat study projects indicates that bull trout in marine waters are more active at night than during the day, may prefer deeper nearshore habitat rather than shallow nearshore habitat, and can be found at depths as great as 197 to 256 feet (60-75 m). Bull trout from different freshwater populations may overlap in their use of marine and estuarine waters. Although bull trout are likely to be found in nearshore marine waters year-round, the period of greatest use is March through July (Goetz and Jeanes 2004). In the Skagit Bay, although bull trout may be found year-round, there appears to be a bi-modal distribution where significant numbers of bull trout are present from April through July and October through December (Beamer and Henderson 2004).

Anadromous bull trout forage and mature in the nearshore marine habitats on the Washington coast, Strait of Juan de Fuca, and in Puget Sound. In Puget Sound, the distribution of bull trout in nearshore waters likely correlates to the nearshore distribution of baitfish (WDFW 1999). It also appears that certain life-history stages may use different marine prey species. For example, the younger bull trout (age 1-3) that move to marine waters appear to select smaller prey items, such as shrimp. By age 4, the diet of anadromous bull trout has shifted largely to fish. Bull trout from Puget Sound prey on surf smelt, Pacific herring (*Clupea harengus pallasi*), Pacific sand lance, pink salmon smolts (*O. gorbuscha*), chum salmon smolts (*O. keta*), and a number of invertebrates (Kraemer 1994).

5.2.3 Species Occurrence in Action Areas

5.2.3.1 Lake Washington Ship Canal, North Lake Washington, South Lake Washington

The Lake Washington Ship Canal, North Lake Washington, and South Lake Washington action areas are combined because they comprise the western portion of the Lake Washington basin. The Lake Washington foraging, migration and overwintering 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. Designated critical habitat includes Lake Washington and the Ship Canal. No streams are designated as critical habitat in these action areas.

Current Range

Population status information and extent of use of this area are currently unknown. Adult and subadult size individuals have been observed infrequently in the lower Cedar River (below Cedar Falls), Carey Creek (a tributary to upper Issaquah Creek), Lake Washington, and at the Locks. 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 Lake Chester Morse (not accessible to bull trout within Lake Washington).

The potential for spawning in the Lake Washington basin is believed to be very low because most accessible habitat is low elevation, below 500 feet (152 m), and thus not expected to have proper thermal regime to sustain successful spawning. There are, however, 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.

Migration

Aside from spawning, Lake Washington drainage has potential benefits and challenges to adult and subadult bull trout. Two large lakes with high forage fish provide significant foraging habitat. Subadult and adult bull trout have been occasionally observed in Lake Washington (Shepard and Dykeman 1977, KCDNR 2000, H. Berge, KCDNRP, pers. comm. 2003). Surface water temperatures in Lake Washington and the Ship Canal are too warm for bull trout during late spring through early fall and probably limit residence time of bull trout that may enter the system through the Locks. Observations of bull trout in the Locks suggest migration is occurring from other watersheds.

Bull trout have been caught in Shilshole Bay and the Locks during late spring and early summer in both 2000 and 2001. In 2000, up to 8 adult and subadult fish (mean size 14.5 inches [36.8 cm]) were caught in Shilshole Bay below the Locks, between May and July. These fish were found preying upon juvenile salmon (40% of diet) and marine forage fish (60% of diet) (Footen 2000, 2003). In 2001, 5 adult bull trout were captured in areas within the Locks and immediately below the Locks. One bull trout was captured within the large locks in June, and in May, one adult was captured while migrating upstream through the fish ladder in the adult steelhead trap at the head of the ladder. Three adult bull trout were also captured below the tailrace during the peak of juvenile salmon migration on June 18, 2001 (F. Goetz, Corps, pers. comm. 2003).

5.2.3.2 Lower Green/Duwamish

The Lower Green/Duwamish action area is considered foraging, migration and overwintering habitat. This foraging, migration and overwintering habitat may be used by several bull trout core populations such as those from the Puyallup and Snohomish rivers. The Duwamish River, including the East and West waterways, is designated critical habitat for the Coastal-Puget Sound DPS.

Current Range

Historically, bull trout were reported to use the Duwamish River and lower Green River in ‘vast’ numbers (Suckley and Cooper 1860). In contrast, bull trout are observed infrequently in this system today. Before permanent redirection of the Stuck River (lower White River) into the Puyallup River system in 1906 (Williams et al. 1975), the lower Green River system provided habitat for populations spawning in the White River. Another factor that may have diminished the Green-Duwamish River system’s value for bull trout is the loss of the Black River due to construction of the Ship Canal in the mid-1910s. The Black River historically connected the Lake Washington basin and Cedar River to the Green-Duwamish River system. Creation of the Ship Canal and Locks lowered Lake Washington 9 feet (2.7 m) and completely redirected flows of the Cedar River and Lake Washington tributaries to the canal (Warner 1996). These diversions left the Green-Duwamish River system with only about one-third of its original watershed (Weitkamp and Ruggerone 2000), which fragmented potential habitats and may have lowered the quality of habitats to support bull trout populations.

Recently, bull trout have been reported in the lower Green River as far upstream as the mouth of Newaukum Creek at about RM 41 and are occasionally reported in the lower Duwamish River (KCDNR 2000, KCDNRP 2002, Goetz et al. 2004). It is presumed that bull trout use the Green River up to City of Tacoma’s Headworks Diversion Dam at RM 61, a barrier to upstream migration since 1912 (KCDNR 2000). Bull trout recently observed in the lower Green River basin likely originated from other watersheds (70 FR 56212). Reports of historic use of tributaries in the lower Green River are rare (KCDNR

2000). Given their size and potential as foraging areas, tributaries such as Newaukum and Soos Creeks may occasionally be used by bull trout. Tributaries within the action area, such as Longfellow Creek, are not likely to be used by bull trout.

The number of bull trout that enter the Duwamish River is small. In April 1978, Dennis Moore, Hatchery Manager for the Muckleshoot Tribe, talked with 3 anglers near North Wind Weir, RM 7 of the Duwamish and identified 4 fish as adult char (Brunner 1999a). In 2000, 8 subadult bull trout were captured in the Duwamish River at the head of the navigation channel at the Turning Basin restoration site at river mile (RM) 5.3. These fish averaged 11 inches (27.9 cm) in length and were captured in August and September. A single char was caught at this same site in September of 2002 (J. Shannon, Taylor Associates, pers. comm. 2002). In May 2003, a 23-inch (58.4 cm) adult char was captured and released at Kellogg Island (J. Shannon, Taylor Associates, pers. comm. 2003). However, no bull trout were captured during weekly beach seining of up to 13 sites per week (RM 1 to RM 8.5) during December 2004 to July 2005 (G. Ruggerone, NRC, pers. comm. 2006).

5.2.3.3 North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound

The North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound action areas have been combined because they border Puget Sound. In this action area, critical habitat extends along the entire City of Seattle Puget Sound nearshore (see Figure 3) from extreme high water to 33 feet (10 m) depth relative to the MLLW. Critical habitat includes tidally influenced freshwater areas at the head of estuaries.

Current Range

Anadromous adult and subadult bull trout may use all marine waters of the action area for foraging and overwintering. The extent is poorly understood however. Kraemer (1994) speculated that the distribution of bull trout in marine waters may be closely timed with the distribution of forage fish and coincidental with their spawning beaches. Goetz et al. (2004) documented that bull trout were most abundant in Puget Sound waters during spring and late summer and relatively few were captured during winter months. The current distribution of bull trout within Puget Sound marine waters is not completely known. But it has been documented from the Canadian border to the Nisqually River Delta (Fresh et al. 1979, Kraemer 1994, McPhail and Baxter 1996, WDFW 1998, Pacific International Engineering 1999, Ballinger 2000, KCDNRP 2002). Bull trout appear to be more abundant along eastern shores compared with western shores of Puget Sound (70 FR 56212).

Puget Sound bull trout prey on surf smelt, Pacific herring, Pacific sand lance, and other small schooling fish (Kraemer 1994, Goetz et al. 2004). These prey species are present in all of the marine areas within the action area. Although foraging bull trout may tend to seasonally concentrate in forage fish spawning areas (nearshore habitats), they can be found throughout accessible estuarine and nearshore habitats.

The extent of past and current bull trout use of smaller independent creek drainages that discharge directly into Puget Sound is not well known. No observations have been made of bull trout use in small streams entering Puget Sound within the action areas. Even if it is determined that many of the small stream systems in Puget Sound are not commonly occupied by bull trout, these streams may contribute to the forage base of bull trout in adjacent nearshore marine waters.

Relatively few bull trout have been observed or captured within nearshore areas of the action area. Most migratory bull trout leave freshwater and enter Puget Sound during late winter and spring, then return to freshwater during late spring and early summer (Goetz et al. 2004). Approximately 16 char have been captured in the Golden Gardens area from 1929 to 2002. Eight adult and subadult bull trout were caught in Shilshole Bay in 2000 (Footen 2000, 2003). Tagging indicated that some bull trout captured near the Locks rapidly migrated to other watersheds. A total of 34 bull trout have been captured in Shilshole Bay since 1949. In Elliott Bay, 1 adult bull trout was captured in a Muckleshoot Tribal net near Pier 91 (Brunner 1999b), and 1 bull trout was observed feeding along the new habitat bench created at the Olympic Sculpture Park in June (Toft et al. 2010; J. Toft, UW, pers comm. 2010).

5.3 Southern Resident Killer Whale

5.3.1 Listing and Critical Habitat Designation

On November 15, 2005, NMFS listed the Southern Resident killer whales (*Orcinus orca*) as endangered under the ESA. This new listing under ESA requires federal agencies to make sure their actions do not jeopardize the continued existence of the whales. Southern Resident killer whales are already protected, as are all marine mammals, by a 1972 law, the Marine Mammal Protection Act, under which the whales were officially listed as a depleted stock in May 2003. The final recovery plan, published in January 2008, reviews and assesses the potential factors affecting the Southern Resident killer whales and lays out a recovery program to address each of the threats.

On November 29, 2006, NMFS designated critical habitat for the Southern Resident killer whale. Critical habitat boundaries for Southern Resident killer whales include 3 areas, 1 of which lies within the Seattle action areas. This area, defined as Area 2, includes all of Puget Sound south of Deception Pass Bridge, the entrance to Admiralty Inlet, and the Hood Canal Bridge. Hood Canal is not included as critical habitat. The extent of critical habitat includes all water greater than 20 feet (6.1m) relative to extreme high water.

The PCEs for **Southern Resident killer whale's critical habitat** include:

- **Southern Resident Killer Whale Critical Habitat PCE #1**: Water quality to support growth and development
- **Southern Resident Killer Whale Critical Habitat PCE #2**: Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth
- **Southern Resident Killer Whale Critical Habitat PCE #3**: Passage conditions to allow for migration, resting, and foraging.

5.3.2 Species Information

5.3.2.1 Life History

The Southern Resident killer whale population consists of 3 pods, identified as J, K, and L pods, that reside for part of the year in the inland waterways of the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound, especially during the spring, summer, and fall (Krahn et al. 2002). The population experienced a 20% decline in the 1990s, raising concerns about its future. The population peaked at 97 animals in the 1990s and then declined to 71 in 2001. There were increases in the overall population from 2002-2007, however the population declined in 2008 with 85 Southern Resident killer whales counted. As of July 1, 2010, the population of Southern Resident killer whales totals 87 individuals (Center for Whale Research 2011). Individual pod sizes include 28 members in J Pod, 19 in K pod, and 40 in L Pod.

Many members of the group were captured during the 1970s for commercial display aquariums. The group continued to be put at risk from vessel traffic, toxic chemicals, and limits on availability of food, especially salmon. It has only a few sexually mature males. Because the population historically has been small, it is susceptible to catastrophic risks, such as disease or oil spills.

Killer whales are strikingly pigmented cetaceans. Killer whales are black dorsally and white ventrally, with a conspicuous white oval patch located slightly above and behind the eye. Sexual dimorphism occurs in body size, flipper size, and height of the dorsal fin. Males are larger and develop larger pectoral flippers, dorsal fins, tail flukes, and girths than females (Clark and Odell 1999).

Killer whales have been classified into 3 forms, or ecotypes, termed residents, transients, and offshore whales. Significant genetic differences occur among the 3 forms (Stevens et al. 1989, Hoelzel and Dover 1991, Hoelzel et al. 1998, Barrett-Lennard 2000, Barrett-Lennard and Ellis 2001, Hoelzel et al. 2002). The 3 forms vary in morphology, ecology, and behavior.

5.3.2.2 Factors for Decline

The exact cause of the recent decline of the Southern Resident population is unknown and could be a combination of 2 or more factors. Factors resulting in decreased numbers to the Southern Resident population are the following:

1. Reduced quantity and quality of prey
2. Persistent pollutants that could cause immune or reproductive system dysfunction
3. Oil spills
4. Noise and disturbances from vessel traffic.

Adequate prey populations are important to healthy killer whale populations and reductions in prey availability may force whales to spend more time foraging and might lead to reduced reproductive and higher mortality rates. Many stocks of salmon have declined due to overfishing and degradation of freshwater and estuarine habitat through urbanization, dam building and forestry, agricultural, and mining practices (NRC 1996, Gregory and Bisson 1997, Lichatowich 1999, Pess et al. 2003). Due to lack of information on the diet of killer whales throughout the year and the importance of the various salmon runs, it is unknown whether current fish stocks are a limiting factor for the Southern Resident population.

Killer whales are experiencing ever-increasing amounts of indirect harassment through expanding contact with human-made sources of marine noise and vessel traffic. Underwater noise pollution originates from several sources, including general shipping and boating traffic, industrial activities such as dredging, drilling, marine construction, and seismic testing of the sea bottom, and military and other vessel use of sonar (Richardson et al. 1995, Gordon and Moscrop 1996, NRC 2003). Many of these activities are prevalent in coastal areas, coinciding with the preferred habitat of most killer whale populations. Killer whales rely on their highly developed acoustic sensory system for navigating, locating prey, and communicating with other individuals. Excessive levels of human-generated noise and the physical presence of vessels have the potential to mask echolocation and other signals used by killer whales thereby causing increased physiological changes and lowered immune function, and can disrupt movements and normal behavioral patterns.

Another primary factor in the decline of killer whales is exposure to elevated levels of toxic chemical contaminants, especially organochlorine compounds such as polychlorinated biphenyls (PCBs) and DDT. Bioaccumulation through trophic (nutritional) transfer allows relatively high concentrations of these compounds to build up in killer whales because they are a top-level marine predator. The effects of chronic exposure to moderate-to-high contaminant levels have not yet been determined in killer whales. There is no evidence that high organochlorine concentrations cause direct mortality in killer whales (O'Shea and Aguilar 2001). However, physiological responses in marine mammals have been linked to organochlorine exposure, including impaired reproduction (Béland et al. 1993), immunotoxicity (Lahvis et al. 1995, Ross et al. 1995, Ross 2002), hormonal dysfunction (Subramanian et al. 1987), disruption of enzyme function and vitamin A physiology (Marsili et al. 1998, Simms et al. 2000), and skeletal deformities (Bergman et al. 1992).

5.3.2.3 Habitat Requirements

Southern Resident killer whales use different summer and winter habitats. All 3 Southern Resident pods regularly occur in the water of the Georgia Basin (the Strait of Georgia, Haro Strait, and the Strait of Juan de Fuca) during late spring, summer, and early fall (Heimlich-Boran 1988). The range of Southern Residents throughout the rest of the year is not well known. During the early fall, movements of Southern Residents, particularly J pod, expand to include Puget Sound (Krahn et al. 2002).

Killer whales are the world's most widely distributed marine mammal (Leatherwood and Dahlheim 1978, Heyning and Dahlheim 1988). Although observed in tropical waters and the open sea, they are most abundant in coastal habitats and high latitudes. In the eastern Pacific Ocean, killer whales occur year-round in southeastern Alaska (Scheffer 1967) and the intercoastal waterways of British Columbia and Washington State (Balcomb and Goebel 1976, Bigg et al. 1987, Osborne et al. 1988). They have been observed near the Aleutian Islands (Murie 1959, Waite et al. 2001) and along the coasts of Washington, Oregon, and California (Norris and Prescott 1961, Fiscus and Niggol 1965, Rice 1968, Gilmore 1976, Black et al. 1997, NMFS 2004).

In Washington, killer whales occur in all marine waters. From late spring to fall, most whales can be found in the inland waters around the San Juan Islands (Heimlich-Boran 1988, Felleman et al. 1991, Olson 1998, Ford et al. 2000). Movements during the winter and early spring are poorly known, but many animals shift their activity to outer coastal areas or depart the state.

Killer whales are highly social animals that occur primarily in groups or pods of up to 40 to 50 animals (Dahlheim and Heyning 1999, Baird 2000). Mean pod size varies among populations, but often ranges from 2 to 15 animals (Kasuya 1971, Condy et al. 1978, Mikhalev et al. 1981, Braham and Dahlheim 1982, Dahlheim et al. 1982, Baird and Dill 1996). Differences in spatial distribution, abundance, and behavior of food resources probably account for much of the variation in group size among killer whale populations.

Diet

As top-level predators, killer whales eat a variety of marine organisms ranging from fish to squid to other marine mammal species. Some populations have specialized diets throughout the year and use specific foraging strategies that reflect the behavior of their prey. Such dietary specialization has probably evolved in regions with abundant prey resources year-round (Ford 2002). Cooperative hunting, food sharing, and innovative learning are other notable foraging traits in killer whales (Smith et al. 1981, Lopez and Lopez 1985, Felleman et al. 1991, Hoelzel 1991, Jefferson et al. 1991, Hoelzel 1993, Simala and Ugarte 1993, Baird and Dill 1995, Guinet et al. 2000, Pitman et al. 2003).

Fish are the major dietary component of resident killer whales (Ford et al. 1998, 2000; Saulitis et al. 2000). Observations indicate that salmon are clearly preferred as prey, especially in spring, summer, and fall. Resident whales spend about 50% to 67% of their time foraging (Heimlich-Boran 1988, Ford 1989, Morton 1990, Felleman et al. 1991). During early autumn, Southern Resident pods, especially J pod, expand their routine movements into Puget Sound to likely take advantage of chum and Chinook salmon runs (Osborne 1999). Little is known about the winter and early spring foraging of resident killer whales. NMFS (2011a) has informed affected constituents about the importance of Chinook salmon to the diet of SR killer whales and the potentially serious implications of the salmon fisheries and other activities affecting Chinook salmon on the survival and recovery of SR killer whales.

While in inland waters during warmer months, all of the pods concentrate their activity in Haro Strait, Boundary Passage, the southern Gulf Islands, the eastern end of the Strait of Juan de Fuca, and several localities in the southern Georgia Strait (Heimlich-Boarn 1988, Felleman et al. 1991, Olson 1998, Ford et al. 2000). Less time is spent elsewhere in other sections of the Georgia Straight, San Juan Islands, Admiralty Inlet and Puget Sound.

Killer whales frequent a variety of marine habitats with adequate prey resources and do not appear to be constrained by water depth, temperature, or salinity (Baird 2000). Killer whales tolerate a range of water temperatures, occurring from warm tropical seas to polar regions with ice floes and near-freezing waters. They occasionally enter brackish waters and rivers (Scheffer and Slipp 1948).

Mortality

Killer whales are polygamous. Males nearly always mate with females outside of their own pods, thereby reducing the risks of inbreeding (Dahlheim and Heyning 1999, Barrett-Lennard 2000, Barrett-Lennard and Ellis 2001). Most mating is believed to occur from May to October, although mating occurs year-round because young are born in all months (Nishiwaki 1972, Olesiuk et al. 1990b, Matkin et al. 1997). Gestation in captive killer whales averages about 17 months (Asper et al. 1988, Walker et al. 1988, Duffield et al. 1995).

Mortality is extremely high during the first 6 months of life, when 37% to 50% of all calves die (Bain 1990, Olesiuk et al. 1990b). Annual death rates for juveniles decline steadily thereafter. Mortality rates are about 0.5% to 1.7% per year until the age of 44.5 years. Mortality increases dramatically among older females, especially those older than 65 years. After reaching sexual maturity, death rates for males increase throughout life, reaching 7.1% annually among individual older than 30 years. Mortality rates appear highest during the winter and early spring.

At birth, the average life expectancy of resident killer whales is about 29 years for females and 17 years for males (Olesiuk et al. 1990b). However, for animals that survive their first 6 months, mean life expectancy increases to about 50 to 60 years for females and 29 years for males. Sexual maturity occurs around 15 years of age in both sexes.

Maximum lifespan is estimated to be 80 to 90 years for females and 50 to 60 years for males (Olesiuk et al. 1990b).

5.3.3 Species Occurrence in Action Areas

5.3.3.1 North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound

SR killer whales spend considerable time in the Georgia Basin from late spring to early autumn, with concentrated activity in the inland waters of the state of Washington around the San Juan Islands, and then move south into Puget Sound in early autumn. While these are seasonal patterns, Southern Resident killer whales have the potential to occur throughout their range (from Central California north to the Queen Charlotte Islands) at any time of the year.

The Whale Museum manages a long-term database of SR killer whale sightings and geospatial locations in inland waters of Washington. While these data are predominately opportunistic sightings from a variety of sources (public reports, commercial whale watching, Soundwatch, Lime Kiln State Park land-based observations, and independent research reports), SR killer whales are highly visible in inland waters, and widely followed by the interested public and research community. The dataset does not account for level of observation effort by season or location; however, it is the most comprehensive long-term dataset available to evaluate broad scale habitat use by SR killer whales in inland waters. For these reasons, NMFS relies on the number of past sightings to assess the likelihood of SR killer whale presence in a project area when work would occur. A review of this dataset from the years 1990 to 2008 indicates that SR killer whales are observed in Puget Sound along the City of Seattle throughout the year. Within Elliott Bay, SR killer whales have been observed in all months except May, June, and July (NMFS 2011b).

The database may be found at www.nwr.noaa.gov/marine-mammals/mm-occurrence.cfm.

5.4 Steller Sea Lion

5.4.1 Listing and Critical Habitat Designation

Steller sea lions (*Eumetopias jubat*us) were designated as threatened on April 5, 1990 (55 FR 12645). In 1997, the North Pacific's population of Steller sea lions was separated into 2 DPSs:

1. West of 144ºW longitude (near Cape Suckling, Alaska)
2. The remainder of the United States.

The population west of 144ºW longitude was designated endangered on June 4, 1997 (62 FR 30772). The other DPS retained a threatened designation.

Critical habitat was designated on August 27, 1993, and includes all United States rookeries, major haul-outs in Alaska, horizontal and vertical buffer zones around these rookeries and haul-outs, and 3 aquatic foraging areas in North Pacific waters (58 FR 45269). No critical habitat is designated in Washington. Rookeries are areas where adults congregate for breeding and pupping, and haul-outs are areas used for rest and socializing. Sites used as rookeries during the breeding season may be used as haul-outs during the remainder of the year. Steller sea lions haul-out on offshore islands, reefs, and rocks, while rookeries generally occur on beaches. Preferred rookeries and haul-out areas are located in relatively remote areas where access by humans and mammalian predators is difficult. Locations are specific and change little from year to year (Steller Sea Lion Recovery Team 1992).

5.4.2 Species Information

5.4.2.1 Life History

Steller sea lions range along the North Pacific Rim from northern Japan, through the Bering Sea and Aleutian Islands, along Alaska's southern coast, and south to California. Centers of abundance and distribution are located in the Gulf of Alaska and Aleutian Islands, respectively (Loughlin et al. 1992). The species is not known to migrate, but individual sea lions disperse widely outside of the breeding season (late May to early July). Exchange between rookeries appears low by breeding adult females and males.

Steller sea lions from the eastern stock use rookeries and haul-outs in the coastal water of southern Alaska, British Columbia, Washington, Oregon and California. Common haul-outs along the outer coast include Split Rock and the South Jetty of the Columbia River. Further north along the Olympic Peninsula coast, haul-outs are located at Carroll Island, Bodelteh Islands, Guano Rock, Umatilla Reef, Skagway Rocks, and Tatoosh Island. Although haul-outs occur in a variety of areas, individual locations used are specific and change little from year to year (WDFW 1993).

Steller sea lions occur year-round in Washington coastal waters, but the number present declines during the summer breeding season as sea lions return to rookeries in California, Oregon, British Columbia, and southeast Alaska. No breeding rookeries have been identified in Washington waters. However, in 1992 a single pup was born on Carroll Island (WDFW 1993). Most of Washington's haul-out sites are located along the northern outer coast. Major haul-out sites are concentrated at large rock complexes including Tatoosh Island, Cape Alva, Carroll Island, Split/Willoughby rocks, and the Columbia River South Jetty (Gearin and Jeffries 1996).

5.4.2.2 Factors for Decline

During the past 30 years, Steller sea lion populations have suffered a dramatic decline. Numbers in the rookeries of central/southern California, the central Bering Sea, and in the core Alaskan ranges have all decreased substantially. A number of natural and human-caused factors have been hypothesized as contributing to these declines, but a primary cause has not been definitively identified. It is generally thought that a nutritional deficiency resulting from a lack of abundance or availability of suitable prey is involved (Steller Sea Lion Recovery Team 1992). Major shifts in the abundance of fish in the Bering Sea over the past several decades are well documented (WDFW 1993).

The Alaska pollock and Atka mackerel fisheries have specifically been implicated in decreasing the availability of prey. A similar decline has not been documented in the region from southeast Alaska through Oregon, where Steller sea lion numbers appeared to have remained stable (Steller Sea Lion Recovery Team 1992).

5.4.2.3 Habitat Requirements

Steller sea lions feed in openwater habitat in nearshore areas out to the edge of the continental shelf (WDFW 1993). Steller sea lion foraging patterns vary depending upon age, season, and reproductive status, as well as the distribution and availability of prey. Foraging patterns of females during the winter months vary considerably. Individuals travel an average of 83 miles (133 km) and dive an average of 5.3 hours per day. The vast majority of feeding dives are 328 feet (100 m) deep.

Diets consist 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). Stomach and scat analyses in British Columbia indicate principal prey items include hake, herring, octopus, Pacific cod, rockfish, and salmon (Olesiuk et al. 1990b). Along the Washington coast, Steller sea lions appear to prey primarily on rockfish, herring, and smelt.

Western United States stock declines have been correlated with increased commercial harvests of walleye Pollack (Lowry et al. 1989). Reduced prey availability remains a concern for eastern United States stocks, although population declines have not been observed.

Steller sea lions are regularly observed in water of the northern Puget Sound and the Strait of Juan de Fuca during winter and spring, but they are not usually seen between April and September. There have been few reports of Steller sea lions in southern Puget Sound. In general, they are not thought to inhabit the project vicinity, although transient animals may migrate through the western end of the Ship Canal during peak abundance periods in winter.

5.4.3 Species Occurrence in Action Areas

5.4.3.1 North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound

There are no Steller sea lion rookeries in Washington although Steller sea lions are occasionally found in state waters. They are most commonly observed in the Strait of Juan de Fuca and are occasionally found on navigation buoys in Puget Sound (Jeffries et al. 2000). No Steller sea lion haul-out sites exist within the action areas. The closest haul-outs are located on Toliva Shoul's Buoy near Tacoma and the navigation buoys and net pen floats near Orchard Rocks, south of Bainbridge Island (NMFS 2011c).

5.5 Humpback Whale

5.5.1 Listing and Critical Habitat Designation

Humpback whales (*Megaptera novaeangliae*) have been protected since 1965, and are currently listed as endangered under the ESA. In the North Pacific, most remaining humpbacks reside in United States territorial waters (i.e. winter and summer grounds).

The humpback whale has a worldwide distribution, with 4 major populations or stocks (NMFS 2009, website http://www.nmfs.noaa.gov/pr/sars/species.htm#largewhales):

1. Western North Atlantic
2. Eastern North Pacific
3. Central North Pacific
4. Gulf of Maine.

5.5.2 Species Information

5.5.2.1 Life History

The humpback whales that can be found within Puget Sound and along the Washington coast belong to the Eastern North Pacific stock (NMFS 2005, Eastern North Pacific Stock

Assessment). These whales winter in coastal Central America and Mexico and migrate to the coast of California to southern British Columbia in summer.

Data in population abundance shows a general upward trend in abundance of humpback whales from 1991 through 1998. From 1999 to 2001, a large, but not significant, drop occurred. In 2001, the humpback whale population was estimated to be 1,109 individuals. Current 2005 estimates of the population of the Eastern North Pacific Stock are 1,769 individuals (Forney 2007).

Females are slightly larger than males averaging 48 feet (14.6 m) in length. Males average 44 feet (13.4 m). The maximum recorded size is 59 feet (17.9 m). A full-grown adult weighs about 30 tons (27.2 metric ton) with an expected lifespan of 40 to 50 years. Humpback whales are characterized by extremely long flippers that are about 0.33% of total body length, a dark back with white pigmentation on the flippers, sides, and ventral surface, a series of wart-like bumps called tubercles on the upper and lower jaw, and long, complex vocalizations. Prey includes herring, sand lance, capelin, mackerel, walleye pollock, haddock, and krill (Bryant et al. 1981, Krieger and Wing 1984). Adult humpback whales consume up to 3,000 pounds (1,360 kg) per day, although likely only feed during the 6 to 9 months of the year they are on their feeding grounds. Humpbacks fast and live off their fat layer for the winter period while on their breeding grounds.

Mating and birth of young probably takes place at the wintering grounds. Females produce their first calf between the ages of 6 and 8, and typically have 1 calf every 2 to 4 years. Humpbacks are born during the winter and are 10 to 13 feet long (3-3.9 m) and weigh about 2,200 lbs (997 kg).

5.5.2.2 Factors for Decline

Humpbacks were killed extensively from the late 1800s through the first part of the 20th century. Worldwide the population of humpbacks is about 10,000. This is 8% of the historical population size, although this species is now protected and recovering. The greatest threats to humpbacks today are entanglements in fishing gear, ship strikes, and coastal habitat pollution. The pre-1905 population of humpback whales in the North Pacific was about 15,000. By 1966, whaling had reduced this population to about 1,200 individuals. More than 6,000 humpback whales currently exist in the North Pacific (Carretta et al. 2001).

5.5.3 Species Occurrence in Action Areas

5.5.3.1 North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound

The occurrence of humpbacks in Puget Sound within the action areas is considered very unlikely or infrequent. Sightings of humpback whales are uncommon along the coast of Washington, although the National Marine Mammal Laboratory has documented humpbacks in Washington state waters in every month except February, March, and April. Humpbacks probably use Washington waters as a migration corridor. Historically, populations of humpbacks were much higher along the Washington coast. In the early 1900s, humpbacks were landed at the Bay City, Washington whaling station from April to October with most taken between June and August. Whaling stations off Vancouver Island also historically caught 500 to 1000 whales with most being humpback (NMFS 1991).

In the past, humpback whales have been intermittently sighted in Puget Sound. A total of 8 sightings have occurred in Puget Sound. Individual humpbacks were observed in May 1976, June 1978, June 1986, 2 juveniles in June and July 1988, Sept 2004, 1 individual observed in May and June 2004 (Falcone et al. 2005), and an injured whale in July 2006. These sightings include Puget Sound and the Georgia Basin (Falcone et al. 2005). The number of humpback sightings reported to the Orca Network has increased from 3 in 2001 to 30 in 2004. Today, 1 to 2 humpback whales typically come into Puget Sound each year (J. Calambokidis, Cascadia Research, pers. comm.). Humpbacks observed in Puget Sound do not remain for long periods and are generally considered to be stragglers.

5.6 Marbled Murrelet

5.6.1 Listing and Critical Habitat Designation

The marbled murrelet (*Brachyramphus marmoratus*) was federally listed as a threatened species in Washington, Oregon, and northern California effective September 28, 1992 (USDI 1992). Extensive harvest of late-successional and old-growth forests—the habitat preferred for nesting by murrelets—was the primary reason for the listing. Other factors include high predation rates and mortality in gillnets and oil spills.

The final rule designating critical habitat for the murrelet (61 FR 26256, USDI 1996) became effective on June 24, 1996. Thirty-two units totaling 3,887,800 acres (1,573,343 ha) were designated on federal, state, county, city, and private lands in Washington, Oregon, and California. Of the 3,887,800 acres designated as critical habitat rangewide, about 1,631,100 acres (600,085 ha) were designated in Washington state (1,800 acres in Congressionally Withdrawn Lands, 1,200,200 acres in late successional reserves, 426,800 acres in state lands, and 2,500 acres in private lands) (USDI 1996). Most of these units (78%) occur on federal lands; 21% on state lands, 1.2% on private lands; 0.2% on county lands; and 0.003% on City lands. Critical habitat designations on state lands were suspended upon completion of the WDNR Habitat Conservation Plan (USFWS 1997). Therefore, about 99.8% of the critical habitat in Washington State is on federal lands.

The USFWS did not include the marine environment in the critical habitat designation because other regulations protect the quality of marine foraging habitat and prey species. While clean water and food in the marine environment were identified as essential to the conservation of the murrelet, the primary threats to these elements are pollution, toxic spills, and degradation of prey habitat. Commercial and recreational fishing did not appear to be a threat to habitat at this time. Several laws specifically regulate activities that could result in pollution, toxic spills, or degradation of prey habitat in the marine environment and attempt to reduce the risk of such events. These include the Clean Water Act; the Marine Protection, Research, and Sanctuaries Act; and the Coastal Zone Management Act. Therefore, the USFWS determined that these areas do not require special management consideration or protection through designation as critical habitat.

5.6.2 Species Information

5.6.2.1 Life History

The marbled murrelet is a small seabird that feeds primarily on fish and invertebrates in nearshore marine waters. Most marbled murrelets are found within or adjacent to the marine environment, although these birds have been detected on rivers and inland lakes (Carter and Sealy 1986). Marbled murrelets spend most of their lives on the ocean and come inland to nest, although they visit some inland stands during all months of the year. Marbled murrelets have been recorded up to 50 miles (80 km) inland in Washington

(Hamer and Cummins 1991). Marbled murrelets are not evenly distributed from the coast to the maximum inland distances, with higher detections being recorded closer to the coast. Hamer and Cummins (1991) found that over 90% of all observations were within 36 miles (60 km) of the coast in the northern Washington Cascades.

Marbled murrelets do not reach sexual maturity until their second year. Like other alcids, adult marbled murrelets produce 1 egg per nest. Alcids typically have a variable (not all adults may nest every year) reproductive rate. Marbled murrelets exhibit this same trend.

Adult marbled murrelets lay 1 egg on the limb of an old-growth conifer tree. Nesting occurs over an extended period from mid-April to late September (Carter and Sealy 1987). Incubation lasts about 30 days and fledging takes another 28 days (Simons 1980, Hirsch et al. 1981). Both sexes incubate the egg in alternating 24-hour shifts (Simons 1980, Singer et al. 1991). Flights by adults are made from ocean feeding areas to inland nest sites most often at dusk and dawn (Hamer and Cummins 1991). The adults feed the chick at least once per day, carrying 1 fish at a time (Carter and Sealy 1987, Hamer and Cummins 1991, Singer et al. 1992). The young are altricial and remain in the nest longer than young of most other alcids. Before leaving the nest, the young molt into a distinctive juvenile plumage. Fledglings appear to fly directly from the nest to the sea, rather than exploring the forest environment first (Hamer and Cummins 1991).

Murrelets tend to be more vocal at sea compared to other alcids (Nelson 1997). Individuals of a pair vocalize after surfacing apart from each other (Strachan et al. 1995). Vocalizations among pairs also occur after a disturbance (Strachan et al. 1995). When pairs are separated by boats, most will vocalize and attempt to reunite (Ralph unpub. data, and Miller pers. comm. in Strachan et al.1995). Strachan et al. (1995) believe that foraging plays a major role in pairing and that some sort of cooperative foraging technique may be being employed. This is evidenced by the fact that most pairs of murrelets consistently dive together during foraging and that they often swim towards each other before diving (Carter and Sealy 1990). Pairs of birds resurface together on most dives, and Strachan et al. (1995) suggest that they may keep in visual contact underwater.

Strachan et al. (1995) defines a ‘flock’ as 3 or more birds in close proximity and maintaining that formation when moving. Various observers throughout the range of the murrelet report flocks of highly variable sizes. In the southern portion of the murrelet’s range (California, Oregon, and Washington) flocks rarely contain more than 10 birds. Larger flocks usually occur during the later part of the breeding season and may contain juvenile and subadult birds (Strachan et al. 1995).

Aggregations of foraging murrelets are probably related to concentrations of prey. In Washington, murrelets are not generally found in interspecific feeding flocks (Strachan et al. 1995). Strong and others (in Strachan et al. 1995) observed that murrelets avoid large feeding flocks of other species and presumed that the small size of murrelets may make them vulnerable to kleptoparasitism or predation in mixed species flocks. Strachan et al. (1995) pointed out that if murrelets are foraging cooperatively, then the confusion of a large flock of birds might reduce foraging efficiency.

At-sea courtship begins in early spring, continues through summer, and has also been noted in winter (Speckman 1996 and G. van Vliet pers. comm. in Nelson 1997). A sharp increase in the number of pairs displaying occurs in late July. Courtship involves bill posturing, swimming together, diving synchronously, vocalization, and chasing in flights just above the surface of the water. Copulation occurs both in trees and on the water (Nelson 1997). Observations of courtship occurring in the winter suggest that pair bonds are maintained throughout the year (Speckman 1996, and G. van Vliet pers. comm. in Nelson 1997).

Adult (after-hatch-year) murrelets have 2 primary plumage types: alternate plumage and 'basic' plumage. The alternate plumage is sometimes referred to as breeding plumage and the basic plumage is often referred to as winter plumage. Adult murrelets go through 2 periods of molt. The pre-alternate molt occurs before the breeding season. This is an 'incomplete' molt during which the birds lose their body feathers but retain their ability to fly. A complete pre-basic molt occurs after the breeding season. During this molt, the birds lose all flight feathers relatively synchronously and are flightless for up to 2 months (Nelson 1997).

Timing of molts varies from year to year and from location to location, as well as among individuals. Factors such as prey resources, stress, and reproductive success influence the timing (Nelson 1997). In general, the pre-alternate molt occurs from late February to mid-May, and prebasic molt occurs from mid-July through December (Carter and Stein 1995). However, in Washington, there is some indication that the pre-basic molt occurs from mid-July through the end of August (C. Thompson, WDFW, pers. comm. 2003).

5.6.2.2 Habitat Requirements

Marbled murrelets use older forest stands near the coastline for nesting. These forests are generally characterized by large trees (> 32 inches [80 cm] diameter at breast height), multi-storied stand, and a moderate to high canopy closure. In certain parts of the range, marbled murrelets are also known to use mature forests with an old-growth component. Trees must have large branches or deformities for nest platforms (Binford et al. 1975, Carter and Sealy 1987, Hamer and Cummins 1990, 1991; Singer et al. 1991, 1992). Marbled murrelets tend to nest in the oldest trees in the stand.

It is difficult to locate individual nests for a species that may only show activity near its nest once per day, and may do so under low light conditions. Therefore, occupied sites or suitable habitat become the most important parameters to consider when evaluating status. Strong indicators of occupied habitat are active nests, egg shell fragments or young found on the forest floor; birds seen flying through the forest beneath the canopy; birds seen landing; or birds heard calling from a stationary perch.

Marbled murrelets more commonly occupy old-growth forests compared to mixed-age and young forests in Washington. Stand size is also an important factor for marbled murrelets. They commonly occupy larger stands (> 500 acres [202 ha]). Marbled murrelets are usually absent from stands less than 80 acres (24 ha) in size (Paton and Ralph 1988, Ralph et al. 1990). In Washington, marbled murrelets are found more often when available old-growth, mature forests make up over 30% of the landscape. Similarly, fewer murrelets are found when clearcut or meadow areas make up more than 25% of the landscape (Hamer and Cummins 1990).

Concentrations of marbled murrelets offshore are almost always adjacent to older forests onshore. Nelson (1990) and Ralph et al. (1990) found marbled murrelets were absent offshore where onshore older forests were absent. Large geographic gaps in offshore marbled murrelet numbers occur in areas such as that between central and northern California (a distance of 300 miles [480 km]), and between Tillamook County, Oregon, and the Olympic Peninsula (a distance of 120 miles [190 km]), where nearly all older forest has been removed near the coast.

Although nesting occurs inland, murrelets spend most of their lives in marine waters (USDI 1992). Most surface time is spent loafing, preening, and wing stretching (Strachan et al. 1995). Marine habitat is also used for courtship activity from early spring through summer (Nelson 1997).

During the summer, murrelets primarily use bays, inlets, fjords, and open ocean within 3.1 miles (5 km) of shore and usually occur in widely dispersed concentrations of singles or pairs of birds (Nelson 1997). In Washington, murrelets are generally foraging in shallow waters within 1.2 miles (2 km) of shore (Strachan et al. 1995). Murrelets aggregate where food is clumped, but will otherwise avoid other individuals while feeding (Carter and Sealy 1990). Juveniles are found closer to shore than adults (rarely >0.6 miles [1 km] offshore) (Beissinger1995). During the breeding season, some feeding areas, referred to as 'traditional nurseries' are used consistently on a daily and yearly basis (Carter and Sealy 1990). Kuletz and Piatt (1999) found that in Alaska juvenile marbled murrelets congregated in kelp beds (*Nereocystis* sp.). Kelp beds are often associated with productive waters and may provide protection from avian predators (Kuletz and Piatt 1999). McAllister (unpub. data, in Strachan et al. 1995) found that juveniles were most common within 3,228 feet (100 m) of shorelines, particularly where bull kelp was present, and that the juveniles were less wary and more approachable by boat.

Little is known about the murrelet's marine-habitat preference during spring and fall, but is thought to be similar to that preferred during breeding (Nelson 1997). Few data are available on winter use of marine habitats. There may be a general shift from exposed outer coasts into more protected waters (Nelson 1997).

Diet

Murrelets use their wings for swimming underwater in pursuit of prey and can dive to great depths within nearshore waters. The deepest record of a marbled murrelet was from a bird captured at 89 feet (27 m) in a gill net (Carter and Erickson 1992). They seem to prefer shallow water (<196 feet [60 m] deep), but are known to forage in water up to 1,312 feet (400 m) deep (Nelson 1997). Prey is captured throughout the water column, including near the bottom (Sanger 1987 in Nelson 1997).

Throughout their range, murrelets are opportunistic feeders, using prey of diverse sizes and species. When feeding chicks, adult murrelets are restricted to selecting single fish that range from 0.8 to 2.4 inches (2-6 cm) long. This restriction forces breeding adults to exercise more specific foraging strategies when feeding chicks. As a result, the distribution and abundance of prey suitable for feeding chicks may greatly influence the overall foraging behavior during the nesting season. The availability of abundant forage fish during the nestling period may significantly reduce the energy demand on adults by reducing both foraging time and number of trips inland for feeding nestlings (USDI 1992).

Throughout the breeding season, the primary fish species taken include Pacific sand lance (*Ammodytes hexapterus*), northern anchovy (*Engraulis mordax*), Pacific herring (*Clupea harengus*), capelin (*Mallotus villosus*), surf smelt (*Hypomesus* sp.), and viviparous seaperch (*Cymatogaster aggregata*) (Nelson 1997). In winter and spring the dominant prey are euphasiids (e.g., *Thysanoessa* sp. and *Euphausia* sp.), mysids (e.g., *Acanthomysis* sp., and *Neomysis* sp.), gammarid amphipods, capelin, smelt, and herring (Burkett 1995 in Nelson 1997).

Some foraging occurs at night but murrelets forage most actively in morning and late afternoon (Strachan et al. 1995). Speckman et al. (2000) found murrelet numbers highest in the morning, declined throughout the day, and then sometimes increased slightly in the evening. They also noted that peak numbers occurred on high or falling morning tides, especially in areas with abundant Pacific sand lance.

Predation

Primary threats to murrelets in the marine environment are entanglement in nearshore fisheries nets and marine pollution. Other threats to murrelets in the marine environment include capture by fishing lures (documented in British Columbia and California), and annoyance and/or flushing by boats, commercial machinery, and recreational activities in important feeding areas (USDI 1992). Recently documented fish kills from pile driving have raised concern over the slight-to-severe impacts to murrelets that may occur as the result of some marine construction activities.

Large nearshore net fisheries occur in Washington and California. Mortality of seabirds from nearshore net fisheries can have serious impacts to local seabird populations. Net-caused mortalities of marbled murrelets have been documented in Alaska, Washington and California. Despite efforts to reduce net-caused mortality, it is likely that net mortality has had and still may have substantial impacts on murrelet populations, especially in Puget Sound (USDI 1992).

Mortality and reduced breeding success of seabirds due to marine pollution is well-known. In the 1900s, large oil spills have killed millions of seabirds worldwide. Because marbled murrelets use nearshore waters extensively, they are highly susceptible to the impacts of oil spills. Marine pollution may affect murrelets as well, though the effects have not been fully investigated (USDI 1992).

5.6.2.3 Species Occurrence in Action Areas

Monitoring of murrelet population size and status is conducted from the effectiveness monitoring program of the Northwest Forest Plan. Annual at-sea population surveys have occurred since 2000. The monitoring survey results indicate a population decline in murrelets throughout their range since 2000 (USFWS 2009). Within Puget Sound (Conservation Zone 1 - which also includes the Straits of Juan de Fuca), there is a significant decline in the population of murrelets. The mean average annual change in the number of murrelets between 2001 and 2008 was a minus 7.9%. Since 2004, data on nest success from radio telemetry and adult:juvenile ratios as an index of breeding success confirms that reproduction in Washington California is too low to sustain populations of murrelets.

No monitoring of murrelets occurs within the action areas. The action areas are included in stratum 3 of the Conservation Zone 1 effectiveness monitoring which includes all of Puget Sound south of the San Juan Islands and south Hood Canal. Five of 47 primary sampling units within stratum 3 are monitored yearly and bird densities for these sites are used throughout the stratum. Densities within stratum 3 between 2004 and 2008 ranged from 0.29 birds/km^2 in 2004 to 2.02 birds/km^2 in 2005 (Falxa et al. 2008). Mean density from 2004 through 2008 is approximately 1.2 birds/km^2.

For determining the density of murrelets for a project and an action area, the USFWS uses the mean density of the stratum for which the project is located. Therefore, the mean density of murrelets within the three action areas of Puget Sound is 1.2 birds/km^2. However, the action areas are highly urbanized, having high barge and ferry traffic, and lack forage fish which makes it unfavorable for murrelets. Forested habitat within the action areas are early-to-late successional forest and therefore not expected to be used by marbled murrelets.

5.7 Puget Sound Steelhead

5.7.1 Listing and Critical Habitat Designation

Puget Sound steelhead (*Oncorhynchus mykiss)* were listed as threatened under the ESA on May 11, 2007 (72FR26722). NMFS determined that naturally spawned winter- and summer-run steelhead populations have had widespread declines in abundance over the last 9 years (since 1996 when NMFS determined that the Puget Sound Steelhead did not warrant listing). The rule protects anadromous *O. mykiss* below longstanding impassable manmade and natural barriers. NMFS will identify areas that may warrant designation as critical habitat in a separate rulemaking decision.

5.7.2 Species Information

5.7.2.1 Life History

Oncorhynchus mykiss exhibit a complex suite of life-history traits. Even within the confines of Puget Sound and the Strait of Georgia there are considerable life-history variations. Resident *O. mykiss*, commonly called rainbow trout, complete their lifecycle completely in freshwater. Anadromous *O. mykiss*, or steelhead, may reside in freshwater for up to 7 years before migrating to the ocean for 1 to 3 years. Under some circumstances, *O. mykiss* apparently yield offspring of the opposite life-history form (i.e., steelhead offspring become resident rainbow trout, and resident rainbow trout offspring become anadromous steelhead). In contrast with other species of Pacific salmon, *O. mykiss* are iteroparous, capable of repeat spawning.

There are 2 major life-history types—stream-maturing and ocean-maturing—expressed by anadromous *O. mykiss*, related to the degree of sexual development at the time of adult freshwater entry (Smith 1969, Burgner et al. 1992). Stream-maturing steelhead, also called summer-run steelhead, enter freshwater at an early stage of maturation, usually from May to October. These summer-run steelhead migrate to headwater areas and hold for several months prior to spawning in the spring. Ocean-maturing steelhead, also called winter-run steelhead, enter freshwater from November to April at an advanced stage of maturation, spawning from March through June. While there is some temporal overlap in spawn timing between these forms, in basins where both winter- and summer-run steelhead are present, summer-run steelhead spawn farther upstream, usually above a partially impassable barrier (Behnke 1992, Busby et al. 1996). In many cases it appears that the summer migration timing evolved to access areas above a series of falls or cascades that present a velocity barrier to migration during high winter flow months (especially in rain and snow driven basins), but are passable during low summer flows. The winter-run of steelhead is the predominant run in Puget Sound, in part because there are relatively few basins in the Puget Sound ESU with the geomorphological and hydrological characteristics necessary to establish the summer-run life history. The summer-run steelhead’s extended freshwater residence prior to spawning results in higher prespawning mortality levels than those of winter-run steelhead. This survival disadvantage may explain why winter-run steelhead predominate where no migrational barriers are present (D. Rawding, WDFW, pers. comm. in BRT 2005) or freshwater migration distances to saltwater are less than 137 miles (200 km).

Steelhead spawn in late winter through spring beginning as early as January and ending in June. Peak spawning usually occurs in April and May. Females dig redds and deposit eggs in the gravel. Eggs hatch after 35 to 50 days depending upon water temperature. Alevins remain in the gravel 2 to 3 weeks until their yolk sac is absorbed and then emerge as fry and begin to actively feed.

Most steelhead juveniles reside in freshwater for 2 years before emigrating to marine habitats, with limited numbers emigrating as 1 or 3-year old smolts. Smoltification and seaward migration occur principally from April to mid-May (WDF et al. 1973). Two-year-old naturally produced smolts are usually 5 to 6 inches (140-160 mm) long (Wydoski and Whitney 2003, Burgner et al. 1992). The inshore migration pattern of steelhead in Puget Sound is not well understood; it is generally thought that steelhead smolts move quickly offshore (Hartt and Dell 1986).

Steelhead oceanic migration patterns are poorly understood. Evidence from tagging and genetic studies indicates that Puget Sound steelhead travel to the central North Pacific Ocean (French et al. 1975, Hartt and Dell 1986, Burgner et al. 1992). Puget Sound steelhead feed in the ocean for 1 to 3 years before returning to their natal stream to spawn. Typically, Puget Sound steelhead spend 2 years in the ocean.

5.7.2.2 Factors for Decline

The following factors have contributed to the decline of Puget Sound steelhead populations identified in the listing rule:

- Reduction or elimination of historically accessible habitat due to water diversions for agriculture, flood control, domestic, and hydropower purposes.
- Degradation, simplification, fragmentation, and losses of habitat from forestry, agriculture, mining, and urbanization.
- Destruction or modification of estuarine areas have resulted in the loss of important rearing and migration habitats.
- Sedimentation and degraded water quality from extensive and intensive land use activities (e.g., timber harvests, road building, livestock grazing, and urbanization).
- Migration barriers and habitat modification (hydrology, temperature, gravel and large woody debris recruitment) from large dams and other human-made barriers.
- Alteration of hydrologic, sedimentation, and stormwater pollution by loss of riparian vegetation and soils from urbanization.
- Loss and reduction of river braiding and sinuosity through land development.
- Inadequacy of existing regulatory mechanisms to reduce risks from habitat degradation from land-use activities and hatchery operations.
- Increased risks to natural populations as a result of food resource competition, increased predation, reduced genetic diversity and reproductive fitness through interbreeding, and masking of trends in natural populations through the straying of hatchery-origin fish onto spawning grounds and other fish hatchery operations.

5.7.2.3 Habitat Requirements

Steelhead use a variety of habitats throughout the freshwater portion of their life history. Small tributary streams with steep gradient (3-5%) are used for spawning and juvenile rearing (Oregon Department of Fish and Wildlife 1998). Substrate sizes no larger than four inches (10.2 cm) are preferred for spawning (Bjornn and Reiser 1991). As with all salmonid species, water temperatures and intra-gravel flow are also important for spawning and incubation. Water temperatures below 59º F (15º C) are preferred for spawning and incubation (Oregon Department of Fish and Wildlife 1998; Myrick and Cech 2001). Intra-gravel flow provides oxygen and removes metabolic waste. Substrates with low percentages (< 10%) of fines (< 0.12 in. [0.3 cm]) provide optimal gravel conditions for spawning and incubation (Raleigh et al. 1986). Water depths required for spawning vary, but range from a few inches to several feet (Bjornn and Reiser 1991, Healey 1991).

After fry emerge from the gravels, they seek complex habitat of boulders, rootwads, and woody material along the stream margins (Oregon Department of Fish and Wildlife 1998, Paron and Nelson 2001). Juvenile steelhead are year-round residents and water velocity is very important in determining habitat utilization (Placer County 2010). Shallow riffles with higher flows are used in the summer (Barnhart 1986), and all flows are used during the winter (Oregon Department of Fish and Wildlife 1998). Juvenile steelhead feed on invertebrates and, therefore, seek habitats (substrate and flows) that minimize energy expenditure (Placer County 2010).

As juveniles get older and larger they move downstream to rear in larger tributaries and mainstem rivers. Undercut banks, large woody debris, and boulders are all utilized by larger juveniles. Juvenile steelhead may stay in freshwater for up to 3 years before moving into the estuary and migrating out to sea. Smolt transformation requires cooler temperatures (43º-50º F or 6.1º-10º C) than rearing (63º-77º F or 17.2º-25ºC) (Placer County 2010). Steelhead spend little time in estuaries prior to heading out to sea (Oregon Department of Fish and Wildlife 1998, Emmett et al. 1991 in KCDNR 2001).

In estuaries, juvenile steelhead feed on gammarid amphipods, small crustaceans, insects, aquatic worms, fish eggs, and small fish. In marine waters, juvenile and adult steelhead eat fish, crustaceans, squid, herring, and insects (Emmett et al. 1991 in KCDNR 2001).

5.7.3 Species Occurrence in the Action Areas

5.7.3.1 Lake Washington Ship Canal, North Lake Washington, South Lake Washington

The Lake Washington Ship Canal, North Lake Washington, and South Lake Washington action areas are combined because they comprise the western portion of the Lake Washington basin.

Current Range

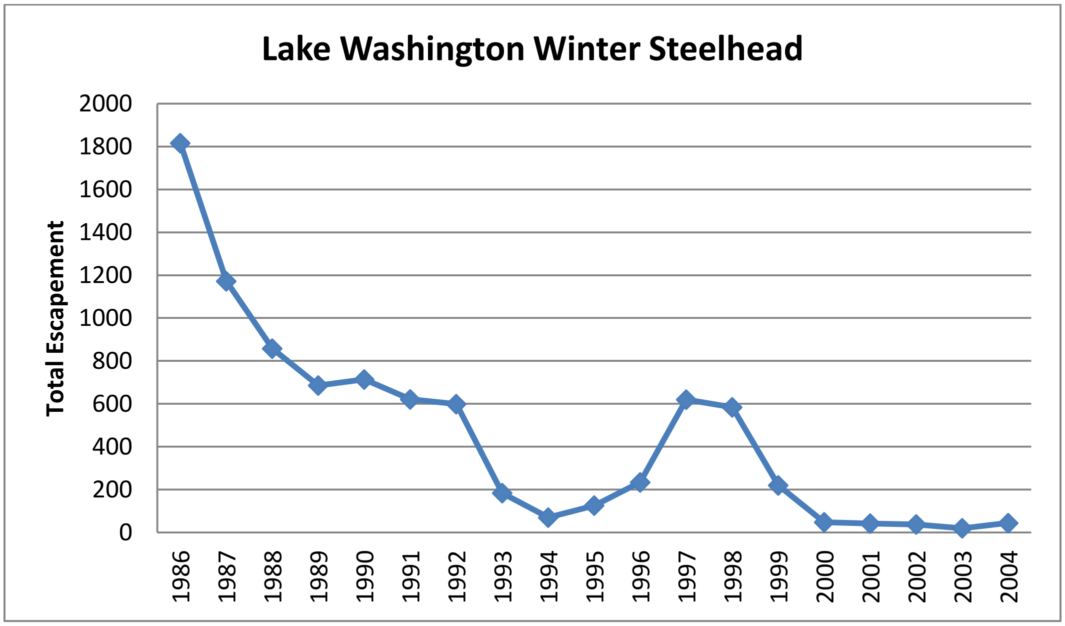
Within the tributaries of the Ship Canal, North Lake Washington, and South Lake Washington action areas, Puget Sound steelhead is limited to Thornton Creek. There have been 2 confirmed sightings of adult steelhead in Thornton Creek since 2001 (McMillan 2006). Steelhead are also found in Lake Washington and the Ship Canal.

The Washington Department of Fish and Wildlife identifies a single stock of winter steelhead within Lake Washington (WDF et al. 1993; WDFW 2010a). This stock includes spawning populations in tributaries to Lake Washington, Cedar River, Lake Sammamish, and the Sammamish River (WDF et al. 1993). The National Marine Fisheries Service identifies two stocks within Lake Washington; the Cedar River and the North Lake Washington populations (NMFS 2005). Geographical isolation exists between spawning populations in at least 8 tributaries, but the degree of straying/mixing between these populations is unknown. In 1992, the Lake Washington stock status was considered depressed because of the steep decline in numbers (18% annual decline) and the low population growth rate (NMFS 2005). In 2002, the stock status was changed to critical due to chronically low escapements and a short-term severe decline in escapement in 2000 and 2001 (WDFW 2010a). The winter steelhead population has steadily decreased since the mid-1980s (Kerwin 2001). Adult Lake Washington winter steelhead have experienced a high rate of predation by California sea lions (*Zalophus californianus*) below the fish ladder at the Locks (up to 60%) (Kerwin 2001).

The Lake Washington basin winter steelhead escapement estimates for 1986 through 2004 (WDFW 2010a) are shown in Figure 4.

Figure 4

Lake Washington basin winter steelhead escapement estimates for 1986 to 2004.



Adult steelhead begin migrating upstream through the Locks beginning in October (NMFS 2005). Smolts migrating to Puget Sound go through the Locks in mid-June to early July (Kerwin 2001). For Chinook salmon, smolts may remain in the Locks area for days to weeks while steelhead smolts may move through the Locks in hours or days.

Thornton Creek

Only 2 adult steelhead have been documented in Thornton Creek since the City of Seattle began spawning surveys in 2001, including weekly surveys after 2002. The 2 sightings include the following: a 20- to 21-inch (51-53 cm) male carcass in the mainstem downstream of 45th Avenue NE on February 7, 2002, and a 26-inch (66 cm) female carcass in the lower 1,500 ft (457 m) of the North Branch on March 30, 2004 (McMillan 2006). Although possible steelhead redds and live fish were documented in Thornton Creek from 2001 through 2004, it is likely that most of these were large adfluvial cutthroat trout from Lake Washington, which commonly spawn in Thornton Creek in the winter and spring (McMillan 2006). Adult steelhead were observed in Thornton Creek in 1991, 1992, and 1995 (Kerwin 2001). Historically, Thornton Creek probably had steelhead (Trotter 2002). In addition, Thornton Creek received state releases of hatchery-reared rainbow and cutthroat trout on and off from 1937 to 1982, including steelhead from the Seward Park Hatchery in 1937 (WDFW fish stocking records).

Drainages Outside of City Limits

Steelhead are found in a number of Lake Washington and Sammamish River tributaries including Bear Creek, Little Bear Creek, North Creek, Swamp Creek, May Creek, Mercer Slough, and Evans Creek. Abundance of steelhead within these tributaries is unknown (Kerwin 2001, NMFS 2005).

5.7.3.2 Lower Green/Duwamish

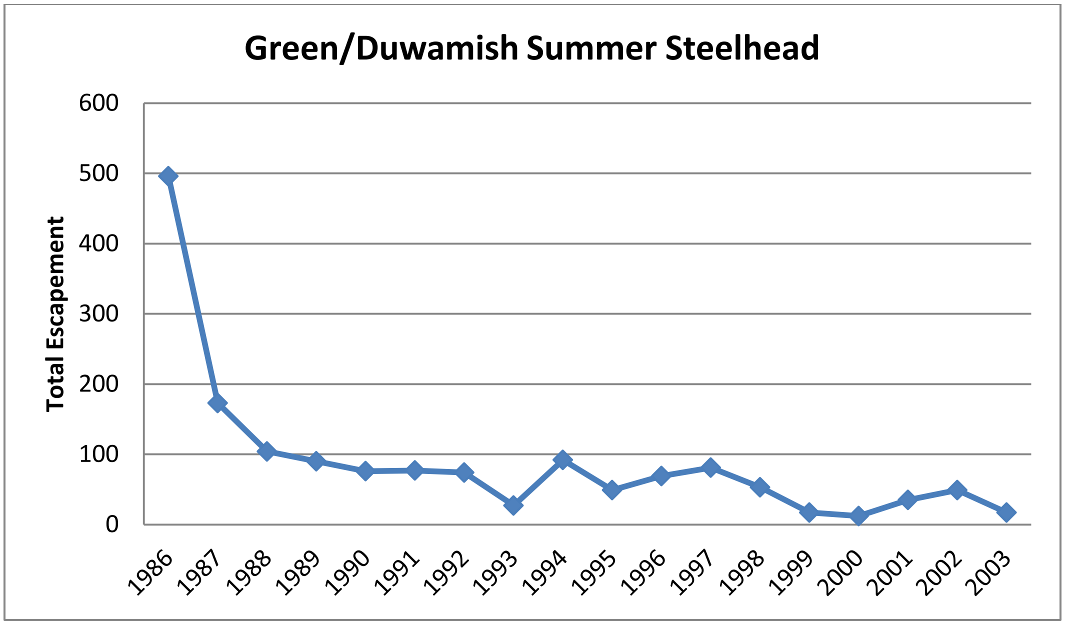
Current Range

Two stocks of Puget Sound steelhead are found within the Green/Duwamish rivers, a summer-run and a winter-run stock. Both populations were considered healthy in 1992 (WDF et al. 1993). In 2002, the status was changed to depressed based on a long-term negative trend and short-term severe decline in 1999 and 2000 in harvest (WDFW 2010a). In 2002, the winter run status stayed the same – healthy. The summer run is a non-native stock sustained by a mixture of artificial and natural production, while the winter run is a native stock, also sustained by a mixture of artificial and natural production. Population trends of Green River wild winter steelhead in the early 1990s began a steady decrease (KCDNR and WSCC 2000).

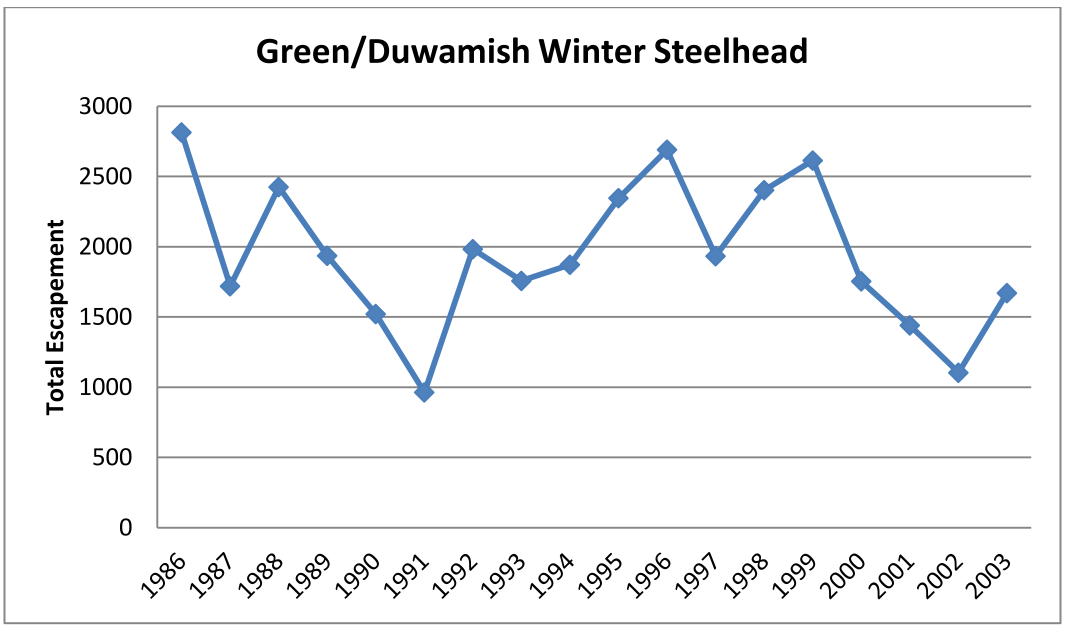
The Green/Duwamish River summer steelhead escapement estimates for 1986 through 2003 (WDFW 2010a) are shown in Figure 5.

Figure 5

Green/Duwamish River Steelhead Escapement Estimates



The Green/Duwamish summer steelhead escapement estimates for 1986 to 2003.



Green/Duwamish River winter steelhead escapement estimates for 1986 to 2003 (WDFW 2010a).

Timing of steelhead migration, spawning/incubation, and rearing varies with the summer- and winter-run stocks. The summer-run stock's upstream migration ranges from April through October, while the winter-run stock ranges from November through May. Spawning for the summer-run stock begins at the end of January and continues through March. The winter-run stock begins spawning in February and ends at the end of June. Incubation begins at the time of spawning and continues through July for the summer-run and August for the winter-run stock. Because of the steelhead life history, juvenile rearing is found throughout the year. Outmigration of juveniles begins in the middle of March and continues to the middle of July for both stocks (KCDNR 2001).

The run size for the winter-run steelhead stock in the Green/Duwamish River was 12,000 to almost 14,000 in 1977 to 1979 and has declined from 3,000 to 4,500 in 1997 and 1998, respectively (KCDNR 2001). Even with the decline in numbers of the Green/ Duwamish winter steelhead, WDFW considers the stock to be healthy (KCDNR 2001).

5.7.3.3 North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound

The North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound action areas are combined because they border Puget Sound. In Puget Sound, nearshore marine waters are important for juvenile salmon rearing, growth and migration (Mavros and Brennan 2001, Williams et al. 2001, Brennan et al. 2004, Nelson et al. 2004). Nearshore areas also provide spawning habitat for forage fish, which are important prey for steelhead.

Current Range

Observations of steelhead are spotty and confined to nearshore habitats. Steelhead have been observed south of Elliot Point, off Golden Gardens, in Shilshole Bay, at Alki Point, and within Elliott Bay at the mouth of the Duwamish River (KCDNR 2001). In a recent study of the nearshore habitat in WRIAs 8 and 9 (including Vashon and Maury Islands in WRIA 9), 591 beach seine samples were collected in 2001 and 2002 (KCDNR 2001). Almost 34,000 salmonids were caught and of these, only 9 were steelhead (Brennan et al. 2004). These steelhead were captured from May through August with no steelhead caught in April, September, October, or December. Samples were not collected in November, or January through March. Of these 9 steelhead, 3 were captured within the action area; 2 were caught at Lincoln Park in 2001, and 1 was caught at Carkeek Park in 2002.

Tributary Use

Puget Sound steelhead historically had runs in some of the smaller tributaries to Puget Sound, such as Piper's Creek (Kerwin 2001). However, these runs have become extinct. Currently, no steelhead are known to use any of the tributary streams that enter directly into Puget Sound.

5.8 Eulachon

5.8.1 Listing and Critical Habitat Designation

Eulachon (*Thaleichthys pacificus*) were listed as threatened under the ESA on May 17, 2010 (75FR13012). NMFS determined that eulachon, also known as Pacific smelt, candlefish, or Columbia River smelt, is comprised of two or more DPSs that qualify as species under the ESA. NMFS listed the southern DPS of eulachon, consisting of populations spawning in rivers south of the Nass River in British Columbia, Canada, to the Mad River in California. Major core populations for eulachon include the Columbia and Fraser rivers.

On January 5, 2011, NMFS proposed critical habitat for eulachon. Proposed designated critical habitat includes the lower Columbia River, six tributaries to the lower Columbia River, and the Elwha River on the Olympic Peninsula. The following are the 3 PCEs for **southern DPS of eulachon proposed critical habitat**:

- **Eulachon PCE #1:** Freshwater spawning and incubation sites with water flow, quality and temperature conditions and substrate supporting spawning and incubation.
- **Eulachon PCE #2:** Freshwater and estuarine migration corridors free of obstruction and with water flow, quality and temperature conditions supporting larval and adult mobility, and with abundant prey items supporting larval feeding after the yolk sac is depleted.
- **Eulachon PCE #3:** Nearshore and offshore marine foraging habitat with water quality and available prey, supporting juveniles and adult survival.

While the nearshore and offshore marine foraging habitat is essential for eulachon survival and growth to adulthood, NMFS stated they have little information on the distribution of eulachon in the marine waters and where foraging habitat might occur. Therefore, they were unable to identify any specific areas in marine waters that meet the definition of critical habitat under the ESA. NMFS will continue to gather information and will consider revising the designation of critical habitat to include portions of the marine environment necessary for the recovery of eulachon.

5.8.2 Species Information

5.8.2.1 Life History

Eulachon are anadromous fish that spawn in the lower reaches of river systems. Spawning generally occurs in rivers that are glacier-fed or have peak spring hydrographs. Eggs and larvae rapidly move out of the stream into estuaries. Imprinting is believed to be on the estuary rather than the individual streams themselves.

Entry into freshwater and spawning varies through the range of eulachon. In the Columbia River system, eulachon migrate into the river and spawn in December and January. In the Fraser River, migration and spawning occurs in April and May. Spawning occurs when water temperatures are cold. Spawning occurs at temperatures from 32 ^{o}F (0 ^{o}C), or under ice, to 45 ^{o}F (7 ^{o}C).

Most spawning occurs when eulachon are 2 or 3 years of age, with data showing that they only spawn once (Clark et al 2007). Eulachon migrate up river beyond the saltwater to spawn. Spawning occurs at night onto clean sand or small gravel (Cambria Gordon 2006). Females may release up to 25,000 eggs in flowing water and males release milt at the same time. Eggs adhere to the sand and gravel substrate.

Eggs incubate for 3 to 4 weeks depending on water temperature. Upon hatching, larvae are carried downstream to the estuary where they feed on plankton. Eulachon are a schooling fish and have been found near the ocean bottom at depths of 66 to 492 ft (20 to 150 m). When adults reach sexual maturity in late summer and early fall, they leave the schools and migrate back to the rivers to spawn.

Eulachon have numerous predators including fish, sea birds, marine mammals, and terrestrial mammals. Fish predators include white sturgeon, spiny dogfish, sablefish, salmon sharks, arrowtooth flounder, salmon, bull trout, Pacific halibut, and Pacific cod. Sea bird predators include harlequin ducks, pigeon guillemots, common murres mergansers, cormorants, gulls, and eagles. Marine mammal predators include baleen whales, orcas, dolphins, and pinnipeds. Terrestrial mammal predators include brown bears and wolves.

5.8.2.2 Factors for Decline

The primary factors responsible for the decline of the southern DPS of eulachon are the destruction, modification, or curtailment of habitat and inadequacy of existing regulatory mechanisms. Specific risks to eulachon include:

- Changes in ocean conditions due to climate change. Marine, estuarine, and freshwater habitat in the Pacific Northwest have been influenced by climate change over the past 50 to 100 years.
- Dams and water diversion for hydropower generation and flood control that block eulachon migration, alter the natural hydrograph, reduce the magnitude of spring freshets, impede or alter bedload movement, and change the composition of the river substrates important to spawning,
- Water quality degradation due to large-scale impoundments that increase water temperature. Chemical contaminants are present due to urbanization and agriculture.
- Dredging in river mouths alter spawning substrates and can directly kill eggs.
- Commercial harvest poses a risk to eulachon, although current harvest levels are magnitude lower than historic harvest levels. Recreation and tribal harvest still exist but at low intensity.
- Predation primarily from marine mammals, fishes, and birds pose a low level of risk.
- Bycatch of eulachon in commercial fisheries is a moderate risk especially in the shrimp fishery.

5.8.2.3 Habitat Requirements

Eulachon use 3 specific types of habitat: estuary, ocean, and freshwater. Each habitat is specific to certain life history stages. The larval life stage uses the estuarine habitat, as eulachon grow, they move out to the deeper ocean habitat, and adults migrate up into the estuaries and then into the streams to spawn.

Eulachon enter the estuary either during the egg stage or immediately after hatching. Eggs and larvae are swept out of the river by high spring flows. Within the estuaries, larval eulachon use the nearshore vegetation to forage and avoid predation. Prey species include phytoplankton, crustaceans such as copepods, and barnacle and worm larvae. Larval eulachon are distributed throughout the water column in the estuary, but most are found near the bottom or intermediate depths (Wilson et al. 2006).

Ocean distribution has been identified through by-catch of the shrimp fishery. Eulachon schools are found near the ocean bottom at depths of 66 to 492 ft (20 to 150 m) foraging on plankton. The migration of eulachon in the ocean is unknown.

Eulachon spend very little time in freshwater. Adults migrate into the freshwater to spawn. Spawning occurs at night or late afternoon. Spawning occurs at a variety of depths ranging from a few inches (mm) to 25 ft (7.6 m) (Wilson et al. 2006). Spawning substrates include silt, sand, gravel, cobbles and detritus. Sand is the most common substrate. Spawning reaches are typically influence by tides, but are above the saltwater wedge.

5.8.3 Species Occurrence in Action Areas

5.8.3.1 North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound

The occurrence of eulachon in Puget Sound within the action areas is considered to be rare or infrequent. Any eulachon in the action areas will be migratory fish originating from river systems outside the action area. Within the greater Puget Sound and Strait of Georgia, eulachon are known to spawn in the Frazier River, but have been identified in the Skagit Bay and in the Puyallup River (BRT 2008). Based on the proposed critical habitat designation, within Puget Sound and the Strait of Georgia, only the Elwha River on the Olympic Peninsula has spawning eulachon and habitat essential to the conservation of the species.

5.9 Bocaccio

5.9.1 Listing and Critical Habitat Designation

Bocaccio (*Sebastes paucispinis*) were listed as endangered under the ESA on April 28, 2010 (75FR22276). NMFS determined that bocaccio is comprised of three DPSs that qualify as species under the ESA; northern coastal, southern coastal, and Georgia Basin DPS. NMFS listed the Georgia Basin DPS.

No critical habitat was designated or proposed with the final rule to list bocaccio. NMFS concluded that critical habitat was not determinable at the time of listing because sufficient information was not available to assess impacts of designation and the physical and biological features essential to the conservation of the species.

5.9.2 Species Information

5.9.2.1 Life History

Bocaccio are a marine species that were once common on steep walls in Puget Sound. The maximum age of bocaccio is 45 years and they can grow to approximately 3 ft (0.9 m) in length, and 15 pounds in weight. Bocaccio mature at approximately 14 in (35.6 cm) in length. Males begin maturing at age three and females at age four. As a rockfish, bocaccio bear live young. Copulation and fertilization occurs in the fall, generally between August and November. Females produce between 20,000 to over 2 million larvae between January and April. Peak release of larvae is in February.

Upon release from the female, larvae bocaccio are pelagic, staying in the water column in the ocean, for 3.5 to 5.5 months. At this time, the juvenile bocaccio settle to shallow areas. Growth is rapid growing 0.02 to .04 in (0.56 to 0.97 mm) per day.

As juveniles grow, they migrate to deeper waters. The adults tend to stay in the same area throughout their life, moving into shallow areas during the day. Some adult bocaccios are migratory and are constantly moving from location to location.

Larval bocaccio feed on plankton floating in the water. Prey includes larval krill, diatoms and dinoflagellates. Juveniles are opportunistic feeders preying on fish larvae, copepods, and krill. Larger juveniles and adults are primarily piscivores eating other rockfish, hake, sablefish, anchovies, lanternfishes, and squid. Predators to bocaccio include Chinook salmon, terns, and harbor seals.

5.9.2.2 Factors for Decline

The primary factors responsible for the decline of the Georgia Basin DPS of bocaccio are overutilization for commercial and recreational purposes, water quality problems including low dissolved oxygen, and inadequacy of existing regulatory mechanisms. Specific risks to bocaccio include:

- Low dissolved oxygen
- Continued losses as by-catch in recreational and commercial harvest
- The reduction of kelp habitat necessary for juvenile recruitment.

5.9.2.3 Habitat Requirements

Rockfish are the most common bottom and mid-water dwelling fish. Adult rockfish use various coastal benthic habitats such as kelp forests, rock reefs, and rocky outcrops at depths that can exceed 980 ft (299 m). Larvae are found in the surface waters and dispersal of rockfish are influenced by diel, tidal, or vertical migration.

Juveniles and subadults are common in the shallow water associated with rocky reefs, kelp canopies, and artificial structures such as piers. Adults generally move into deeper water as they increase in size and age, and many exhibit strong site fidelity to rocky bottoms and outcrops. Adult bocaccio are generally associated with hard substrate, but will move into mud flats.

5.9.3 Species Occurrence in Action Areas

5.9.3.1 North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound

Bocaccio occurrence in the Georgia Basin is limited to certain areas. Bocaccio made up 8% to 9% of the Puget Sound recreational catch in the late 1970s, with the majority of the fish caught in the areas around Point Defiance and the Tacoma Narrows in the South Basin. Bocaccio are rare in the North Puget Sound.

Adult bocaccio have been documented within Elliott Bay (Washington et al., 1978, WDFW unpublished data, Dinnel et al., 1986). Portions of the City of Seattle shoreline, including Elliott Bay, that support kelp will also support juvenile bocaccio, particularly during spring and summer. Larval rockfish have been document within Elliott Bay, but were not documented to species (Waldron 1972). Larvae bocaccio could occur within the action areas throughout the year.

5.10 Canary Rockfish

5.10.1 Listing and Critical Habitat Designation

Canary rockfish (*Sebastes pinniger*) were listed as threatened under the ESA on April 28, 2010 (75FR22276). NMFS determined that canary rockfish is comprised of two DPSs that qualify as species under the ESA; coastal and Georgia Basin DPS. NMFS listed the Georgia Basin DPS.

No critical habitat was designated or proposed with the final rule to list canary rockfish. NMFS concluded that critical habitat was not determinable at the time of listing because sufficient information was not available to assess impacts of designation and the physical and biological features essential to the conservation of the species.

5.10.2 Species Information

5.10.2.1 Life History

Canary rockfish were once considered fairly common in the greater Puget Sound area. Canary rockfish maturity ranges from 3 to 13 years of age. Females produce between 260,000 and 1.9 million eggs per year. Fertilization begins in September. In Washington, parturition, birth of young, is between September and March with peaks in December and January.

Canary rockfish tend to move to deeper water as they grow larger. They can be both transient and resident. Transient canary rockfish have been found to move up to 435 mi (700 km) over several years. There is also some seasonal migration where canary rockfish can be found at depths of 525 to 689 ft (160 to 210 m) in winter to 328 to 558 ft (100 to 170 m) in summer.

Larvae are planktivores feeding on nauplii and other invertebrate eggs and copepods. Juveniles are zooplanktivores feeding on crustaceans, barnacle cyprids, and euphasiid eggs and larvae. Adults are planktivores/carnivores consuming euphasiids and other crustacean and small fish. Predators on juvenile canary rockfish include other fishes, lingcod, cabezon and salmon, as well as birds and porpoise.

5.10.2.2 Factors for Decline

The primary factors responsible for the decline of the Georgia Basin DPS of canary rockfish are overutilization for commercial and recreational purposes, water quality problems including low dissolved oxygen, and inadequacy of existing regulatory mechanisms. Specific risks to canary rockfish include:

- Low dissolved oxygen
- Continued losses as by-catch in commercial and recreational harvest
- Loss of near shore habitat
- Chemical contamination,

5.10.2.3 Habitat Requirements

Adult canary rockfish are most common at depths of 262 to 656 ft (80 to 200 m) but have been found as deep as 1,440 ft (439 m). Juveniles are found in the intertidal, in surface water, and occasionally as deep as 2,749 ft (838 m).

Larvae and pelagic juveniles are found in the upper 328 ft (100 m) of the water column. Larvae remain in the upper water column from 1 to 4 months after which they settle to tide pools, rocky reefs, kelp beds, low rock and cobble areas. Juveniles may occur in groups near the rock-sand interface in 49 to 66 ft (15-20 m) depth during the day and then move into sandy areas at night. Juveniles remain on rocky reefs in shallower areas for up to three years before moving to deeper waters. Fish move to deeper waters as they increase in size. Adults are found on the rocky shelf and pinnacles.

5.10.3 Species Occurrence in Action Areas

5.10.3.1 North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound

Canary rockfish were consistently observed in the recreational catch in the mid-1960s. Canary rockfish were 1-2% of the catch in Puget Sound Proper (south of Admiralty Inlet) and 2-5% in north Puget Sound. Canary rockfish have become less frequent in the recreational catch since 1965. From 1980-1989, they were reported at a frequency of

1.1% and 1.4% in south and north Puget Sound respectively. From 1996-2001, they were reported at frequencies of less than 0.73%.

Canary rockfish have been documented in the Strait of Georgia, but most research focuses on the areas west of Vancouver Island and in Queen Charlotte Strait. Adult canary rockfish have been documented within Elliott Bay (Washington et al., 1978, WDFW unpublished data, Dinnel et al., 1986). Portions of the shoreline of Elliott Bay that support kelp will also support juvenile canary rockfish, particularly during spring and summer. Larval rockfish have been document within Elliott Bay, but were not documented to species (Waldron 1972). Larvae canary rockfish could occur within Elliott Bay throughout the year.

5.11 Yelloweye Rockfish

5.11.1 Listing and Critical Habitat Designation

Yelloweye rockfish (*Sebastes ruberrimus*) were listed as threatened under the ESA on April 28, 2010 (75FR22276). NMFS determined that yelloweye rockfish is comprised of two DPSs that qualify as species under the ESA; coastal and Georgia Basin DPS. NMFS listed the Georgia Basin DPS.

No critical habitat was designated or proposed with the final rule to list the yelloweye rockfish. NMFS concluded that critical habitat was not determinable at the time of listing because sufficient information was not available to assess impacts of designation and the physical and biological features essential to the conservation of the species.

5.11.2 Species Information

5.11.2.1 Life History

Yelloweye rockfish are rare in Puget Sound. Yelloweye rockfish are internally fertilized and can store sperm for several months until fertilization occurs, commonly between the months of September and April. Birth occurs in early spring to late summer. Maturity ranges from 15 to 20 years of age. Females can produce from 1.2 to 2.7 million eggs over a reproductive season. In Puget Sound, there is evidence of at least two spawning periods per year.

Yelloweye rockfish are opportunistic feeders, targeting different food sources at different phases of their life history. Juveniles are zooplanktivores feeding on crustaceans, barnacle cyprids, and euphasiid eggs and larvae. Because adult yelloweye rockfish obtain such large sizes, they are able to handle much larger prey, including smaller yelloweye, and are preyed upon less frequently, though predation of killer whales on yelloweye rockfish has been reported. Typical prey of adult yelloweye rockfish include sand lance, gadids, flatfishes, shrimp, crabs, and gastropods.

5.11.2.2 Factors for Decline

The primary factors responsible for the decline of the Georgia Basin DPS of yelloweye rockfish are overutilization for commercial and recreational purposes, water quality problems including low dissolved oxygen, and inadequacy of existing regulatory mechanisms. Specific risks to yelloweye rockfish include:

- Low dissolved oxygen
- Continued losses as by-catch in commercial and recreational harvest

- Loss of near shore habitat
- Chemical contamination.

5.11.2.3 Habitat Requirements

Yelloweye rockfish use a broad range of depths throughout their life history. Juveniles can be found at depths of 49 ft (15 m) and adults up to 1,801 ft (549 m). Adults are most commonly found between 299 and 591 ft (91 and 180 m).

Juvenile yelloweye rockfish habitat includes shallow water, high relief zones, and crevices. Adults are associated with rocky, high relief areas. Adults have a high affiliation with caves and crevices while spending large amounts of time lying at the base of rocky pinnacles and boulder fields.

Larvae are pelagic for up to 2 months. Juvenile move from the shallow rock reefs to deeper pinnacles and rocky habitats as they get larger. Yelloweye rockfish adults are not known to migrate and are considered to be site-attached.

5.11.3 Species Occurrence in Action Areas

5.11.3.1 North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound

Yelloweye rockfish caught in the recreational fishery in the mid-1960s were similar to the canary rockfish. Yelloweye rockfish comprised 1-2% of the catch in Puget Sound Proper and 2-5% in north Puget Sound. The frequency of yelloweye rockfish in Puget Sound Proper appears to have increased from a frequency of 0.34% in 1980-1989 to a frequency of 2.7% in 1996-2001.

Adult yelloweye rockfish have been documented within Elliott Bay (Washington et al., 1978, WDFW unpublished data, Dinnel et al., 1986). Juvenile yelloweye rockfish do not typically occupy shallow waters (Love et al., 1991) and are very unlikely to be in Elliott Bay. Larval rockfish have been documented within Elliott Bay, but were not documented to species (Waldron 1972). Larvae yelloweye rockfish could occur within Elliott Bay throughout the year.

Table 5-3 provides a quick reference for listed species and designated critical habitat within the City of Seattle action areas.

Table 5-3

Quick reference for ESA-listed species and critical habitat in the Seattle action areas. For smaller streams within the larger action area, please see appropriate section in the SBE for presence of ESA-listed species. (Shading indicates presence in action area)

		Action Area							
		Elliott Bay	Lake Washington Ship Canal	Lower Green/ Duwamish	North Seattle/ Puget Sound	North Lake Washington		South Seattle/ Puget Sound	South Lake Washington
							Thornton Ck		
Puget Sound Chinook Salmon 	Species								
	Critical Habitat								
Coastal-Puget Sound Bull Trout 	Species								
	Critical Habitat								
Killer Whale 	Species								
	Critical Habitat								
Steller Sea Lion									
Humpback Whale									

		Action Area							
		Elliott Bay	Lake Washington Ship Canal	Lower Green/ Duwamish	North Seattle/ Puget Sound	North Lake Washington		South Seattle/ Puget Sound	South Lake Washington
							Thornton Creek		
Marbled Murrelet 									
Puget Sound Steelhead 									
Eulachon 	**Species**								
	Critical Habitat								
Bocaccio 									
Canary Rockfish 									
Yelloweye Rockfish 									

Section 6

Environmental Baseline

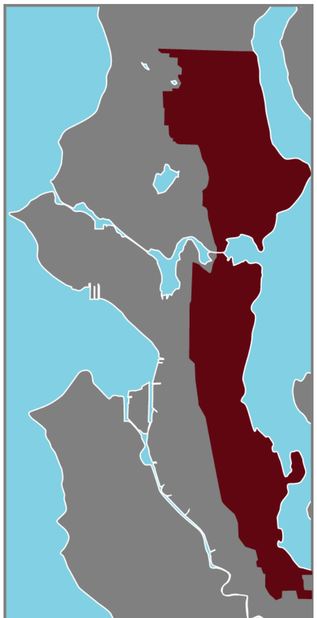
This section describes the current environmental conditions of the seven action areas of the SBE. The environmental baseline provides the foundation for analyzing proposed changes in the action area and benefits or impacts to listed species. Action areas have been combined when the current conditions within those areas affect a larger or common waterbody (*e.g.*, Lake Washington and Puget Sound). The following are the seven action areas for the Seattle Biological Evaluation (see Figure 1).

1. North Lake Washington
2. South Lake Washington
3. Lake Washington Ship Canal
4. Lower Green/Duwamish
5. North Seattle/Puget Sound
6. South Seattle/Puget Sound
7. Elliott Bay

There are 49 stream systems within the City of Seattle (Tabor *et al* 2006). Five of these streams are considered major watersheds based on the size of the watershed and amount of available stream habitat. These environmental baseline conditions of the five streams are described below in the action area they are found. The other streams are mentioned but not described. Fish species found within these streams are provided.

6.1 North Lake Washington and South Lake Washington Action Areas

The North Lake Washington and South Lake Washington action areas are combined for the purposes of this section because they experience similar environmental conditions.



North Lake Washington and South Lake Washington Action Areas

Lake Washington is part of Water Resource Inventory Area (WRIA) 8. WRIA 8 also includes the Sammamish River and Lake Sammamish, their tributaries, and the Cedar River watershed. Lake Washington is the largest lake in Washington State west of the Cascade Mountains, with a surface area of 22,138 acres (8,959 ha). It is about 20 miles (32.2 km) long with over 50 miles (80.5 km) of shoreline. Mercer Island in the southern part of the lake has an additional 30 miles (48.3 km) of shoreline. The City of Seattle borders the west side of the lake with 20.1 miles (32.3 km) of shoreline within the city limits. The main inflow to the system is the Cedar River, which was rerouted from the Green/Duwamish watershed to flow into the southeast corner of Lake Washington in 1916. The Cedar River contributes about 53% of the lake's mean annual inflow. The Sammamish River flows into the northeast corner of Lake Washington and contributes about 27% of the inflow. Numerous other small tributaries, including Thornton, Taylor, Juanita, Kelsey, Lyon and May creeks, also drain into Lake Washington. Thornton and Taylor creeks are the major City of Seattle creeks that drain to Lake Washington (see Figure 2).

The Lake Washington shoreline has been dramatically altered over the last 100 years. The physical changes that have occurred include lowering of the lake, loss of riparian vegetation, loss of large woody debris, modification of the substrate composition in front of bulkheads, shading of shallow water areas by overwater structures, the addition of new types of habitats (piers and pilings), and a reduction in the amount of shallow water habitat that is available to juvenile salmon (Warner and Fresh 1998, Kahler *et al.* 2000).

Before 1916, Lake Washington drained through the Black River into the Duwamish River and then into Elliott Bay. However, with construction of the Lake Washington Ship Canal (Ship Canal) in 1916, Lake Washington's outlet to Puget Sound became the Ship Canal. The Hiram M. Chittenden Locks (Locks) system maintains a higher water level in the Ship Canal and Lake Washington than in the tidally-influenced area of Puget Sound, just west of the Locks.

Fourteen streams are located within the North Lake Washington (four streams) and South Lake Washington (ten streams) action areas. Thornton Creek (North Lake Washington) and Taylor Creek (South Lake Washington) are described below. Table 6-1 identifies the location of the other streams and any fish species found within the stream (Tabor *et al* 2006).

Table 6-1 **Smaller streams and fish present within the North Lake Washington and South Lake Washington action areas.**		
Stream	Action Area	Fish Species Present
Inverness Creek	North Lake Washington	None
Yesler Creek	North Lake Washington	Not accessible
Ravenna Creek	North Lake Washington	Rainbow trout
Washington Park Creek	South Lake Washington	Cutthroat trout Prickly sculpin Threespine stickleback Smallmouth bass Goldfish Brown bullhead Common carp
Interlaken Creek – East Reach	South Lake Washington	None
Interlaken Creek – Middle Reach	South Lake Washington	None
Interlaken Creek – West Reach	South Lake Washington	None
Madrona Creek	South Lake Washington	None
Unnamed Creek LW01	South Lake Washington	None
Frink Creek	South Lake Washington	None
Mount Baker Creek	South Lake Washington	None
Mapes Creek	South Lake Washington	Threespine stickleback

6.1.1 Water Quality

Although the watershed is highly urbanized, the current status of water quality in Lake Washington is generally very good. This is due in part to the high quality of water entering Lake Washington from tributaries such as the Cedar and Sammamish rivers. In addition, water quality in Lake Washington was dramatically improved when wastewater was diverted away from the lake by King County (formerly Metro) in the 1960s. However, localized water and sediment quality problems such as elevated concentrations of metals, bacteria, nutrients, and organic compounds have been found in the vicinity of major storm drain and combined sewer overflows (CSO) during storm events (EVS 2000).

King County (2003) noted that Lake Washington rapidly recovered from the eutrophic conditions that existed in the 1950s and 1960s after wastewater diversion. The report also noted a recent trend of decreasing total phosphorus concentrations between 1993 and 2001. From 1990 to 2001, whole-lake total phosphorus concentrations averaged 15 µg/L during January when the lake is well mixed. Likewise, summer total phosphorus concentrations have averaged 16 µg/L over the same time period. These total phosphorus levels along with dissolved oxygen concentrations and deficit rates indicate that Lake Washington is in a mesotrophic (aging) condition (King County 2003). However, the study noted that because Lake Washington is sensitive to phosphorus loading, particularly from external sources, holding phosphorus loadings at or below current levels will be key to maintaining present day water quality conditions (King County 2003).

Lake Washington is on the 2008 Ecology 303(d) list of threatened and impaired waterbodies for water, sediment, fish tissue, and habitat. The 303(d) listings are summarized in Table 6-2.

Table 6-2

Summary of 303(d) listings for Lake Washington

	Category		
Media	**2[1]**	**4C[2]**	**5[3]**
Water	Ammonia-N Fecal coliform bacteria Lead Mercury Total PCBs		Fecal coliform bacteria Total Phosphorus
Sediment	Sediment bioassay		Sediment bioassay
Fish tissue	2,3,7,8-TCDD TEQ		Total PCBs 2,3,7,8-TCDD 4,4'-DDT 4,4'-DDE Total Clordane
Habitat		Invasive Exotic Species	

[1]Water of concern – water body shows evidence of a water quality problem, but pollution level is not high enough to violate the water quality standard, or there may not be enough violations to categorize it as impaired.

[2]Water body is impaired by a non-pollutant that cannot be addressed through a water quality improvement project (total maximum daily load (TMDL) or pollution control program).

[3]Water body has violated water quality standards and no TMDL or pollution control program has been developed for the pollutant.

Source: Ecology 2008

Most of the Seattle area swimming beaches (Magnuson Beach off-leash area, Matthews Beach, Madison Beach, Mount Baker Park, Seward Park, and Pritchard Park) are listed as impaired waterbodies (Category 5) for fecal coliform bacteria. Madrona Beach is listed as a water of concern (Category 2) for fecal coliform bacteria.

6.1.2 Sediment Quality

Sediment in Lake Washington contains elevated concentrations of metals, tributyltin, polychlorinated biphenyls (PCBs), polynuclear aromatic hydrocarbons (PAHs), phthalates, and dibenzofuran (Moshenberg 2004). Samples were collected in 1999 to 2001 from multiple sites throughout Lake Washington (including ten stations along the Seattle shoreline) and tested for metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc), semivolatile organic compounds, pesticides, and PCBs. In the absence of freshwater sediment standards, a sediment quality triad analysis—which uses sediment chemistry, bioassays, and benthic data—was used to evaluate toxicity. The most impacted sites in Lake Washington are located near the Henderson combined sewer overflow and the Sayer site, which is the area used to prepare boats for the Seafair hydroplane races (Moshenberg 2004).

The Washington State Department of Health has recently issued advisories against the consumption of the northern pike minnow (squawfish) that come from Lake Washington due to observed bioaccumulation of PCBs and mercury (WDOH 2005). Other species that were found to have elevated PCB concentrations were large yellow perch greater than 10.5 inches (25.4 cm) and large cutthroat trout greater than 12 inches (30.5 cm). The study advises only a moderate consumption of these species of fish (WDOH 2005).

6.1.3 Shoreline and Aquatic Habitat

Lowering Lake Washington exposed 1,334 acres (540 ha) of shallow water habitat, reducing lake surface area by 7%, and decreasing the shoreline by 10.5 miles (16.9 km), a 12.8% reduction (Chrzastowski 1981). The most extensive changes occurred in the sloughs, delta areas, and shallows of the lake. The area of freshwater marshes decreased from an estimated 1,136 acres (460 ha) before construction of the Locks to 74 acres (30 ha) by the early 1980s (Chrzastowski 1981). The mouths of tributaries entering the lake have moved some distance to the new lake shoreline, often across what had previously been a relatively shallow sloped alluvial delta (Warner and Fresh 1999). Historically, the mouths of the tributaries often presented fish passage problems due to shallow depth. Some of these areas continue to present fish passage problems today. New wetlands and riparian zones have developed in the former shallow-water habitats of Union Bay and Portage Bay since the Ship Canal was completed (Dillon *et al.* 2000).

Lake Washington water level elevations are maintained through conjunctive operation of the Ship Canal's large and small locks, spillway gates, smolt passage flumes, and saltwater drain system. The water level typically fluctuates 2 feet (0.6 m) each year, from a low of 20 feet (6 m) in December to a high of 22 feet (6.7 m) (Corps datum) in May. There are 4 periods of seasonal operation:

1. The spring refill period from February 15 until May 1, when the lake level is allowed to rise to 22 feet (6.7 m)
2. The summer conservation period, when the lake level is maintained at 22 feet (6.7 m) as long as possible, and involuntary drawdown begins usually in late June or early July

3. The fall drawdown period beginning at the onset of the autumn rains and continuing until December 1
4. The winter holding period, from December 1 through February 15, when the lake level is maintained at 20 feet (6.1 m)

The shoreline riparian and littoral (intertidal) zones of Lake Washington have undergone considerable change since pre-settlement times. Shoreline vegetation has changed dramatically from a dense undergrowth of small trees, brush, and tule grass to landscaped residential properties with bulkheads where most natural vegetation has been removed. An estimated 81% of the shoreline in Lake Washington east of the Montlake Cut has bulkheads and more than 2,700 residential piers (NMFS 2007). Eurasian water-milfoil dominates the aquatic vegetation in the shallow-water habitat along the shoreline. Milfoil has replaced the native aquatic vegetation and altered the substrate characteristics of much of the littoral zone of the lake (Patmont *et al.* 1981).

6.1.4 Habitat Access: Barriers

Lake Washington has no physical barriers to salmonid migration. Water temperatures during the summer and early fall may be too high and may impede fish migration in the Ship Canal (see section 6.2.1, Water Quality).

6.1.5 Non-Native and Predator Fish in Lake Washington

The Lake Washington Basin contains more than 50 freshwater and anadromous fish species (Table 6-3). More than 20 of these species are non-native species introduced into the system by agencies and private individuals over the last 140 years. Cutthroat trout, and possibly prickly sculpin, appear to exhibit the greatest predation rate overall in Lake Washington.

Predation rates in Lake Washington may have increased due to four major factors (City of Seattle 2003). First is that littoral zone habitats have been extensively modified over the last 100 years with the changes in lake level; construction of piers, docks, and bulkheads; removal of large woody debris; and the expansion of milfoil. Second is the population size of predator species. Third is the effect of water temperature on predator consumption rates. An increase in water temperatures increases the metabolic rate of predators, increasing consumption rates. Fourth is the introduction of non-native, piscivorous fish into Lake Washington. Non-native piscivores introduced into Lake Washington include smallmouth bass, largemouth bass, rainbow trout (which can only be sustained by hatchery releases), hatchery-produced Chinook and coho salmon, and yellow perch.

Table 6-3

Migratory and freshwater fish of the Lake Washington basin

Common name	Scientific name	Life-history strategy
Native Species		
Western brook lamprey	*Lampetra richardsoni*	Stream resident
Pacific lamprey	*Lampetra tridentate*	Anadromous
River lamprey	*Lampetra ayresi*	Anadromous

Common name	Scientific name	Life-history strategy
White sturgeon	*Acipenser transmontanus*	Anadromous
Pygmy whitefish	*Prosopium coulteri*	Adfluvial
Mountain whitefish	*Prosopium williamsoni*	Fluvial
Cutthroat trout	*Oncorhynchus clarki clarki*	Anadromous, adfluvial, resident
Steelhead and rainbow trout	*Oncorhynchus my kiss*	Anadromous, adfluvial, resident
Dolly Varden	*Salvelinus malma*	Anadromous
Bull trout	*Salvelinus confluentus*	Adfluvial, anadromous
Coho salmon	*Oncorhynchus kisutch*	Anadromous
Chinook salmon	*Oncorhynchus tshawytscha*	Anadromous
Sockeye salmon and kokanee	*Oncorhynchus nerka*	Anadromous, adfluvial, resident
Chum salmon	*Oncorhynchus keta*	Anadromous
Pink salmon	*Oncorhynchus gorbuscha*	Anadromous
Longfin smelt	*Spirincus thaleichthys*	Anadromous, adfluvial
Redsided shiner	*Richardsonius balteatus*	Resident
Longnose dace	*Rhinichthys cataractae*	Resident
Northern squawfish	*Ptychocheilus oregonensis*	Lake resident
Peamouth chub	*Mylocheilus caurinus*	Lake resident
Speckled dace	*Rhinichthys osculus*	Resident
Largescale sucker	*Catastomus macrocheilus*	Resident
Three-spine stickleback	*Gasterosteus aculeatus*	Resident
Coastrange Sculpin	*Cottus aleuticus*	Resident
Shorthead sculpin	*Cottus confuses*	Resident
Torrent sculpin	*Cottus rhotheus*	Stream resident
Prickly sculpin	*Cottus asper*	Resident
Riffle sculpin	*Cottus gulosus*	Stream resident
Reticulate sculpin	*Cottus perplexus*	Resident

Common name	Scientific name	Life-history strategy
Olympic mudminnow	*Novumbra hubbsi*	Stream resident
Non-Native Species		
American shad	*Alosa sapidissima*	Anadromous
Lake whitefish	***Coregonus clupeaformis***	Lake resident
Brown trout	*Salmo trutta*	Adfluvial, anadromous
Atlantic salmon	*Salmo salar*	Anadromous
Brook trout	*Salvelinus fontinalis*	Stream resident
Lake trout	*Salvelinus namaycush*	Lake resident
Weather loach	*Misgurnus anguillicaudatus*	Lake resident
Common carp	*Cyprinus carpio*	Lake resident
Grass carp	*Ctenopharyngodon idella*	Lake resident
Goldfish	*Carassius auratus*	Stream or lake resident
Tench	*Tinca tinca*	Lake resident
Channel catfish	*Ictalurus punctatus*	Lake resident
Brown bullhead	*Ameiurus nebulosus*	Lake resident
Black bullhead	*Ameiurus melas*	Lake resident
Largemouth bass	*Micropterus salmoides*	Stream or lake resident
Smallmouth bass	*Mictropterus dolomieu*	Stream or lake resident
Black crappie	*Pomoxis nigromaculatus*	Lake resident
White crappie	*Pomoxis annularis*	Lake resident
Warmouth	*Lempomis gulosus*	Lake resident
Bluegill	*Lepomis macrochirus*	Lake resident
Pumpkinseed sunfish	*Lepomis gibbosus*	Lake resident
Yellow perch	*Perca flavescens*	Lake resident
Chinese weather loach	*Misgurnus Angullicaudatus*	Lake resident
Walleye	*Sander vitreus*	Stream or lake resident

Source: American Fisheries Society 1991

Extensive sampling of 1,875 predators in southern Lake Washington from February to June 1995 to 1997 found only 15 juvenile Chinook salmon in the stomachs of cutthroat trout, prickly sculpin, smallmouth bass, and largemouth bass. Most of the predation loss was attributed to prickly sculpin, a substantially larger population than the other predators. Predatory fishes were thought to have consumed fewer than 10% of juvenile Chinook salmon that entered the lake from the Cedar River (Tabor *et al.* 2004c). Smallmouth bass become more prevalent in shallow areas in May and June and were always associated with an overhead structure (Tabor and Piaskowski 2002).

Both smallmouth bass and juvenile Chinook salmon may be found in the littoral zone from January until mid-May. However, predation rates are low primarily due to low water temperatures. Bass consumption rates increase as water temperatures warm. Smallmouth bass prefer temperatures above 68º F (20º C) when they feed most actively, and feed little when temperatures are below 50º F (10º C) (Wydoski and Whitney 2003).

In mid-May, water temperatures warm, which results in increased consumption rate of smallmouth bass, but at this time, Chinook salmon begin to move into deeper water (Tabor *et al.* 2004c). In addition, juvenile Chinook tend to use finer substrates than do bass and cottids (Tabor et al. 2004c). Smallmouth bass tend to use shoreline areas devoid of vegetation and composed of gravel and cobble that have a gradual slope and a drop-off (Pflug and Pauley 1984). Table 6-4 summarizes lake residency findings for juvenile salmon (Tabor *et al.* 2004c).

Table 6-4

Lake Washington residency findings for juvenile salmon predation

Parameter	**Finding**
Habitat	The influence of habitat on juvenile salmon survival to outmigration is linked to habitat overlap with predators. Some degree of habitat segregation occurs that may limit predation mortality for young-of-year outmigrants.
Water Temperature	Influences the extent to which juvenile salmon use shoreline habitat. As temperatures warm, juveniles appear to use deeper water.
	Influences smallmouth and largemouth bass habitat use, consumption rates, and activity level. At lower temperatures (50 ºF or 10 ºC), bass tend to be inactive. Bass prefer temperatures about 68 ºF or 20 ºC or higher.
	May be an important control on predation rate. At lower temperatures, juvenile salmon and bass may use similar habitat, but feeding rate is low. At warmer temperatures, feeding rates increase, but juvenile salmon may be less common in the best bass habitat, and move to deeper water.
Substrate	Young-of-year Chinook salmon tend to use openwater areas with finer gravel and sand substrates. They will use woody debris for cover during the day. They generally avoid overwater structures. As they grow, they move to deeper water.
	Bass tend to use areas with coarser substrates or aquatic vegetation and are less likely to avoid overwater structures.

Parameter	Finding
Age	Chinook juveniles can aggregate and feed near the surface during the day.
	Predation rate reflects body size of predator species and juvenile salmon. Larger cutthroat trout are found in the limnetic zone, whereas smaller trout tend to be found in the littoral zone. Most consumed salmon during the spring appear to be young-of-year fish.
	Population level predation rates overall may be small for young-of-year salmon. Fewer than 10% of juveniles entering Lake Washington from the Cedar River may be consumed by piscivorous fish.
Source: Tabor *et a*l 2004c	

6.1.6 Thornton Creek (North Lake Washington Action Area)

The Thornton Creek system, located in northeast Seattle, drains a 7,402-acre (2,995 ha) watershed (Figure 6). Thornton Creek has a channel length of 20.7 miles (33.3 km), which includes two main forks, the North Branch and the South Branch (otherwise known as Maple Leaf Creek), and 20 tributaries. About 53% of the land use in Thornton Creek watershed is residential (single- and multi-family), 26% is dedicated to roads and rights-of-way, and 8% is commercial and industrial. Only 9% of the watershed area is in parks, green space or vacant land.

6.1.6.1 Water Quality

Thornton Creek has a large number of storm drains that deliver stormwater runoff to the watercourse. Two hundred sixteen storm drains flow into the creek. No combined sewer overflows exist in Thornton Creek.

Thornton Creek is on the 2008 Ecology 303(d) list of threatened and impaired waterbodies. The 303(d) listings are summarized in Table 6-5.

Table 6-5

Summary of 303(d) listings for Thornton Creek (including S.F. Thornton Creek and Maple Leaf Creek)

	Category	
Media	**2[1]**	**5[2]**
Water	Mercury Dissolved oxygen Lead	Temperature Dissolved oxygen Fecal coliform bacteria

[1]Water of concern – water body shows evidence of a water quality problem, but pollution level is not high enough to violate the water quality standard, or there may not be enough violations to categorize it as impaired.

[2]Water body has violated water quality standards and no TMDL or pollution control program has been developed for the pollutant.

Source: Ecology 2008

King County has been collecting monthly samples near the mouth of Thornton Creek since about 1972. Samples are analyzed for conventional water quality indicators (temperature, dissolved oxygen, fecal coliform bacteria, pH, total suspended solids, and turbidity), metals, and nutrients. Summary statistics for conventional water quality parameters from monthly samples collected by King County (undated) between 1972 and 2005 are shown in Table 6-6.

Table 6-6

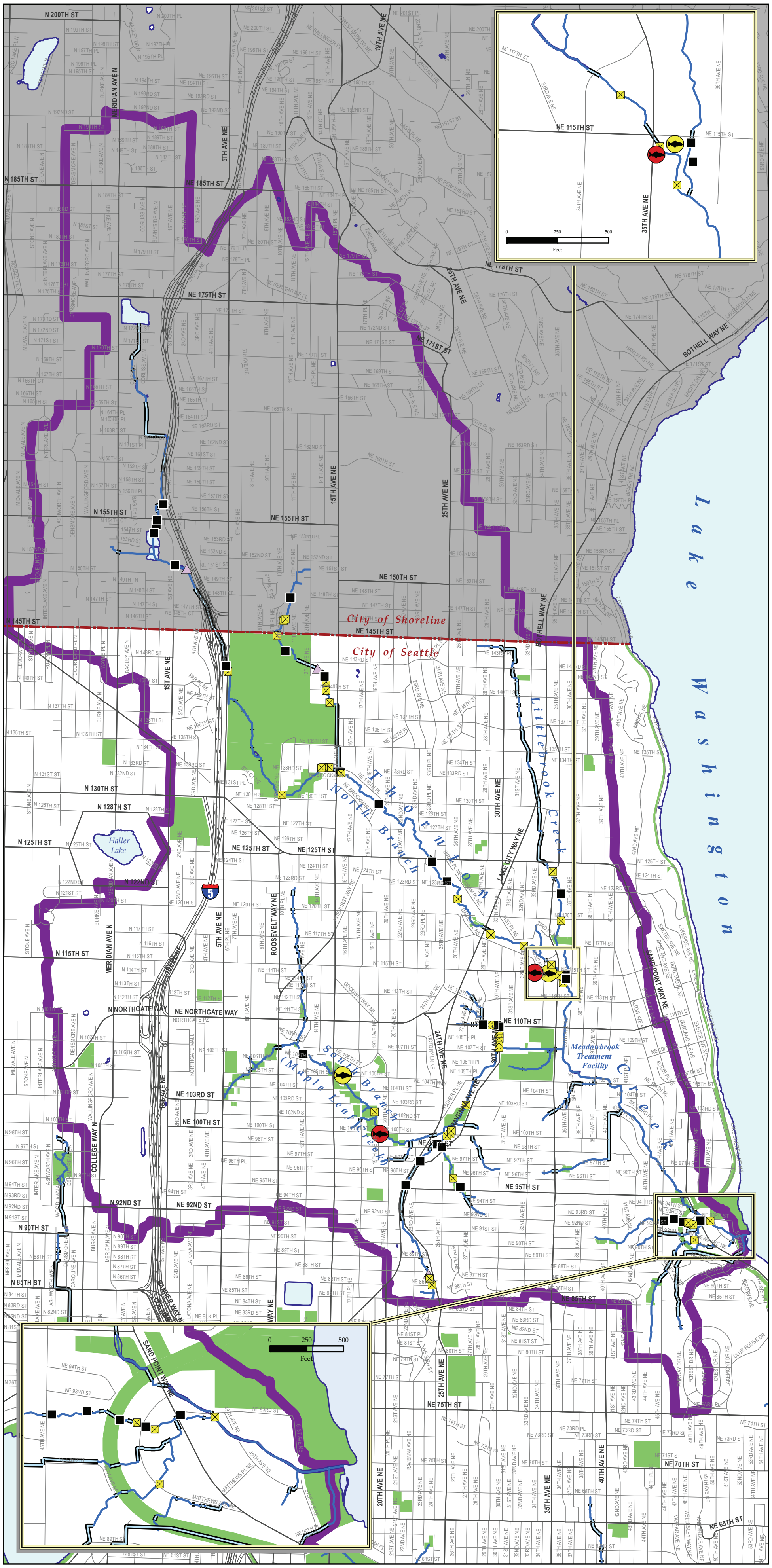
Summary statistics for conventional water quality parameters in Thornton Creek near mouth

	DO* (mg/L)	Temp. (degree C)	Fecal coliform (cfu/100 mL)	pH	TSS (mg/L)	Turbidity (NTU)
No. of samples	394	450	451	399	401	402
Minimum	6.9	1.6	14	6.4	0.6	0.1
Maximum	14.7	23.2	31,000	11.2	180	66
Median	10.5	11.3	690	7.5	5.7	3.2
Mean	10.5	11.1	1,507	7.5	15.0	6.3
5th percentile	8.8	5.4	115	6.9	2.0	1.2
95th percentile	12.6	16.2	5,500	7.9	56	22.9

*DO: dissolved oxygen

Source: Reference Station 0434. King County (undated)

Figure 6: Thornton Creek Watershed



Seattle Biological Evaluation

City of Seattle

FIGURE 6

Thornton Creek Watershed

Drainage Basin

- Thornton Creek Watershed Boundary

Stream Networks

- Open Channel
- Culvert

Observed Upstream Extent of Adult Salmonids, per 1999-2005 SPU Spawning Survey Data*

- Chinook
- Coho

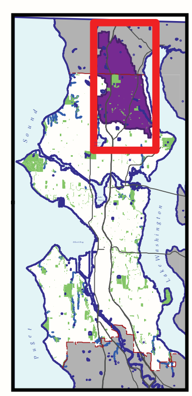
* This information pertains only to creeks.

Fish Barriers

- Barrier
- Partial Barrier
- Unknown Barrier

Other

- City Limit
- Freeway
- Arterial Street
- Residential Street
- Park



N W E S

0 0.25 0.5
Miles

October 1, 2012

Produced by SPU - IT, Data Services, GIS Products & Services
No warranties of any sort, including accuracy, fitness or merchantability, accompany this product.
Coordinate System: State Plane, NAD83-91, WA North Zone

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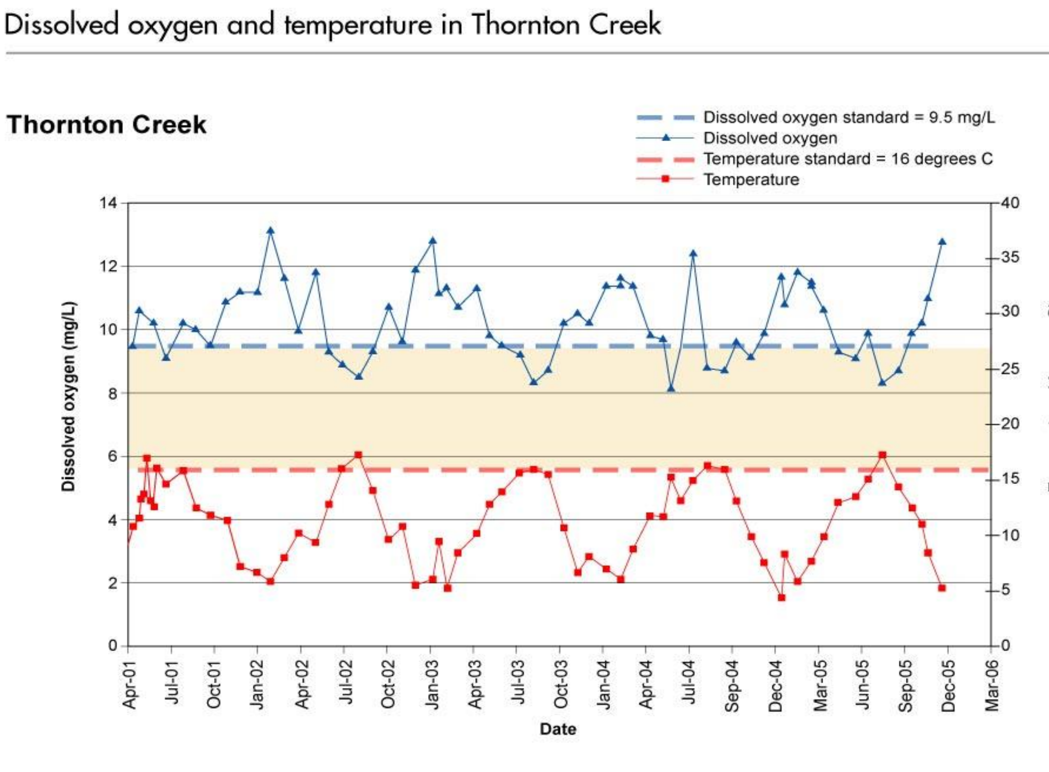
Water quality is currently being investigated as a potential contributor to the unusually high rates of coho salmon pre-spawn mortalities reported in urban creeks in the Puget Sound since 1999 (Reed *et al.* 2003). Between 1999 and 2005, pre-spawn mortality rates in Thornton Creek averaged 79% (McMillian 2006, SPU unpub. data). Pre-spawn mortality surveys were stopped in 2010 to analyze and publish the data and to define a path to move forward with the pre-spawn mortality issue and to pinpoint the causal factors (Davis, J. USFWS pers. comm. 2011).

As shown in Figure 7, dissolved oxygen and temperature typically exhibit a seasonal trend with higher temperatures and lower dissolved oxygen concentrations in the warm summer months. Thornton Creek frequently does not meet state water quality standards for temperature and dissolved oxygen during the summer months (mid-June through mid-September). Temperature and dissolved oxygen excursions (points at which these parameters exceed limits) are probably related to the lack of riparian vegetation throughout most of its length. Thornton Creek passes through private property; consequently the riparian zones are largely unprotected.

Figure 7



Station 0434. King County (undated).
Note: The areas between the two dashed lines show the samples that do not meet state water quality standards.

Dissolved oxygen and temperature in Thornton Creek

Thornton Creek also frequently exceeds state water quality standards for fecal coliform throughout the year. Annual geometric mean levels exceeded the standard for extraordinary primary contact recreation (50 cfu/100 mL) in all of the last ten years (480-1,200 cfu/100 mL) and 93% to 100% of the samples exceeded 100 cfu/100 mL. Under the state water quality standards, no more than 10% of all samples are permitted to exceed 100 cfu/100mL.

Metal concentrations within Thornton Creek are relatively low with the exception of mercury. Mercury was found to exceed the chronic toxicity criterion for aquatic life, but concentrations were below the laboratory reporting limit. Thornton Creek is a water of concern for mercury.

Nutrient levels in Thornton Creek are generally high and frequently exceed recommended water quality criteria. For example, total phosphorus concentrations in Thornton Creek (7-413 µg/L) frequently exceed the U.S. EPA (1976) water quality criterion (100 µg/L), which establishes a desired goal for the prevention of nuisance plant/algal growth in streams or other flowing waters not discharging directly to lakes or impoundments. In addition, total nitrogen concentrations in Thornton Creek (50-2,000 µg/L) frequently exceed U.S. EPA (2000) recommended nutrient criterion for streams in the western United States (340 µg/L for Ecoregion II). These criteria represent conditions in surface waters that are minimally impacted by human activities and are designed to prevent eutrophication and water quality problems associated with nutrient enrichment.

Concentrations of toxic materials in Thornton Creek are generally low. Ammonia-nitrogen levels were consistently below toxic levels. For metals, only dissolved lead exceeded the state water quality standards under non-storm flow conditions. The U.S. Geological Survey (USGS) has also found low levels of some pesticides in stormwater, sediment, and fish tissue collected from Thornton Creek (Voss and Embrey 2000). Stormwater samples collected from the north fork, south fork, and mouth of Thornton Creek contained detectable levels (0.013-0.16 µg/L) of several herbicides and their metabolites (2,4-D, 2,6-dichlorbenzmide, atrazine, dichlobenil, MCPA, mecoprop, pentachlorophenol, prometon, simazine, tebuthiuron, and trichlorpyr) and two insecticides and one insecticide metabolite (carbaryl, diazinon, and 4-nitrophenol at concentrations ranging from 0.003-0.154 µg/L). With the exception of diazinon, concentrations were below reported toxic effects levels for aquatic organisms. In 2003, the U.S. EPA cancelled diazinon product registrations and restricted the sale of this pesticide to existing stocks. As a result, diazinon concentrations in Thornton Creek should begin to decline as existing stocks are depleted.

6.1.6.2 Sediment Quality

Several organochlorine pesticides (dieldrin, chlordane, DDD, DDE, DDT, methoxychlor) ranging in concentration from 1.2 µg/kg to 8.1 µg/kg were also found in streambed sediment near the mouth of Thornton Creek (MacCoy and Black 1998). Freshwater sediment standards have not been established in Washington State. Interim sediment quality guidelines have been developed by the Canadian Council of Ministers of the Environment (1995). Sediment samples from Thornton Creek exceeded the threshold effects level of the interim Canadian sediment quality guidelines for DDD and DDE. DDE concentrations in Thornton Creek sediments also exceeded the probable effects level (the concentration above which biological effects are usually or always observed). Other organic compounds found in the streambed sediment include polynuclear aromatic hydrocarbons (concentrations of individual PAH compounds ranged from 19-310 µ/kg, with total low molecular weight PAH of 368 µ/kg and total high molecular weight PAH of 2,340 µ/kg), phthalates (estimated at 10-990 µ/kg), phenol (estimated at 29 µ/kg), p-cresol (estimated at 35 µ/kg), and several other PAH compounds (15-71 µ/kg). Some of the PAH compounds exceeded the threshold effects levels, but none exceeded the probable effects levels.

In addition, several organochlorine pesticides (5.3-97 µg/kg wet weight), and PCBs (310 µg/kg wet weight) were found in sculpin tissue samples collected at the mouth of Thornton Creek during the USGS study (MacCoy and Black 1998).

6.1.6.3 Shoreline and Aquatic Habitat

Factors limiting aquatic habitat within Thornton Creek include altered hydrology and peak high flow events, loss of floodplain connectivity, shortage of gravel recruitment, restricted access to upstream habitat, and loss of riparian vegetation.

Thornton Creek contains severely degraded aquatic habitat. The creek channel is highly simplified, with a plane-bed channel type, abundant glide habitat, low riffle-to-pool ratios and a thin and irregularly distributed substrate layer. The creek width averages less than 12 feet (3.6 m) wide, reduced from former widths of about 30 feet (9.1 m) that allowed the aquatic system to function in a more natural manner. The channel is also incised, with bank heights averaging 4 to 6 feet (1.2-1.8 m) above the streambed, compared with bank heights of less than 1 foot (0.3 m) in less impacted reaches of Thornton Creek. The high bank heights in combination with the square shape of the channel severely restrict the connection between the floodplain and the channel.

The hydrology of Thornton Creek has been severely altered and the creek experiences higher than historic peak flows during storm events. Incision, armoring, and encroachment prevent the stream from meandering across the floodplain to create and maintain habitat diversity and dissipate energy. This results in a very simple channel structure—lack of backwater areas and deep pools—in which fish are unable to find refuge or rearing opportunities. Adult fish spawning areas are also limited.

Streambank armoring and channelization have reduced gravel recruitment in Thornton Creek. The lack of instream structure, in combination with the high flow velocities, results in poor gravel retention in the system, with the exception of Meadowbrook Pond. The lack of coarse sediment limits the production of bottom-dwelling insects that other animals feed upon.

Extensive urban development and encroachment have also resulted in a loss of healthy native riparian habitat. High-quality vegetation occurs in disconnected patches along a small portion of Thornton Creek's banks, especially within parks. Areas without mature vegetation consist of residential yards or are dominated by invasive plant species. The lack of riparian vegetation minimizes both terrestrial insects and leaf litter that fuel aquatic production. Restoration activities conducted by the City of Seattle throughout Thornton Creek are improving riparian conditions and instream habitat.

Fish Use

Fish that can be found in Thornton Creek include cutthroat and rainbow trout, steelhead, Chinook, coho, chum, and sockeye salmon, peamouth chub, large-scale sucker, three-spine stickleback, prickly sculpin, coast-range sculpin, lamprey, and long-nose dace. Nonnative fish species have been introduced to Thornton Creek and include rock bass, pumpkinseed, largemouth bass, and oriental weatherfish (City of Seattle 2007, Tabor *et al.* 2010).

Based on carcass counts, coho salmon are the most numerous with an average of 33 carcasses per year (range 5 to 94). Chinook average four carcasses per year, sockeye seven, and only one chum carcass has been found between 2001 and 2008.

While fish passage barriers are not a problem on the mainstem of Thornton Creek, barriers are a problem on the North Branch and, to a lesser extent, the South Branch. On the North Branch, barriers are located just upstream of the confluence with Littlebrook Creek at NE 115th St and 35th Ave NE. On the South Branch, anadromous salmon have not passed a partial barrier located upstream of Lake City Way at NE 107th St. and 12 Ave. NE. Approximately 12 mi (19.3 km) of Thornton Creek is potentially fish-bearing, including both branches and lower segments of the larger tributaries.

Few anadromous smolts are caught in Thornton Creek. The low smolt numbers are a result of poor rearing habitat and lack of pools in the stream. High flows can also wash out juvenile fish.

6.1.7 Taylor Creek (South Lake Washington Action Area)

Taylor Creek, located in southeast Seattle in the South Lake Washington action area, receives runoff from a 629-acre (254.5 ha) watershed that includes parts of unincorporated King County (Figure 8). Taylor Creek has a total channel length of 2.8 mi (4.5 km), which includes two forks, the West and East Forks. Land use in the watershed is predominately residential (53%). While 18% is covered by roads, parking and right-of-way, 8% is used for commercial and industrial activities, and 21% is contained in parks or vacant land. About 60% of Taylor Creek flows through park or vacant land (mostly transmission line right-of-way).

6.1.7.1 Water and Sediment Quality

Twenty-one storm drains discharge to Taylor Creek (City of Seattle 2007). The West Fork of Taylor's Creek receives water from 8 storm drains. Two of these are relatively large draining 60 to 90 acres (24.3 to 36.4 ha). The East Fork receives water from 10 drains, two of which drain more than 30 acres (12.1 ha). No combined sewer overflow outfalls discharge to the watercourse.

Taylor Creek is on the 2008 Ecology 303(d) list of threatened and impaired waterbodies. The 303(d) listings are summarized in Table 6-7.

Table 6-7
Summary of 303(d) listings for Taylor Creek

	Category	
Media	**2[1]**	**5[2]**
Water	Dissolved oxygen	
Other	Bioassessment	

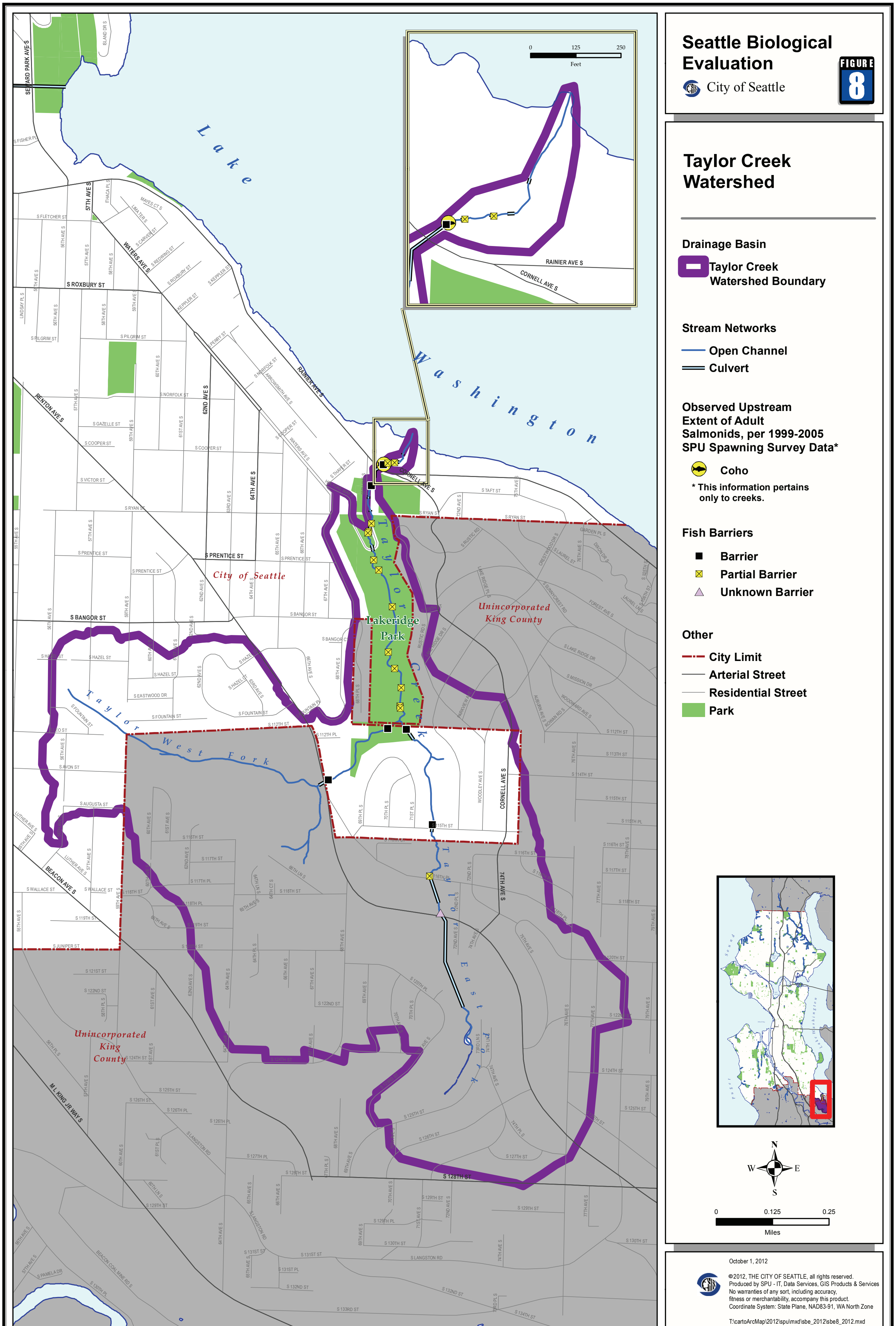
[1]Water of concern – water body shows evidence of a water quality problem, but pollution level is not high enough to violate the water quality standard, or there may not be enough violations to categorize it as impaired.
[2]Water body has violated water quality standards and no TMDL or pollution control program has been developed for the pollutant.
Source: Ecology 2008

6.1.7.2 Shoreline and Aquatic Habitat

The habitat of Taylor Creek is relatively good compared with other creeks in Seattle. Several factors contribute to this:

- Large extent of park and vacant land surrounding the creek
- Hard glacial substrates that resist erosion
- Presence of instream structures that help the channel to resist incision
- Minimal encroachment from development

Figure 8: Taylor Creek Watershed


Seattle Biological Evaluation
City of Seattle
FIGURE 8
Taylor Creek Watershed
Drainage Basin
Taylor Creek Watershed Boundary
Stream Networks
Open Channel
Culvert
Observed Upstream Extent of Adult Salmonids, per 1999-2005 SPU Spawning Survey Data*
Coho
* This information pertains only to creeks.
Fish Barriers
Barrier
Partial Barrier
Unknown Barrier
Other
City Limit
Arterial Street
Residential Street
Park
0 0.125 0.25
Miles
0 125 250
Feet
Lake Washington
Lakeridge Park
Taylor Creek
Taylor West Fork
Taylor East Fork
City of Seattle
Unincorporated King County
RAINIER AVE S
CORNELL AVE S
S 128TH ST
October 1, 2012
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Coordinate System: State Plane, NAD83-91, WA North Zone
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Factors limiting aquatic habitat within Taylor Creek include altered hydrology and peak high flow events, limited access to upstream habitat, and lack of floodplain connectivity.

Within Lakeridge Park, habitat quality is relatively high. This portion of the creek maintains a floodplain connection and has high-quality riparian vegetation. Taylor Creek has a good amount of instream structure, especially in the Lakeridge Park areas, although it is not as dense as it would be in a forested system of similar size and gradient (Perkins 2002).

Outside of the park, Taylor Creek is comparable with other Seattle creeks, particularly in the East Fork and lower mainstem areas which lack land-water connectivity. The channel has been confined by armoring, lacks instream structure and channel complexity, and much of the riparian zone has been cleared, disturbed, or replaced by invasive species.

Development of the watershed, loss of forested wetlands and swales, and the presence of stormwater outfalls have increased runoff and high flows in the channel. The sections of creek that are located within the park and vacant areas appear to have sufficient floodplain connection and instream structure to handle increased stormwater runoff. The remaining sections of the creek, however, are impacted (*e.g.,* the East Fork and main channel downstream of Lakeridge Park). In addition, the West Fork wetland of Taylor Creek has a moderating effect on flood peaks by providing detention and storage.

The lower portion of Taylor Creek has been substantially changed due to residential development. The channel in this section is 80% armored and contains numerous bridge crossings and about one-third of the watercourse runs through culverts. Flooding is a major issue due to the undersized culverts. As the creek flows into Lake Washington, sediment deposition occurs and a new delta has formed which provides important habitat for fish rearing in the lake.

Fish Use

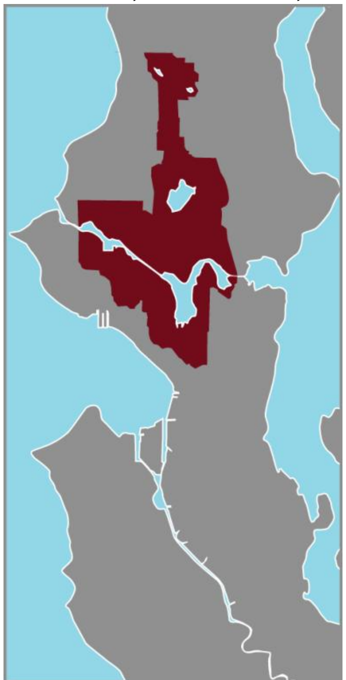
Fish species that can be found in Taylor Creek include coho and sockeye salmon, rainbow and cutthroat trout, three-spine stickleback, lamprey and prickly, torrent, and coast-range sculpin (City of Seattle 2007, Tabor *et al*. 2010). Chinook salmon are found in the lower portions of the creek (Tabor *et al* 2010). Access to Taylor Creek habitat is affected by two barriers that prevent anadromous fish from reaching most spawning and rearing habitat in the creek. The barriers are located approximately 600 feet (183 m) and 900 feet (274 m) upstream of the mouth of the creek. The barriers are the Rainier Avenue South culvert and a privately-owned concrete dam.

Taylor Creek contains 1.64 mi (2.6 km) of channel that supports fish, of which 774 feet (236 m) is culverted. Salmon (sockeye and coho) are restricted to the lower 600 feet (183 m) of Taylor Creek, between the mouth of Taylor Creek and the culvert under Rainier Avenue South.

Due to the limited access to the creek, few adult salmon spawn within Taylor Creek. On average, about 19 adult sockeye (range 0 to 32) and 1 adult coho (range 0 to 4) use the watercourse. Only 16% of potential suitable habitat is accessible and spawning occurs in the lower 250 to 300 feet (76.2 to 91.4 m) of the stream.

6.2 Lake Washington Ship Canal Action Area

The Ship Canal connects Lake Washington to Puget Sound. The Ship Canal action area, from upstream to downstream, is composed of Union Bay, Montlake Cut, Portage Bay, Lake Union, Fremont Cut, and Salmon Bay. The Locks bisect Salmon Bay. Shilshole Bay is outside of Salmon Bay. There is confusion as to the exact locations of Salmon Bay and Shilshole Bay. Some documents show Salmon Bay on both sides of the Locks, and some show it as only on the upstream or east side of the Locks. This document refers to Salmon Bay on both sides of the Locks, bisected by the Locks, with Shilshole Bay part of the Salmon Bay and Shilshole Bay estuary between the Locks and the deeper waters of Puget Sound (see Figure 2).



Lake Washington Ship Canal Action Area

The Ship Canal receives runoff from approximately 5,500 acres (2,226 ha) in the Ballard, Fremont, Wallingford, and University areas north of the Ship Canal and a small primarily commercial area east of I-5 and south of Lake Union. Land use in the basin is evenly distributed between roadways (38%) and residential (32%), with lesser amounts of industrial (7%), commercial (14%), and open space/vacant land (6%). Drainage conveyance systems in the basin consist mostly of piped networks.

The Ship Canal is about 8 miles (12.8 m) long and is located entirely within the city limits of Seattle. The Montlake Cut connects Lake Washington to Portage Bay, which has a natural surface connection to Lake Union. Lake Union is linked to Salmon Bay through the Fremont Cut. Finally, the Locks form a dam at Salmon Bay, at the outlet of the Lake Washington basin.

The Locks structure and its operation influence the physical characteristics of the surrounding waterbodies. Operation of the navigational locks involves raising or lowering the water level so that vessels may pass between the two waterbodies. Other habitat modifications at the Locks include extensive shoreline hardening along both sides of the Locks and the armoring of Salmon Bay both upstream and downstream of the structure.

Due to the intensive industrial and commercial land use within the area, overall habitat conditions are more modified in the Ship Canal than in Lake Washington. The shoreline is heavily armored and the presence of bulkheads, docks, and overwater structures provide little natural shoreline within the system (Weitkamp *et al.* 2000). The south side of Portage Bay, portions of the Gas Works Park shoreline, and small areas at the south end of Lake Union are the only areas that have retained any seemingly natural shoreline characteristics (Weitkamp *et al*. 2000).

Four streams are located within the Lake Washington Ship Canal action area. Table 6-8 identifies the location of the streams and any fish species found within the creeks (Tabor *et al* 2006).

Table 6-8 **Smaller streams and fish present within the Lake Washington Ship Canal action area.**		
Stream	Action Area	Fish Species Present
Licton Spring Creek	Lake Washington Ship Canal	None
Mahteen Creek	Lake Washington Ship Canal	None
Lawton Creek	Lake Washington Ship Canal	None
Wolfe Creek	Lake Washington Ship Canal	None

6.2.1 Water Quality

Although water quality in the Ship Canal is generally good due to the high quality of inflowing water from the Lake Washington and Cedar River watersheds, the Ship Canal experiences seasonal temperature and dissolved oxygen problems, as well as occasional problems with fecal coliform bacteria levels. Water temperatures are often elevated during summer and frequently exceed the levels considered critical for salmon (64.4° F or 18° C). Water temperatures in surface samples (3.3 feet or 1 m depth) collected by King County between 2000 and 2005 from four stations along the Ship Canal and one station in south Lake Union generally ranged from 60.8° to 73.4° F (16-23° C) between June and September compared with 44.6° to 60.8° F (7-16° C) during other times of the year (King County undated). In addition, dissolved oxygen at the two stations where measurements are recorded at depth 29.5 to 32.8 feet (9-10 m), regularly dropped below 6 mg/L (2.8-9.8 mg/L), during the summer months when the water temperatures were above 68° to 69.8° F (20-21° C). Dissolved oxygen levels of 6 mg/L and above are optimal for salmon.

Water temperatures in the Ship Canal have been increasing steadily over the last 30 years, with an increase in the number of days that temperatures are greater than 68° F (20° C) (Weitkamp *et al*. 2000). The primary factor associated with these increases appears to be air temperature (Weatherbee and Houck 2000). The increased duration of warm water temperatures has a series of implications for salmon. Water temperatures increase the metabolism of fish and increase rates of predation, increasing the predation risks that juvenile salmon face in the Ship Canal. Water temperatures can also delay migrating adults near the Locks, or prevent their upstream movement all together (Fresh *et al.* 2000).

A particular water quality challenge for Lake Union has been caused by the introduction of saltwater through the Locks into the freshwater areas upstream. This saltwater intrusion is more of a problem in the summer when flows from the Cedar River and Lake Washington are lower, producing slower flushing rates of Lake Union. Because the density of saltwater is greater than freshwater, the saltwater intrusion forms a wedge that flows along the bottom of the Ship Canal and Lake Union. This salinity gradient combines with summer thermal stratification to cause the bottom layers of the water column (hypolimnion) to become anoxic (no oxygen). These anoxic conditions limit the areas of the Ship Canal that can be used for fish habitat (Weitkamp and Ruggerone 2000, King County 2012).

Fecal coliform bacteria numbers in the Ship Canal occasionally exceed the state water quality standards for lakes (geometric mean of 50 cfu/100 mL with no more than 10% of all samples exceeding 100 cfu/100 mL). Between 2000 and 2005, the annual geometric mean measured at 4 stations along the Ship Canal ranged from 7 to 132 cfu/100 mL (King County undated). Only one station, located near the Locks (King County Station 512), exceeded the state water quality standard (in 2000 and 2002). Between 2% and 31% of the 171 samples collected exceeded 100 cfu/100 mL; the 10% criterion was exceeded only at Station 512 (31%) and in Lake Union (11% at King County Station A522).

The Ship Canal is on the 2008 Ecology 303(d) list of threatened and impaired waterbodies for water and sediment. The 303(d) listings are summarized in Table 6-9.

Table 6-9

Summary of 303(d) listings for Lake Washington Ship Canal and Lake Union

	Category		
Media	**2[1]**	**4C[2]**	**5[3]**
Water	pH Temperature Dissolved oxygen 4,4'-DDD 4,4'-DDE Zinc		Lead Aldrin Fecal coliform bacteria Total phosphorus
Habitat		Invasive exotic species	

[1]Water of concern – water body shows evidence of a water quality problem, but pollution level is not high enough to violate the water quality standard, or there may not be enough violations to categorize it as impaired.

[2]Water body is impaired by a non-pollutant that cannot be addressed through a water quality improvement project [total maximum daily load (TMDL) or pollution control program).

[3]Water body has violated water quality standards and no TMDL or pollution control program has been developed for the pollutant.

Source: Ecology 2008

6.2.2 Sediment Quality

Elevated concentrations of arsenic, copper, lead, mercury, and zinc have been observed in sediment throughout the Ship Canal (Cubbage 1992). PAHs and arsenic concentrations are highest along the northshore near Gas Works Park, although elevated concentrations of other metals (antimony, cadmium, copper, lead, mercury, nickel, silver, and zinc), as well as tributyltin, ethylbenzene, PCBs, phenol, and carbazole have also been reported in this area (Cubbage 1992, Floyd/Snider and MCS 2005). The City of Seattle and Puget Sound Energy are conducting remedial investigations/feasibility studies in the northshore area to assess the extent and severity of the contamination and to evaluate cleanup options.

Moshenberg (2004) also reported elevated concentrations of metals, tributyltin, PAH, and phthalates, and PCBs in sediment throughout the Ship Canal. With the exception of PCBs, concentrations of most contaminants were markedly higher in Lake Union compared to Lake Washington and Lake Sammamish. The nearshore areas in Lake Union exhibited the highest contaminant levels, particularly stations along the south and southwest shorelines, and along the western edge of the lake (Moshenberg 2004).

6.2.3 Shoreline and Aquatic Habitat

The Ship Canal extends from the locks eastward through Union Bay and terminates at Webster Point beyond which is the main body of Lake Washington. The Ship Canal shorelines are largely modified. Seventy-five percent of the shoreline is retained by bulkheads or riprap. There is an average of 32.6 docks per mile, and 17.3% of the shoreline is shaded (Toft *et al.* 2003).

The authorized depth of Salmon Bay, just upstream of the Locks, is 30 feet (9.1 m), with a variable width ranging from 100 to 200 feet (31 to 61 m). Before construction of the Locks, this area was tidally influenced and navigable only by shallow-draft vessels at high tide. Historically, Salmon Bay was a saltwater inlet (at least during high tide). At low tide, it was almost dry, with the water level dropping nearly 20 feet (6.1 m) between extreme high and low tides (Williams 2000). Construction of the Locks raised and stabilized the water level in this section of the canal converting it from an estuarine to freshwater/pseudo-estuarine environment.

The Fremont Cut is about 5,800 feet (1,767.8 m) long and connects Salmon Bay and Lake Union. The Fremont Cut was dredged to an authorized depth of 30 feet (9.1 m) and has a channel width of 350 feet (106.7 m). Concrete sills, bolstered by riprap, line both sides of the channel. Upland of the concrete revetments, the riparian zone consists of a row of Lombardy poplars and other landscaped vegetation.

Lake Union is about 581 acres (235 ha) in area. The mean water level in Lake Union was not changed by construction of the Ship Canal, but the range of water level has been reduced. The elevation at the Locks only ranges 2 feet (0.6 m) from 20 to 22 feet (6.1 to 6.7 m). Overwater coverage, bulkheads, and shoreline armoring are extensive.

Relatively little shallow water habitat either natural or altered is left along Lake Union shorelines, including riparian zone vegetation. Lake Union is lined with a large variety of commercial and industrial facilities, including ship repair and scrapping yards, marinas, and office buildings. More than 80% of the shoreline has been modified by bulkheads or other forms of bank stabilization (City of Seattle 2000). Eurasian water-milfoil is a problem in the lake. The species contributes a large amount of organic material to the lake, which affects dissolved oxygen levels (WDNR 1999).

Lake Union has an arm extending eastward known as Portage Bay. Portage Bay is lined by University of Washington facilities, commercial facilities, and houseboats. The southeastern portion of Portage Bay has an area of shallow, freshwater, and marsh habitat. The remainder of the shoreline has been developed, and several marinas are located in the bay.

The Montlake Cut is about 2,500 feet long (762 m) and connects Portage Bay and Union Bay, which is part of Lake Washington. The Montlake Cut was dredged to an authorized depth of 30 feet (9.1 m) and has a channel width of 350 feet (106.7 m). Similar to the Fremont Cut, the Montlake Cut has concrete revetments that line both sides of the channel. The tops of the revetments are used as waterside walks. The Montlake Cut is characterized by steep side slopes, planted with a combination of English ivy, deciduous and evergreen trees, and native shrubs and grasses.

Before construction of the Ship Canal, Union Bay consisted of open water with the shoreline extending north to 45th Street. After construction, Union Bay was lowered by 9 feet (2.7 m) and a marsh was created on fill placed in the northern portion of the bay. The southern limits of the marsh consist of remnant cattail marshes that still exist at the southern edge of the Montlake fill. Much of the marsh that was created after construction has since been filled, leaving only the fringe marsh on the southern end (Jones and Jones 1975).

Union Bay has several areas of freshwater marsh, milfoil, and associated fauna. The south side of the bay is bordered by the University of Washington's Arboretum and traversed by the Evergreen Point Floating Bridge, creating a network of smaller embayments and canals with marsh habitats. The north side of Union Bay contains the marshy fill area and numerous private residences with landscaped waterfronts, and dock facilities dominate the remainder of the shoreline.

Important shallow-water habitat has declined for juvenile salmon as a result of development (Toft 2001, Piaskowski and Tabor 2001, Tabor and Piaskowsi 2002). Development of lakefront property has armored about 70% of the shoreline (Toft 2001). The banks along the Ship Canal are about 96% armored (Weitkamp *et al.* 2000). These bank conditions are coupled with overwater structures such as docks and piers. As of 2000, 2,737 docks lined the lake shoreline covering about 4% of the lake's surface area within about 100 feet (30 m) of shore (Fresh and Lucchetti 2000, Weitkamp *et al.* 2000, Toft 2001, R. Malcolm and E. Warner, Muckleshoot Indian Tribe, unpub. data). These overwater docks and piers have increased shading and segmented the Ship Canal shorelines. Bank armoring, overwater structures, and accompanying homes, decks, and yards, have reduced native riparian vegetation and woody debris. Cumulatively, such alterations influence juvenile salmonid migration movements, prey availability, and predator behavior and distribution (Warner and Fresh 1998, Kahler *et al.* 2000, Koehler 2002, Fresh *et al.* 2003).

Important impacts on habitat include reduced amounts of woody debris in littoral areas (Christensen *et al.* 1996), reduced shallow-water refuge area, reduced riparian cover, decreased sockeye beach spawning areas through aquatic macrophyte growth, and elimination of beach spawning habitat through altered substrate composition and water circulation patterns (Fresh and Lucchetti 2000).

Within the Ship Canal, the only fragments of Lake Union that retain some natural shoreline are along the south side of Portage Bay, portions of the Gas Works Park and a few small areas at the south and east sides of Lake Union. The specific impact these conditions have on migrating juvenile and adult salmon is unknown but of concern. The bank armoring and bulkheads and docks along most of this shoreline severely limit the amount of desirable habitat and cover available to rearing and migrating juvenile salmon. For returning adult Chinook salmon, the Ship Canal is primarily a passageway that is traversed in a few days (Fresh *et al.* 2000).

6.2.4 Habitat Access: Barriers

The Locks provide a barrier for salmonid migration in both directions. Passage is possible through the Locks *via* the fish ladder, large lock, small lock, the saltwater drain, and the smolt passage flumes. Adult salmonids migrating to freshwater primarily pass via the fish ladder and the two lock chambers. Juveniles are thought to primarily pass *via* the smolt passage flumes, but also use the large lock miter gates and the filling culverts.

The fish ladder allows upstream migration of anadromous fishes. The ladder is located on the south side of the spillway. The ladder is 8 feet (2.4 m) wide, with three adjustable weirs at the upper end fish exit, 18 fixed weirs with submerged orifices, one adjustable and one fixed slot in the entrance. The lower six weirs are designed with diffusers that provide transportation and attraction water (Corps 1992). Flow through the fish ladder includes 23 cubic feet/sec (0.65 cu m/sec) freshwater from the surface of the Ship Canal, as well as 160 cubic feet/sec (4.5 cu m/sec) attraction water into the diffusers from the saltwater drain. The attraction water was provided in 1976 when the original 1917 fish ladder was rehabilitated to allow saltwater to be mixed with freshwater as a means to attract more fish and to facilitate upstream migration. This additional water was provided *via* a 'Y' valve from the saltwater drain pipe. Water is released through the fish ladder year-round, except during ladder maintenance periods (typically one week in late May or early June).

The saltwater drain system allows upstream migration of adult fish via the drain outlet. However, in the late 1970s at the request of WDF (now WDFW) the Corps began operating the system to exclude adult salmonids from using this route. This was done because it was determined that adults are able to migrate through the saltwater drain system in the Ship Canal, or follow the 'Y' to the diffuser well in the fish ladder, where they may become trapped. The Corps operates the saltwater drain when tide elevation is less than or equal to 6.5 feet (2 m) MHHW. Fish can access the saltwater drain system when tides are higher than 7 feet (2.1 m) MHHW. In 2008, a 50 x 60 foot screen structure was placed over the upstream end of the saltwater drain system. The screen was installed to prevent adult salmon from entering the saltwater drain and getting caught in the diffuser wells of the fish ladder. The screen has hinged doors that are closed during the adult migration period (June through mid-September).

Adults also migrate to freshwater through the large and/or small locks. Adult anadromous fish enter the large and small locks when the lower gates (west end) are open to allow boats to leave or enter the locks.

In early to mid-April, four flumes are installed in spillway gates 4 and 5 of the Locks to improve smolt passage through the Locks. Before 1995, little or no water was spilled over the spillway during most days in June and July. In 1995, at the request of the WDFW and NMFS, the Corps built and installed a prototype low-flow smolt bypass system. The smolt passage flume used 20% to 25% of the water volume of a 1-foot (0.3 m) spillway gate opening. The prototype flume was installed each year by mid-April and operated for as long as water was available during 1995 through 1999. In 2000, together with funding from the City of Seattle and King County, the prototype flume was replaced with four smolt passage flumes.

Each flume can be opened or closed independently, allowing a large range of available flow conditions, ranging from 50 to 400 cubic feet/sec (1.4-11.3 cu m/sec). Installation of these flumes has allowed the Corps to increase their operational flexibility and to use water more efficiently for safe smolt passage within a wider range of available flows. The primary concern with the smolt passage flumes is the potential lack of available water to allow operation of the flumes during the later part of June and July when most juvenile Chinook salmon are migrating through, or rearing below, the Locks. When water isn't available, Chinook salmon and other smolts are forced to select other routes (fish friendly or not) to exit the Locks.

Tagging studies have indicated that significant numbers of Chinook migrating upstream through the Locks hold for an extended period in the area just above the saltwater intake drain in the area known as the coolwater refuge before moving into the watershed (Fresh et al. 1999; Corps 2001). An acoustic tagging study funded by King County and the Corps tracked 45 adult Chinook migrating upstream in and around the Locks between July and October 2000 (Corps 2001). The study found the following:

1. The average residence time of tagged fish within the hydrophone array immediately upstream of the Locks was 19 days.
2. The earlier a fish entered the system, the longer it remained before moving upstream with all tagged fish exiting the system (the monitored area) between August 10 and October 2, with a mean departure date of September 4
3. Prominent holding or residence areas were located in front of the saltwater drain intake, in the small lock, and in the large lock

Tagging studies also showed that annually 30% to 40% of the acoustic tagged adults fell back below the Locks one or more times (Fresh *et al.* 2000). Fallback fish may move back and forth through the Locks (presumably the large locks) up to four times. This may be due to the abrupt changes in salinity or because of the high temperature gradient between the freshwater and the saltwater.

Smolt and juvenile migratory behavior through the Locks is based on four years of monitoring smolt passage at the Locks and information from other water control projects in the Pacific Northwest (Corps 1999, Williams 2000). Juvenile salmonids encounter complex water currents above and below the Locks, but currents are negligible until fish are within several hundred feet of the Locks. In contrast to the constraints imposed on juvenile salmonid movements near the Locks, juveniles in a natural estuary would be free to move up and down the channel selecting preferable temperature and salinity and habitat rearing areas.

In studying PIT-tagged juvenile Chinook after passage through the Locks, it was found that some juveniles pass through the Locks more than once (DeVries 2005). Of 1,990 detected PIT-tagged Chinook, 32 passed through the flumes twice. Juvenile Chinook salmon were passed back up into the Ship Canal through either the large or small locks before passing through the flumes a second time. The time from the first to the second flume detection (recycling time) ranged from five to 40 days. It was also thought that smaller fish were more likely to rear for longer periods at the Locks which increased the probability they would be passed through the Locks more than once. There was no relation between the recycling time and fish size (at the time the fish were tagged). Little information is available to determine the importance of a freshwater lens below the Locks (for rearing or migratory juvenile Chinook salmon) although it is believed that some portion of the juveniles can make the transition faster than others. A large fraction of PIT-tagged fish caught by beach seine below the Locks made the transition to saltwater (>20%) in less than two days.

In late spring/early summer, the smolt flumes are used to control lake elevations. In most years, by late spring, the flow volume into the Ship Canal is usually reduced such that the spillway gates cannot be opened wide enough to allow safe passage of smolts. Lake elevations below acceptable levels, continued dry weather forecasts, and inflows below normal trigger conservation measures at the Locks. Conservation measures begin with closing the saltwater drain, decreasing hours of operation for the flumes, and initiating lockage restrictions. Reduced inflow requires conservation of water to maintain elevations of Lake Washington and results in modifications to Locks operation. The first conservation measure is closing all spillway gates. Secondary measures include reducing lockages and altering saltwater management practices. However, if inflows to Lake Washington and therefore the Ship Canal increase, the spillways may have to be used. In this case, the spillways are opened at least 0.5 foot (0.15 m) for safe fish passage.

The fish ladder passes a small number of migrating juvenile salmon. In 1994, before the prototype flume installation in 1995, the estimate of outmigrants using the fish ladder was about 40,000 fish out of an expected 3 to 5 million smolts or about 1% of all smolts (Kerwin 2001). All juvenile fish passing through the fish ladder from the exit (top pool) to the entrance (bottom pool) are presumed to be uninjured. It is unlikely that juvenile Chinook would pass back upstream through the fish ladder.

Historical fish protection measures to the saltwater drain have included screening the intake and the outlet so adult salmon would not enter the culvert. During rehabilitation of the fish ladder in 1976 to1977, a fiberglass mesh screen was installed across the entrance of the saltwater drain intake (freshwater side) to exclude fish from entering the intake and becoming entrained into the culvert. This screen was removed by 1980 as large volumes of debris became impinged on the screen reducing the volume and efficiency of the drain. From 1980 to 1994, a screen to exclude adults covered the outlet of the saltwater drain (marine side), but the screen was removed in 1994 after the WDFW observed smolts impinged on the upstream surface of the screen.

The saltwater drain cannot be eliminated as a pathway for juvenile salmon under current operating conditions. Even during periods of little or no spill, however, the saltwater drain intake is less likely to be a major pathway for juvenile fish than the large lock culvert intakes for several reasons:

1. The drain intake is at a greater depth (50 feet (15 m) average vs. 33 feet (10 m) for Lock culvert intake)
2. Velocities into the intake (0.5-1.0 feet/sec [0.15-0.3m/sec) are much lower than velocities typically encountered and selected by smolts that passed through either the flumes or the culvert intakes (3-5 feet /sec [0.9-1.5m/sec)
3. Poor water quality conditions (low dissolved oxygen) may exist for sustained periods

No direct monitoring of juvenile salmon passage has been conducted in the small lock, although anecdotal information indicates few fish use this pathway (Kerwin 2001). Previous observations of smolt use of the small locks and direct monitoring of the large lock suggest that few, if any, fish would use the small lock when there is enough available water to run three or more flumes. Even if fish were to use this pathway, attributes of the small lock suggest few fish would be injured because the small lock, unlike the large lock, is not lined with barnacles, and conduits in the small lock operate under lower head and velocity than the large lock.

6.2.5 Non-Native and Predator Fish in Ship Canal

The primary freshwater predators in the Ship Canal include the non-native smallmouth and largemouth bass and the native northern pikeminnow. The northern pikeminnow appears to be an important predator but little data are available on their abundance. There are an estimated 3,400 smallmouth and 2,500 largemouth bass in the Ship Canal (Tabor et al. 2000).

Six anadromous salmonid species pass through the Locks and Ship Canal:

1. Chinook salmon
2. Coho salmon
3. Sockeye salmon
4. Coastal cutthroat
5. Steelhead
6. Bull trout

Since the separation of the Lake Washington drainage basin from the Green/Duwamish drainage basin, at least two stocks of anadromous salmon may have been extirpated from the Lake Washington system: chum and pink salmon, possibly native to the Cedar River. Since 1936, at least eight stocks have been introduced and are maintained either as hatchery stocks (*e.g.*, Chinook, coho) or have established naturally reproducing, self-sustaining populations (*e.g.*, sockeye).

Predation of salmonids is often greatest at bottleneck areas where fish aggregate. Within the Ship Canal, juveniles may be vulnerable to predation as they migrate from Lake Washington to the Locks, pass through the Locks, aggregate below the Locks, and as they rear in the relatively small estuary.

Several species of marine organisms exist in the lower portion of the Ship Canal up to and including the Locks (Table 6-10). Some marine and estuarine species migrate through the Locks or live in the transition zone immediately below the Locks. For example, starry flounder occur in the lower Ship Canal while shiner surfperch are found above the Locks through much of the summer, and Pacific herring and longfin smelt move above and below the Locks during up-lockage, the period when the Locks are used to pass boats upstream.

Table 6-10

Aquatic species inhabiting or migrating through Hiram M. Chittenden Locks

Common name	**Genus**	**Species**	**Resident or migratory**
Marine/Estuarine Fish			
Starry flounder	*Platichthys*	*stellatus*	R
Wolfeel	*Anarrhichthys*	*ocellatus*	R
Shiner surfperch	*Cymatogaster*	*aggregata*	R
Striped surfperch	*Embiotoca*	*lateralis*	R
Pacific herring	*Clupea*	*pallasi*	R
Anadromous Fish			
Chinook salmon	*Oncorhynchus*	*tshawytscha*	M

Common name	Genus	Species	Resident or migratory
Coho salmon	*Oncorhynchus*	*kisutch*	M
Sockeye salmon	*Oncorhynchus*	*nerka*	M
Chum salmon	*Oncorhynchus*	*keta*	M
Steelhead trout	*Oncorhynchus*	*mykiss*	M
Cutthroat trout	*Oncorhynchus*	*clarki clarki*	M
Bull trout	*Salvelinus*	*confluentus*	M
Dolly Varden	*Salvelinus*	*malma*	M
Atlantic salmon	*Salmo*	*trutta*	M
Pacific lamprey	*Lampetra*	*tridentatus*	M
River lamprey	*Lampetra*	*ayresi*	M
American shad	*Alosa*	*sapidissima*	M
Longfin smelt	*Spirincus*	*thaleichthys*	M
Freshwater Fish			
Yellow perch	*Perca*	*flavescens*	R
Black Crappie	*Pomoxis*	*nigromaculatus*	R
Peamouth Chub	*Mylocheilus*	*caurinus*	R
Smallmouth bass	*Micropterus*	*salmoides*	R
Marine Invertebrates			
Barnacles	*Balanus*	*crenatus*	R
Barnacles	*Balanus*	*cariosus*	R
Blue mussel	*Mytilus*	*edulis*	R
Amphipods			R
Isopods			R
Annelids			R
Scallop	*Pododesmus*	Sp.	R
Sea cucumber	*Eupentacta*	Sp.	R
Sea urchin	*Strongylocentrotus*	Sp.	R
Starfish	*Pycnopodia*	Sp.	R

Common name	Genus	Species	Resident or migratory
Tunicates (Sea squirts)	*Chelyosoma*	Sp.	R
Anemome	*Tealia*	Sp.	R
Other Marine Organisms			
Sponge			R
Algae	*Fucus*	Sp.	R
Algae	*Amphora and Synedra*		R
Bryozoans	***Crisia***	**Sp.**	R

In 2000, the Muckleshoot Indian Tribe conducted pilot studies of predation of juvenile Chinook salmon below the Locks (Footen 2000). The most abundant predators in the inner bay were sea-run cutthroat trout and staghorn sculpin and in the outer bay the key predators were staghorn sculpin and resident Chinook (blackmouth). Bull trout were another important predator on juvenile Chinook salmon. Chinook salmon made up 12% of the cutthroat trout diet; 34% were other smolts, mostly chum. Bull trout diet consisted of 27% Chinook salmon and 12% other salmonids. Fifty percent of the sculpin diet was Chinook salmon, but this estimate was influenced by a single sample.

Most of the consumed juvenile salmon within the Ship Canal appear to be subyearling fish (Tabor *et al.* 2004c). Tabor noted that preliminary research done by the Muckleshoot Indian Tribe, USFWS, and University of Washington in 1995 and 1997 indicated that smallmouth bass may be an important predator of salmonid smolts in the Ship Canal. Subsequent sampling of stomach contents of over 900 predators from the end of April to the end of July indicated that both bass species and northern pikeminnow consumed smolts from mid-May to the end of July. Lowest densities of predators appeared to occur in Salmon Bay, in fact few freshwater piscivorous fish have been found there (Tabor *et al.* 2004c). Smallmouth bass of all size categories consumed salmonids, with greatest predation rate occurring in June when salmonids made up about 50% of their diet. Largemouth bass consumed salmon at a generally low rate and only by bass 5.8 to 9.8 inches (148-249 mm) long. Largemouth bass appeared to eat more coho and fewer Chinook and sockeye. About 45% of the diet of northern pikeminnow consisted of salmon, of which 45% were Chinook smolts, 40% were coho and 15% were sockeye.

Tabor *et al.* (2004c) estimated that about 3,400 smallmouth bass and 2,500 largemouth bass longer than 5 inches (130 mm) fork length reside in the Ship Canal. They used bioenergetics and direct meal-turnover models to estimate total consumption of smolts. The bioenergetics model predicted smallmouth bass consumed 27,300 salmonids and largemouth bass consumed 8,700. The direct meal-turnover model predicted smallmouth bass consumed 41,100 salmonids and largemouth bass consumed 4,600. The highest predicted consumption occurred in age 2 fish because of their large population size and high growth rates. The overall mortality rate was on the order of 1% for Chinook smolts passing through the Ship Canal and being consumed by small- and largemouth bass. Tabor could not derive a population estimate for northern pikeminnow, but reasoned that because salmonids made up a substantial portion of their diet, this species had the potential to be a significant predator if their population size in the Ship Canal is large.

Largemouth bass are more common in vegetated areas with gentle slopes and fine substrates such as south Portage Bay, Lake Union, and Salmon Bay, whereas smallmouth bass tended to use areas with steeper slopes. Tabor *et al.* (2004c) found smolts tended to be less concentrated in largemouth bass habitat than in smallmouth bass habitat. However, estimated smallmouth bass predation rates on Chinook smolts were relatively low, ranging between 0.4% and 3.0% (Tabor *et al*. 2004c). Most consumed Chinook were small and likely to use similar habitats to smallmouth bass more frequently than larger Chinook smolts during the warmer part of outmigration season when bass consumption rates were higher. Northern pikeminnow were thought to be less selective feeders than bass, but were nonetheless an important predator. The extent to which habitat overlap and temperature affect predation rates is unknown, however, in part because of the difficulty in catching them (Tabor *et al.* 2004c). Based on other systems, it is possible that northern pikeminnow could congregate in areas where smolt numbers are high in the Ship Canal, and could be present in deeper water where smolts are thought to become more concentrated as water temperatures warm.

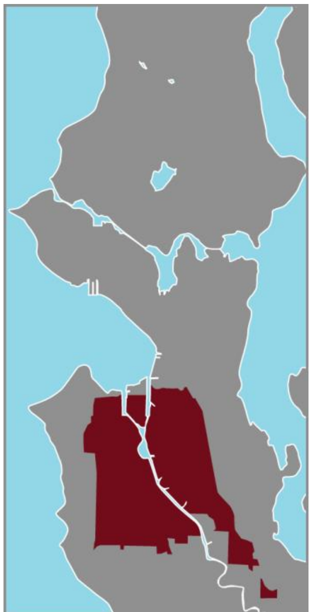
Tabor *et al.* (2004c) also noted that catch rates of predators were generally lower in Salmon Bay than elsewhere in the Ship Canal. The lower catch rates may have reflected differences in habitat structure and water quality including the effects of saltwater intrusion, sampling difficulties, and possibly the effect of sediment contamination in Salmon Bay on piscivorous predator survival.

Acoustic tracking studies were conducted from 2006 through 2009 of smallmouth bass, largemouth bass, and northern pikeminnow (Tabor *et al* 2010). Smallmouth bass commonly used overwater structures, areas of sparse vegetation, vegetation edges, and areas with gravel and sand substrate. Smallmouth bass primarily used 6.5 to 13.1 feet (2 to 4 m) deep water and were rarely in water that was more than 39.4 feet (12 m) deep. A large portion of the smallmouth bass migrates out of the Ship Canal into Lake Washington between June and October and remain there until early spring.

Northern pikeminnow usually inhabited Lake Washington, but from May through August some of the tagged northern pikeminnow moved into the Ship Canal (Tabor *et al.* 2010). Here, they were concentrated close to shore during the day and were often associated with vegetation. At night, northern pikeminnow occupy a wide range of depths.

6.3 Lower Green/Duwamish Action Area

The Duwamish River estuary is located at the lowermost extent of the Green/Duwamish River system (WRIA 9), a 93-mile-long (149.6 km) river system that originates in the Cascade Mountains near Stampede Pass and flows generally west and northwest toward the City of Seattle. Currently, the Green/Duwamish River basin drains 483 square miles (1,251 sq/km) (Weitkamp and Ruggerone 2000). Tidal influences on river height are observed upstream to about RM 15 (T. Nelson, King County, pers. comm. 2005). The saltwater wedge typically extends along the channel bottom up to a small rapid near Boeing Bridge at RM 7; saltwater may move farther upstream during extreme high tides. This reach is an important transitional area for both juvenile and adult salmon that acclimate to changes in salinity during their migration. The last 4.6 miles (7.4 km) of the watershed are located within Seattle. The lower portion of the Duwamish River, called the Duwamish Waterway, splits into East and West Waterways as it moves north and enters Elliott Bay.



Lower Green/Duwamish Action Area

Circulation of water within a stratified estuary comprises a net upstream movement of water within a lowermost saltwater wedge and a net downstream movement of fresher water in the layer overriding the wedge (Pritchard 1955). The saline wedge water, which has its source in Elliott Bay, oscillates upstream and downstream with the tide. During periods of low freshwater inflow and high tide stage, the saltwater wedge has extended as far upstream as the Foster Bridge, 10.2 miles (16.4 km) above the mouth. At freshwater inflow greater than 1,000 cubic feet/sec (28 cu m/sec), the saltwater wedge does not extend upstream beyond the East Marginal Way Bridge (RM 7.8) regardless of the tide height (Stoner 1967).

The Duwamish River transports fine material in a freshwater plume emptying into Elliott Bay. Sediments return from Elliott Bay to the Duwamish as a near-bottom sediment load contained in the saltwater wedge (GeoSea Consulting 1994).

The waterway receives runoff from approximately 11,600 acres (4,694 ha) of land in south Seattle. The waterway has been developed mainly for industrial uses, including a large shipping port. As such, the majority of the tidelands, tidal swamps, and tidal marshes have been filled. The channel has been straightened and is maintained for navigation through dredging (Blomberg *et al.* 1988). The banks of the river have been heavily armored and contain many overwater structures to support the operation of shipping-related businesses. Land use in the basin is evenly distributed between roadways (27%), residential (22%), and industrial (28%) uses, with lesser amounts of commercial (6%) and open space/vacant land (14%).

A recent survey of outfalls in the river identified over 200 outfalls discharging to the river between the turning basin near the south end of Seattle City limits and the south end of Harbor Island, near the mouth of the river. About 40 of these outfalls are publicly-owned storm drains (Seattle, King County, Port of Seattle, Washington Department of Transportation, City of Tukwila), ten are combined sewer overflows (2 City of Seattle and 8 King County overflows), five are emergency overflows from city/county sewer pump stations, and the remainder are either private storm drains or other outfalls of unknown origin/ownership (Herrera 2004). Additionally, approximately 40 storm drains, seven pump station emergency overflows, and six combined sewer overflows discharge into the East and West waterways.

Six streams are located within the Lower Green/Duwamish action area. Longfellow Creek is described below. Table 6-11 identifies the location of the other streams and any fish species found within the creek (Tabor *et al* 2006).

Table 6-11

Smaller streams and fish present within the Lower Green/Duwamish action area.

Stream	Action Area	Fish Species Present
Puget Creek	Lower Green/Duwamish	Rainbow Trout
Unnamed DW01	Lower Green/Duwamish	Dry
Durham Creek	Lower Green/Duwamish	Threespine stickleback, Coho salmon
Unnamed DW02	Lower Green/Duwamish	None
Hamm Creek – North Fork	Lower Green/Duwamish	None

6.3.1 Water Quality

Water quality in the Duwamish River has been adversely affected by discharges from public and private storm drains, combined sewer overflows, industrial and municipal wastewater discharges, contaminated groundwater, and spills and leaks that discharge directly to the river from waterfront or overwater activities. Since the 1980s, industrial and municipal wastewater inputs have been significantly reduced as a result of increased surveillance monitoring and the construction of the wastewater effluent transfer line which diverted Renton Treatment Plant effluent from the Duwamish River to Puget Sound. Removal of the South (Renton) Treatment Plant outfall led to significant decreases in the ammonia and phosphorus concentrations in the Green River (Kerwin and Nelson 2000).

Monthly monitoring conducted in the lower Duwamish Waterway at three stations between the East Marginal Way S bridge near S 115th St and the south end of Harbor Island show that maximum water temperatures have increased by about 3.6° F (2° C) since 1970 (Kerwin and Nelson 2000). Likewise, the number of times state freshwater quality standards for temperature have been exceeded has increased from one in 1970 to three in the 1980s to seven between 1990 and 1998. Between 1996 and 1999, two of the three stations (at the 16th Ave S bridge and at the East Marginal Way S bridge near S 115th St) exceeded the salmon migration blockage threshold 69.8° F (21° C) and/or the Class B marine standard 66.2° F (19° C).

Dissolved oxygen levels in the lower Duwamish River have improved since the diversion of the South Treatment Plant discharge, although occasionally state water quality standards continue to be exceeded. For example, between 1996 and 1999, fewer than 1% of the samples collected (2 out of 783) did not meet the Class B marine standard (5 mg/L). Both excursions occurred at the S Spokane Street Bridge. In addition, mortalities or delays in Chinook salmon migration—which used to occur frequently—have not been observed since the diversion (Kerwin and Nelson 2000).

Based on King County samples collected from five to nine sites along the Lower Duwamish River between 1996 and 1999, toxic pollutants such as metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc), ammonia, and pentachlorophenol do not appear to be a problem for water quality (Kerwin and Nelson 2000). However, data are lacking for organic compounds.

The Duwamish River/Duwamish Waterway is on the 2008 Ecology 303(d) list of threatened and impaired waterbodies for water, sediment, and fish tissue. The 303(d) listings are summarized in Table 6-12.

Table 6-12

Summary of 303(d) listings for the Duwamish River/Duwamish Waterway

	Category			
Media	**2**[1]	**4A**[2]	**4B**[3]	**5**[4]
Water	Bis (2-ethylhexyl)-phthalate Dissolved oxygen pH Temperature	Ammonia-N		Dissolved oxygen Fecal coliform bacteria pH
Tissue	4,4'-DDE Bis (2-ethylhexyl) phthalate Chlordane Dieldrin			4,4'-DDD 4,4'-DDE 4,4'-DDT Alpha-BHC High molecular weight polycyclic aromatic hydrocarbons (HPAH) Total PCBs
Sedi-ment	1,2,4-Trichlorobenzene 1,2,4-Trichlorobenzene 1,2-Dichlorobenzene 1,4-Dichlorobenzene 2,4-Dimethylphenol 2-Methylnaphthalene 2-Methylphenol 4-Methylphenol Acenaphthene Acenaphthylene		1,2,4-Trichlorobenzene 1,2-Dichlorobenzene 1,4-Dichlorobenzene 2,4-Dimethylphenol 2-Methylnaphthalene 2-Methylphenol 4-Methylphenol Acenaphthene Acenaphthylene Anthracene	1,2,4-Trichlorobenzene 1,2-Dichlorobenzene 1,4-Dichlorobenzene 2,4-Dimethylphenol 2-Methylnaphthalene 2-Methylphenol 4-Methylphenol Acenaphthene Acenaphthylene Anthracene

	Benzo[ghi]perylene Benzo[ghi]perylene Bis (2-ethylhexyl) phthalate Butylbenzylphthalate Butylbenzylphthalate Cadmium Dibenzo[a,h]anthracene Dibenzofuran Diethyl phthalate Dimethyl phthalate Hexachlorobenzene Hexachlorobenzene Hexachlorobutadiene Indeno (1,2,3-cd) pyrene Naphthalene N-Nitrosodiphenylamine Pentachlorophenol Phenanthrene Phenol Total PCBs		Arsenic Benzo[a]anthracene Benzo[a]pyrene Benzo[ghi]perylene Benzofluoranthenes Total (b+k+j) Bis (2-ethylhexyl) phthalate Butylbenzylphthalate Cadmium Chromium Chrysene Copper Dibenzo[a,h]anthracene Dibenzofuran Dibutyl phthalate Diethyl phthalate Dimethyl phthalate Di-N-Octyl Phthalate Fluoranthene Fluorene Hexachlorobenzene Hexachlorobutadiene High molecular weight polycyclic aromatic hydrocarbons (HPAH) Indeno(1,2,3-cd) pyrene Lead Low molecular weight polycyclic aromatic hydrocarbons (LPAH) Mercury Naphthalene N-Nitrosodiphenylamine Pentachlorophenol Phenanthrene	Arsenic Benzo[a]anthracene Benzo[a]pyrene Benzo[ghi]perylene Benzofluoranthenes Total (b+k+j) Benzoic Acid Benzyl Alcohol Bis (2-ethylhexyl) phthalate Butylbenzylphthalate Cadmium Chromium Chrysene Copper Dibenzo[a,h]anthracene Dibenzofuran Dibutyl phthalate Diethyl phthalate Dimethyl phthalate Di-N-Octyl Phthalate Fluoranthene Fluorene Hexachlorobenzene Hexachlorobutadiene High molecular weight polycyclic aromatic hydrocarbons (HPAH) Indeno (1,2,3-cd) pyrene Lead Low molecular weight polycyclic aromatic hydrocarbons (LPAH) Mercury Naphthalene N-Nitrosodiphenylamine

			Phenol Pyrene Sediment Bioassay Silver Total PCBs Zinc	Pentachlorophenol Phenanthrene Phenol Pyrene Sediment Bioassay Silver Total PCBs Zinc

[1]Water of concern – water body shows evidence of a water quality problem, but pollution level is not high enough to violate the water quality standard, or there may not be enough violations to categorize it as impaired.

[2]Water body has an approved TMDL in place and is actively being implemented.

[3]Water body has a pollution control program in place that is expected to solve the pollution problem. The water body is still impaired, but the pollutant is being addressed.

[4]Water body has violated water quality standards and no TMDL or pollution control program has been developed for the pollutant.

Source: Ecology 2008

6.3.2 Sediment Quality

In 2001, the U.S. EPA listed about 5 miles (8 km) of the Lower Duwamish Waterway, extending from near the turning basin at the south end of the Seattle City limits to the south end of Harbor Island, as a Superfund site due to elevated concentrations of contaminants in the waterway sediments. The contaminants in the waterway sediments include PCBs, PAHs, metals (arsenic, cadmium, copper, lead, mercury, and zinc), and phthalates. The U.S. EPA, the Washington State Department of Ecology, and other partners are investigating and cleaning up sediment contamination under Superfund and other programs.

A remedial investigation/feasibility study is being prepared by the members of the Lower Duwamish Waterway Group (City of Seattle, Port of Seattle, King County, and The Boeing Company). Based on a preliminary risk assessment, seven areas have been identified as candidates for early action cleanup. The following cleanup activities have occurred or are scheduled to occur:

- Norfolk dredge/cap completed by King County in 1999
- Diagonal/Duwamish dredge/cap completed by King County in 2004
- Terminal 117 waterway and upland cleanup being conducted. Cleanup has been occurring since 1999 and future alternatives to continue to address contaminants is ongoing. The Port of Seattle is responsible for cleanup of the sediments and upland property and the City of Seattle is responsible for cleanup of streets and yards.
- Slip 4 cleanup has been occurring since 2003, but was put on hold in 2007 when it was discovered that PCBs were still discharging from outfalls. In

February 2010, the City of Seattle and Boeing have agreed to share future cleanup expenses in Slip 4 (City of Seattle 2010).

Due to rising concentrations of PCBs in tissue samples, the Washington State Department of Health has issued advisories against the consumption of any resident fish, shellfish, or crab that come from the Duwamish River (WDOH 2005).

The East and West waterways adjacent to Harbor Island are also the subject of remedial investigations because of contaminated sediment. Contaminants include arsenic, copper, lead, mercury, zinc, tributyltin, PCBs and PAHs, (USEPA 2005). Between 2004 and 2005, the Port of Seattle dredged a 20-acre (8-ha) area in the East Waterway to remove PCB-contaminated sediment. A remedial investigation/feasibility study will be conducted to determine the need for additional cleanup in the East Waterway. Several contaminated areas in the West Waterway were dredged and capped by Lockheed Martin and Todd Shipyards between 2003 and 2005. EPA has determined that no additional cleanup is necessary in the West Waterway (USEPA 2005).

6.3.3 Shoreline and Aquatic Habitat

Lingering effects of more than a century of development combined with ongoing activities have affected the aquatic habitat of the Lower Green/Duwamish action area. The ongoing activities include expanding urbanization, railroads, shipping, logging, agriculture, and other industries. The effects of those activities are industrial waste discharge, stormwater runoff from impervious surfaces, freshwater diversions for industrial and domestic use, and flood control (Howard Hanson Dam, RM 64, and numerous levees).

Development began to affect the Lower Duwamish River in the early 1900s. The Cedar River historically flowed into the Black River, then into the Duwamish River and into Elliott Bay. In 1916, the Cedar River was diverted into Lake Washington and the Black River ceased to exist (except as a small tributary to the Duwamish River). The White River, which historically flowed into the Green River, was diverted into the Puyallup River in 1906. The diversion of these rivers reduced the Duwamish/Green drainage basin by 75% and its average flow up to 81%. At about the same time, the lower river was dredged to create the Duwamish Waterway, replacing 9 meandering miles (14.4 km) of river with a straight, deep, 5.3-mile-long (8.5 km) navigation channel (City of Seattle 2003).

The Duwamish estuary is characterized by industrial development (43%) and residential development (39%). In the lower portion of the estuary, the loss of estuarine and riparian habitat has been extensive (Kerwin and Nelson 2000). The estuary shoreline has been dramatically altered: 21,000 feet (6,400 m) have been lost due to straightening of the channel and 53,000 feet (16,154 m) have been filled and developed. Only 19,000 feet (5,791 m) of vegetated riparian shoreline remain. The once extensive 3,850 acres (1,558 ha) of tidal mudflats, marshes, and swamps have been reduced to only 45 acres (18 ha). Ninety-seven percent of the estuary has been filled.

Between the mouth and RM 6.0 (just upstream from Turning Basin No. 3 at the south end of the Duwamish Waterway), 55% of the shoreline is riprapped with asphalt, boulders, or cobbles; 20% is bulkheads, and 7% is faced with vertical sheet piling (TerraLogic and Landau 2004). Furthermore, a considerable portion of the remaining intertidal and shallow subtidal portions of the lower Duwamish Waterway is covered by barges (Muckleshoot Indian Tribe Fisheries Division [MITFD] unpub. data). The effects of eliminating natural shorelines were compounded by the filling of marshes and mudflats, the creation of steep bulkhead and riprap banks, the removal of vegetation, and the construction of buildings, piers, and impervious pavement. Altogether, these actions eliminated about 98% of the Lower Duwamish River's emergent marshes and intertidal mudflats and 100% of its tidal swamps (Blomberg *et al.* 1988). The surviving highly modified habitats generally provide poor habitat for juvenile salmon (Spence *et al.* 1996).

Estuaries provide essential habitat where salmon undergo osmoregulatory transitions when initially entering saltwater as juveniles and entering freshwater as adults. Estuaries also provide important foraging areas where growth may be rapid before entering the ocean and encountering new and abundant predators. In estuaries, juveniles typically utilize low velocity habitats, such as braided channels and tidal sloughs. In the Duwamish estuary, the historical migration routes of anadromous salmonids into off-channel distributary channels and sloughs have largely been eliminated.

Evidence indicates that the primary area used by juvenile salmon in the Duwamish for transitioning from freshwater to saltwater has shifted upstream (in response to dredging and channel modifications) to approximately RM 4.7 to RM 6.5. This is the primary reach where freshwater initially mixes with saltwater and where eddies provide low velocity rearing habitats. Salmon densities (all species) are relatively high in this area (Nelson et al. 2004, Ruggerone *et al.* 2006).

In the Lower Duwamish estuary, the banks have been straightened, steepened, hardened, and denuded of riparian vegetation. Warner and Fritz (1995) found the greatest abundance of juvenile salmon using shallow, sloping, soft mud beaches compared with sites having sand, gravel, or cobble substrates. The Kellogg Island area, located one mile upstream of the river mouth, has remnant intertidal shallows (Terminal 107 and Kellogg Island Reserve), restored upper intertidal habitats (Herring House Park), and relatively large riparian zones that provide insect prey for juvenile salmon. This area provides the majority of the remaining intertidal wetlands in the Duwamish estuary (Simenstad *et al.* 1991).

Research indicates that densities of juvenile Chinook salmon are lower at Kellogg Island compared with those near RM 4.7 to RM 6.5. Although restored habitats near Kellogg Island provide important salmon habitat, it appears salmon spend less time in this area compared with areas near Turning Basin No. 3. It is probable the high densities of juvenile salmon shifted upstream to the new freshwater/saltwater transition zone after initial dredging of the Duwamish Waterway. Mark and recapture studies in restored off-channel habitats, such as Herrings House near Kellogg Island, indicated only a small fraction of the Chinook population utilized these habitats because the areas are small and because fish entered the habitat for only one high tide, on average (Ruggerone and Jeanes 2004).

Chemical contamination of sediments in certain areas of the Duwamish River has compromised the effectiveness of the small amount of remaining habitat (USEPA 2002). Chemicals of concern found at elevated concentrations included PAHs, PCBs, metals (arsenic, mercury and zinc), phthalates, phenols, and pesticides (DDT, DDE, DDD). Varanasi et al. (1993) found juvenile Chinook salmon from the Duwamish Waterway displayed a lower immune system response compared with juvenile Chinook salmon from the Nisqually River, a comparable estuary without significant industrial contaminants. However, other studies suggested PCBs and PAHs in diets likely to occur in the Duwamish may not adversely affect the immune system of Chinook salmon (Powell *et al.* 2003, Palm et al. 2003). In 2002, residence time of natural Chinook salmon in the Duwamish estuary declined steadily from approximately 28 ± 7 days in late May to 20 ± 7 days in early June to 15 ± 3 days in late June (Ruggerone and Volk 2004). Residence time data provide new information on the potential exposure of juvenile salmon to contaminated prey. There is concern that contaminants could bioaccumulate to levels that may affect the ability of the individual salmon to grow and mature properly (NOAA Fisheries 2002).

6.3.4 Habitat Access: Barriers

There are no barriers that block the migration of salmonids in the Duwamish estuary. Large docks and other large overwater structures may inhibit juvenile salmonids migrating along shallow-water habitats of Puget Sound. Changes in the migration route of salmonids in response to overwater structures may increase their susceptibility to predation if the new pathway leads the salmonids to areas frequented by predators (Simenstad *et al.* 1982).

6.3.5 Non-Native and Predator Fish

Most of the fish predators (smallmouth and largemouth bass) found in freshwater systems such as Lake Washington are not present in the Duwamish estuary. Predators in the Duwamish estuary may include river lamprey, juvenile coho salmon, yearling and older Chinook salmon, bull trout, sculpins, and avian species including great blue heron, western grebe, merganser, cormorant, pigeon guillemot, and kingfisher. River lamprey may be a significant predator on juvenile Chinook salmon with 7% of juveniles observed showing lamprey marks (Salo 1969). Lamprey marks have also been observed on salmon in recent years (Ruggerone et al. 2004). Specific studies of river lamprey predation on juvenile Chinook have not been conducted in the Duwamish estuary, but Beamish and Neville (1995) estimated that lamprey were killing 25% to 65% of the young Chinook and coho migrating out of the Fraser River.

Although the Duwamish estuary contains many overwater structures and piers, fish predators are rarely present under these piers (Weitkamp and Farley 1976, Weitkamp and Katz 1976, Weitkamp 1982, Ratte 1985, Williams and Weitkamp 1991). Insufficient information is available to determine what effect other predators may have on juvenile salmonid survival in the estuary (Weitkamp *et al.* 2000). However, few salmon predators have been captured by beach seine in the estuary during winter through summer and by purse seine during winter (Nelson et al. 2004, SAIC *et al.* 2005, Ruggerone *et al.* 2006).

6.3.6 Longfellow Creek (Lower Green/Duwamish Action Area)

Seattle's second largest creek, Longfellow, is located in the Delridge Valley in West Seattle (Figure 9). It is a tributary of the West Waterway of the Duwamish River and drains about 1,667 acres (679 ha) of mainly residential property (31%) and roadways (22%), with small amounts of commercial (13%) and industrial (8%) property. About 16% of the watershed is contained in parks and open space. Overall, 52% of the watershed is covered by impervious surfaces. Almost the entire Longfellow Creek watershed (99%) drains to a formal drainage system.

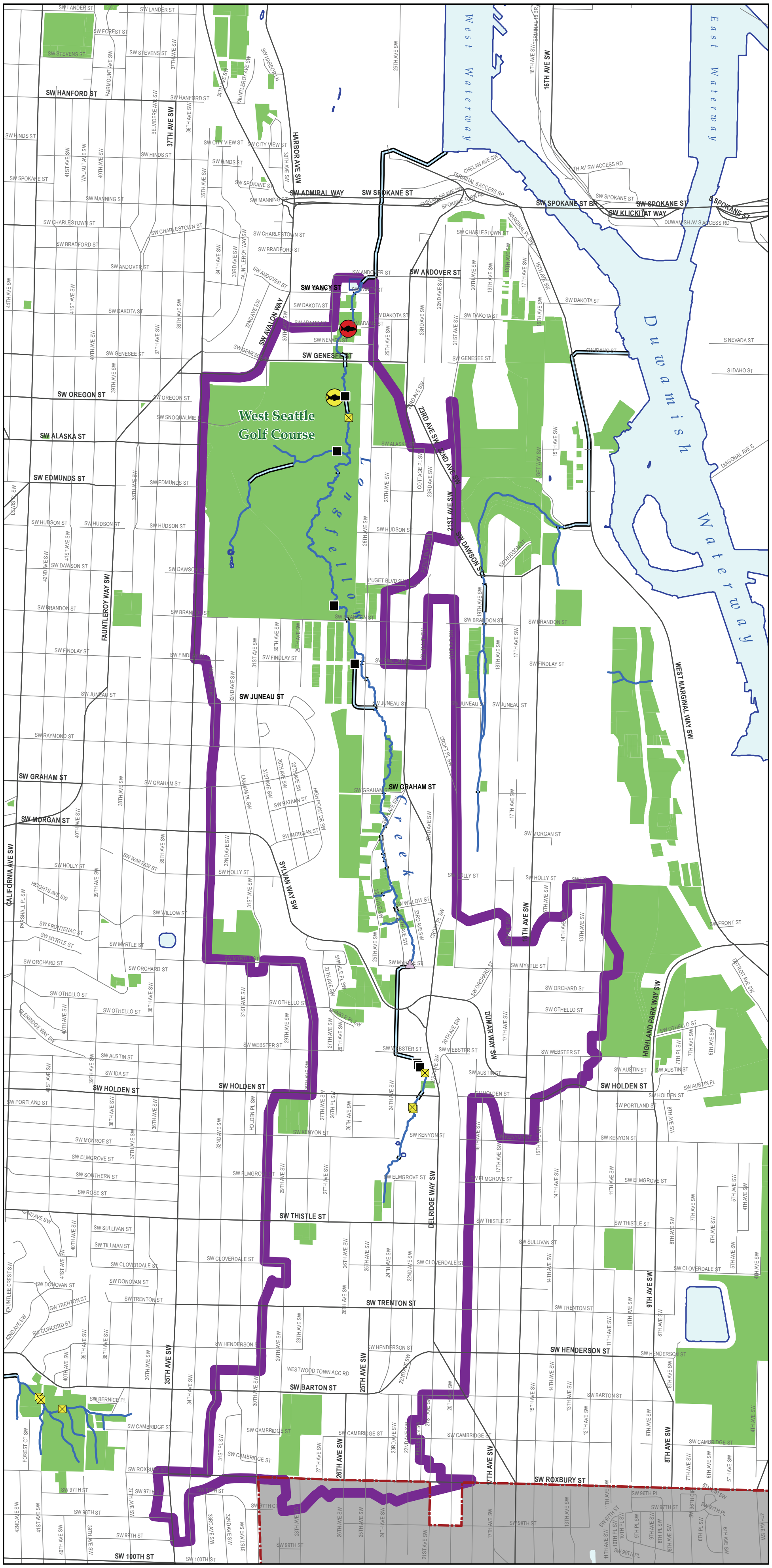
Longfellow creek is about 4.7 miles (7.6 km) long from the headwaters and consists of roughly 3 miles (4.7 km) of open channel, although the lower 0.6 mile (1 km) of the creek is piped. The headwaters of the creek originate at underground springs and travel 1 mile (1.6 km) before reaching the open channel of the creek. The headwaters were once a natural wetland and peat bog at the southern city limits, and are now contained in Roxhill Park and the adjacent retail development. Over 40% of the open channel portion of Longfellow Creek is located on park property, most of which is occupied by the West Seattle Golf Course. The remaining 60% flows through private property. Much of the riparian corridor has been developed. As a result, little of the native vegetation remains along a significant portion of the creek.

Figure 9. Longfellow Creek Watershed

Seattle Biological Evaluation

City of Seattle

FIGURE 9



Longfellow Creek Watershed

Drainage Basin

Longfellow Creek Watershed Boundary

Stream Networks

Open Channel

Culvert

Observed Upstream Extent of Adult Salmonids, per 1999-2005 SPU Spawning Survey Data*

Chinook

Coho

* This information pertains only to creeks.

Fish Barriers

Barrier

Partial Barrier

Unknown Barrier

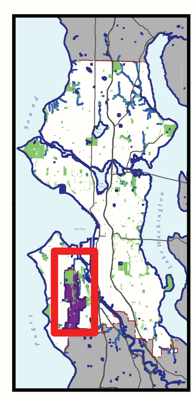
Other

City Limit

Arterial Street

Residential Street

Park



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October 1, 2012

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No warranties of any sort, including accuracy, fitness or merchantability, accompany this product.
Coordinate System: State Plane, NAD83-91, WA North Zone

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6.3.6.1 Water Quality

Sixty-four storm drains discharge stormwater runoff directly to Longfellow Creek. Three other outfalls infrequently deliver combined sewer overflows to the watercourse. On average four CSO events occur per year (range 0 to 11).

Longfellow Creek is on the 2008 Ecology 303(d) list of threatened and impaired waterbodies. The 303(d) listings are summarized in Table 6-13.

Table 6-13

Summary of 303(d) listings for Longfellow Creek

	Category	
Media	**2**[1]	**5**[2]
Water	Temperature Dissolved oxygen	Fecal coliform bacteria Dissolved oxygen

[1]Water of concern – water body shows evidence of a water quality problem, but pollution level is not high enough to violate the water quality standard, or there may not be enough violations to categorize it as impaired.

[2]Water body has violated water quality standards and no TMDL or pollution control program has been developed for the pollutant.

Source: Ecology 2008

King County has been collecting monthly samples in Longfellow Creek (at SW Yancy St and SW Brandon St) since about 1979. Samples are analyzed for conventional water quality indicators (temperature, dissolved oxygen, fecal coliform bacteria, pH, total suspended solids, and turbidity), metals, and nutrients. Summary statistics for conventional water quality parameters from monthly samples collected by King County (undated) between 1979 and 2005 are presented in Table 6-14. As shown in Figure 10, dissolved oxygen and temperature typically exhibit a seasonal trend with higher temperatures and lower dissolved oxygen concentrations in the warm summer months. Longfellow Creek frequently does not meet state water quality standards for temperature and dissolved oxygen during the summer months. Temperature and dissolved oxygen excursions are probably related to the lack of riparian vegetation throughout most its length. Large sections of Longfellow Creek pass through private property; consequently the riparian zones are largely unprotected.

Longfellow Creek also frequently exceeds state water quality standards for fecal coliform throughout the year. Over the past ten years, annual geometric mean levels (98 to 1,124 cfu/100 mL) exceeded the standard for primary contact recreation (100 cfu/100 mL) in all but 2005 at SW Yancy St, and 8% to 92% of the samples exceeded 200 cfu/100 mL. The 200 cfu/100 mL standard, which is allowed in no more than 10% of the samples, was met only once, at SW Yancy St in 2005. Seattle Public Utilities has been collecting two to three stormwater samples per year from Longfellow Creek since 1999. Stormwater samples generally contain higher levels of fecal coliform bacteria than do non-stormwater samples. The geometric mean for non-storm samples ranged from 100 to 1,100 cfu/100 mL compared with 2,900 to 5,200 cfu/100 mL in the stormwater samples.

Table 6-14

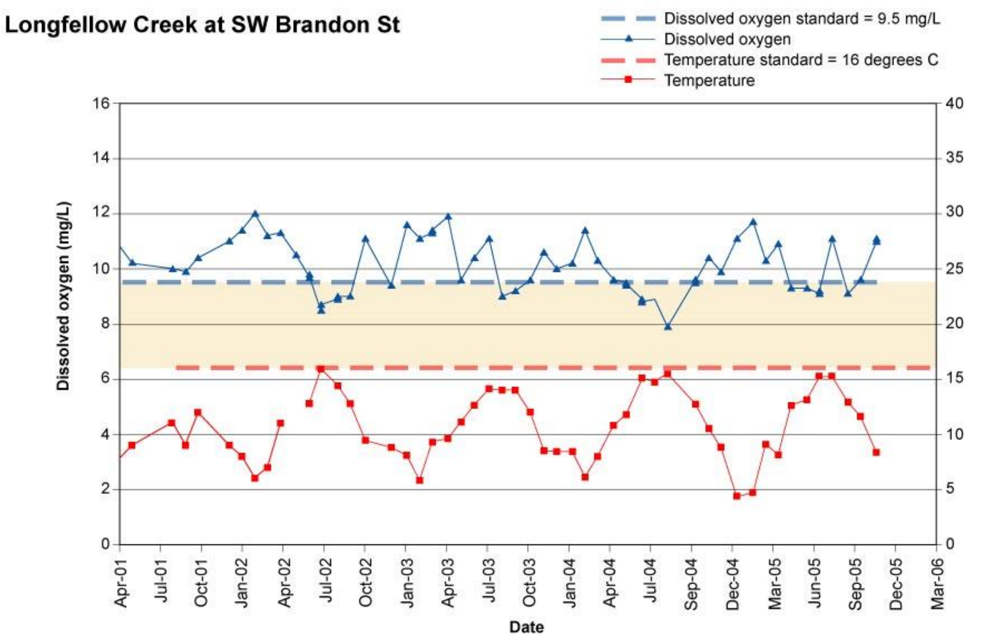
Summary statistics for conventional water quality parameters in Longfellow Creek

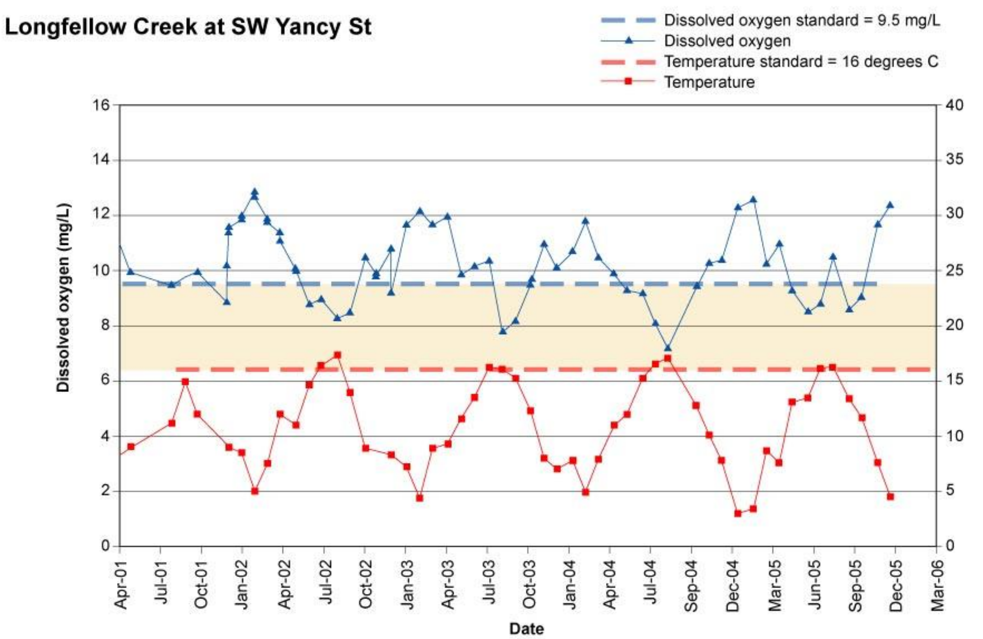
	DO (mg/L)	Temp. (degrees C)	Fecal coliform (cfu/100 mL)	pH	TSS (mg/L)	Turbidity (NTU)
Longfellow Creek at SW Yancy St (C370)						
No. of samples	217	197	214	215	182	221
Minimum	7.1	1.2	9	6.3	0.3	0.5
Maximum	15.0	20.2	25,000	9.4	463	160
Median	10.6	11.0	350	7.8	3.5	3.8
Mean	10.6	11.1	1,258	7.7	12.5	9.8
5th percentile	8.6	5.0	46	7.0	1.1	1.5
95th percentile	13.0	17.0	6,000	8.5	33.8	41
Longfellow Creek at SW Brandon St (J370)						
No. of samples	168	158	168	165	139	170
Minimum	6.5	3.0	10	5.2	0.5	0.5
Maximum	14	19.2	39,000	8.9	203	93
Median	10.2	10.9	410	7.7	2.1	2.5
Mean	10.2	11.0	1,346	7.6	7.2	5.7
5th percentile	8.7	6.0	59.05	6.9	0.8	1.0
95th percentile	12	16.0	6,000	8.2	20.1	20

Source: Reference Stations C370 and J370. King County (undated)

Figure 10

Dissolved oxygen and temperature in Longfellow Creek





Reference: Stations C370 and J370. King County (undated).

Note: The areas between the two dashed lines show the samples that do not meet state water quality standards.

Nutrient levels in Longfellow Creek are generally high and exceed recommended water quality criteria. For example, total phosphorus concentrations in Longfellow Creek (5 to 970 µg/L in non-storm samples and 91 to 670 µg/L in stormwater samples) frequently exceed the U.S. EPA water quality criterion (100 µg/L), which establishes a desired goal for the prevention of nuisance plant/algal growth in streams or other flowing waters not discharging directly to lakes or impoundments (USEPA 1976). In addition, total nitrogen concentrations in Longfellow Creek (170-3,250 µg/L) frequently exceed U.S. EPA (2000) recommended criterion for streams in the western United States (340 µg/L for Ecoregion II). These criteria represent conditions in surface waters that are minimally impacted by human activities and are designed to prevent eutrophication and water quality problems associated with nutrient enrichment.

Concentrations of toxic materials in Longfellow Creek are generally low. Ammonia-nitrogen levels exceeded state water quality standards in only 1% of the samples collected since 1979. For metals, only dissolved copper exceeded the state water quality standards (in two stormwater samples collected by Seattle Public Utilities in 2004).

The USGS has also found low levels of some pesticides in stormwater collected from Longfellow Creek during a May 14, 1998 storm (Voss and Embrey 2000). Three stormwater samples collected during the rising limb of the storm contained detectable levels (0.03-0.35 µg/L) of several herbicides and their metabolites (2,4-D, acetochlor, dicamba, dichlobenil, dichlorprop, MCPA [4-chloro-2-methylphenoxyacetic acid.], mecoprop, pentachlorophenol, prometon, and trichlorpyr) and 1 insecticide (diazinon at 0.046 µg/L) and 1 insecticide metabolite (4-nitrophenol at 0.05-0.12 µg/L). With the exception of diazinon, concentrations were below reported toxic effects levels for aquatic organisms.

To support an ongoing NOAA coho prespawn mortality investigation, the USGS and Seattle Public Utilities collected time-weighted composites (1-hour composites composed of 15-minute grab samples) from Longfellow Creek (between SW Alaska St and SW Genesee St) during three storms in October and November 2003 (SPU unpub. data). A total of 16 stormwater samples were analyzed for semi-volatile organic compounds. In addition, one sample was analyzed for pesticides and PCBs. Bis(2-ethylhexyl)phthalate—a plasticizer used in polyvinyl chloride (PVC) resins to fabricate flexible vinyl products such as upholstery, tubing, and gloves, as well as paper and paperboard, defoaming agents, adhesives, and lubricants—was detected most frequently (100% of the samples), followed by pentachlorophenol (88%), phenol (88%), benzyl alcohol (75%), benzoic acid (62%), and PAHs (6-50%).

Water quality is being investigated as a potential contributor to the unusually high rates of coho salmon pre-spawn mortalities reported in urban creeks in the Puget Sound since 1999 (Reed et al. 2003). Between 1999 and 2005, pre-spawning mortality rates in Longfellow Creek averaged 71% (McMillan 2006, SPU unpub. data). Water and sediment quality is still being investigated as a potential factor related to this pre-spawning mortality. Conventional water quality parameters (e.g., temperature and dissolved oxygen) and disease do not appear to be causal. Rather, the weight of evidence suggests that adult coho—which enter small urban streams following fall storm events—are acutely sensitive to non-point source stormwater runoff (Scholtz 2006, S. McCarthy, NMFS, pers. comm. 2006). No sediment quality data have been collected at this time. Pre-spawn mortality surveys were stopped in 2010 to analyze and publish the data and to define a path to move forward with the pre-spawn mortality issue and to pinpoint the causal factors (Davis, J. USFWS pers. comm. 2011).

6.3.6.2 Shoreline and Aquatic Habitat

Factors limiting aquatic habitat within Longfellow Creek include alterations to the stream hydrology, reduced floodplain connectivity, lack of longitudinal connectivity, lack of gravel recruitment and retention, abundance of fine sediment, lack of channel complexity, and reduced riparian vegetation.

Longfellow Creek habitat is severely degraded by substantial hydrological alterations. The narrow, straight, elongated shape of the basin requires much of the Longfellow Creek's flow energy to be dissipated within the channel. Creek conditions are also affected by reduced connectivity between the stream and its floodplain. Encroachment and confinement of the channel migration zone through armoring is a major change in the Longfellow watershed. More than 40% of the channel has been piped including the lower 3,258 feet (993 m), and the upper mile of former plateau wetlands. Buildings, roads, yards, and armoring (23% of open channel) confine much of the remaining open channel. In contrast to stream widths that average 12 feet (3.6 m), unconfined sections in the golf course canyon reach an average of 19 feet (5.8 m) and are as wide as 30 feet (9.1 m) within the channel. When in-channel wetlands are included, these areas can have channel widths up to 100 feet (30 m).

Longfellow Creek largely contains poor habitat. In most areas, the creek channel is incised, riprapped, concrete, and featureless, with a plane-bed channel dominated by glide habitat. The creek has bank and streambed erosion problems especially in the upper reaches. As a result of the lack of land-water connectivity, Longfellow Creek does not contain much instream structure. The limited pool habitat (18% of open channel length) and pockets of gravel are usually associated with structures placed in the creek during improvement projects. Most of the confined, incised sections of Longfellow Creek do not have sufficient channel capacity to add structure due to flooding and bank erosion problems. Many of the confined incised sections have been restored and improvements have been made to sections along the golf course.

The lack of floodplain connectivity also limits gravel recruitment and retention. As a result, the creek has thin to nonexistent channel substrates throughout most of the open channel area. Isolated pockets of gravel-dominated substrate are found primarily in the golf course and in restored areas. While coarse sediment is typically supplied by erosion of the bed and banks, floodplain sources have been cut off from Longfellow Creek channel by armoring and encroachment. In addition, the Longfellow Creek channel is dominated by loose sand and silt. This is mostly due to bank erosion and limited landslides in areas with fine sediment (sand and silt).

Development near the stream has degraded the riparian zone around Longfellow Creek. Only a few short reaches of the stream, outside of the golf course, have good riparian areas. These areas are located in parks. The golf course has the best riparian corridor along the stream averaging 100 feet in width. Two fairways crossing the creek break-up the continuous riparian corridor. Yard encroachment in some areas has reduced canopy cover, allowing creek temperatures to increase. Invasive species can also be found along sizeable portions of the creek. There have been some restored areas where planting has occurred and although the vegetation is becoming established, monitoring and maintenance would be useful. Sections of the creek in the golf course offer good canopy cover (shade), but lack diversity, especially mature native conifers.

Fish Use

Historically, Longfellow Creek contained coho salmon, sea-run cutthroat trout and steelhead. Both cutthroat and steelhead are now absent from the creek. A variety of fish continue to use the creek, most commonly coho and chum salmon and resident rainbow trout. Prickly sculpin, Pacific staghorn sculpin, and three-spine stickleback are also found in the creek. Chinook salmon have been found in Longfellow Creek in 2001 and 2003 (Shapiro 2001; City of Seattle 2007, Tabor *et al* 2010).

Longfellow Creek has the largest coho salmon run in the city. On average, 141 coho carcasses (range 32 – 277) have been found in Longfellow Creek between 1999 and 2005 (City of Seattle 2007). It is estimated that over 400 adult coho may use Longfellow Creek. An average of 17 chum carcasses (range 0 -67) have been found. Smolt traps within Longfellow Creek show indicate low production of coho salmon possibly due to poor rearing habitat, lack of pools, low spawning success as a result of redd superimposition, or coho prespawn mortality.

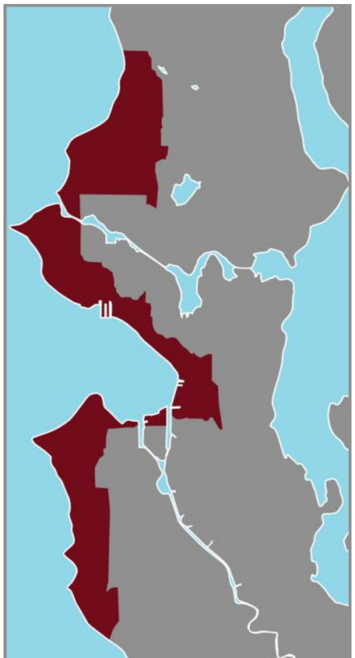
Spawning for anadromous salmon is limited to 15% of the open-channel due to manmade barriers. The lowest downstream barrier is located at a dam and culvert at the 12th fairway of the West Seattle golf course. Approximately 1,900 feet of open channel is available for spawning and rearing. Barriers within Longfellow Creek may also limit resident rainbow trout distribution. The farthest upstream point at which rainbow trout have been recorded is at 25th Ave SW.

6.3.6.3 Habitat Access Barriers

Longfellow Creek has substantial fish passage barriers. The downstream-most fish passage barrier, located in the golf course at the 12th Fairway culvert, restricts anadromous fish to the lower 2,400 feet (731 m) of open channel. The need for additional habitat is indicated by both adult and juvenile salmon use of the stream. Superimposition of salmon redds suggests that there may not be sufficient spawning habitat (< 800 feet [243 m]) available for the existing fish (maximum entry was an estimated 600 coho and 90 chum in 2001), despite an average 71% pre-spawning mortality of coho (McMillan 2006, SPU unpub. data). Low numbers of outmigrating coho smolts (fewer than 1 fish/day) and the absence of juvenile salmonids (coho, rainbow trout) recorded during surveys may indicate a lack of adequate rearing habitat, as well as the effects of pre-spawning mortality. Barriers at the upstream end of the golf course and at Juneau Street are the remaining barriers blocking most of the remaining open channel habitat in Longfellow Creek.

6.4 North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound Action Areas

Seattle's marine nearshore area extends from North 145th Street south to Seola Creek in West Seattle and includes 29.5 miles (47.5 km) of Puget Sound shoreline. This section of the Puget Sound shoreline has been grouped for this document as the North Seattle Puget Sound, Elliott Bay, and South Seattle Puget Sound action areas.



North Seattle/Puget Sound, Elliot Bay, and South Seattle/ Puget Sound Action Areas

The nearshore environment in Seattle includes areas within both WRIA 8 and WRIA 9. About 8 miles (12.8 km) of shoreline is within Elliott Bay and 2.5 (4 km) miles of shoreline is within Shilshole Bay. The nearshore has one of the highest degrees of shoreline modification in Puget Sound at over 80% (Kerwin and Nelson 2000). Most shoreline modification such as seawalls and bulkheads were placed to protect residential development from erosion or to support the railroad.

The mile-long, 300-feet-wide (91-m) estuary west of the Locks serves as the 'estuarine' area with the Locks creating an abrupt transition between fresh and saltwater (Kerwin 2001). The estuarine area of the canal downstream of the Locks is dredged to an authorized depth of 34 feet (10.3 m) MLLW and has a maximum tidal range of 19.3 feet (5.8 m). This area lacks the diversity of habitats and brackish water refuges characteristic of estuarine habitat. This area has experienced substantial bank armoring, which has reduced the quantity and quality of shallow intertidal habitat. A marina was constructed by the Port of Seattle, just north of Shilshole Bay and south of Golden Gardens Park. Construction of the marina, known as the Shilshole Bay Marina, consisted of a large breakwater jetty, dredging, and shoreline filling/armoring, which has resulted in the loss of both subtidal and intertidal habitats. The most 'natural' shoreline areas are found adjacent to the cliffs and bluffs in Discovery Park and within the sand beach areas of Golden Gardens Park (Williams *et al.* 2001).

The nearshore environment in Puget Sound possesses an extremely productive and dynamic ecosystem. Tides, currents, wave action, and intermixing of saltwater with freshwater create a complex physical environment situated at the juncture between land and water. The marine nearshore environment encompasses the area from upland bluffs, banks, and beaches, and the lower limit of the photic (light penetration) zone, which varies with season and climatic conditions. Some define the lower limit of the photic zone at about 100 feet (30 m) below the MLLW line. The nearshore area includes a wide variety of upland, marine, and estuary habitats including marine riparian areas, backshore areas, beaches, tidal marshes, tidal flats, eelgrass meadows, kelp forests, and exposed habitats. Terrestrial habitats along the shoreline such as bluffs, sand spits, and coastal wetlands are also included within the nearshore environment, as well as the tidally-influenced region found within the lower sections of mainstem rivers and coastal streams.

The Puget Sound marine waters offshore of Seattle receive runoff from about 9,900 acres (4006 ha) in north, central, and south Seattle. Land use in the basin is primarily residential (50%) and roadways (22%), with lesser amounts of industrial (6%), commercial (4%), and open space/vacant land (17%). Drainage conveyance systems in the basin consist mostly of piped networks. Piper's Creek and Fauntleroy Creek (discussed below) are the only significant open channel systems in the basin.

Twenty-five streams are located within the North Seattle/Puget Sound (12 streams), Elliott Bay (7 streams) and South Seattle/Puget Sound (6 streams) action areas. Piper's Creek (North Seattle/Puget Sound) and Fauntleroy Creek (South Seattle/Puget Sound) are described below. Table 6-15 identifies the location of the other streams and any fish species found within the creek (Tabor *et al* 2006).

Table 6-15
Smaller streams and fish present within the North Seattle/Puget Sound, Elliott Bay, and South Seattle/Puget Sound action areas.

Stream	Action Area	Fish Species Present
Unnamed PS01	North Seattle/Puget Sound	None
Unnamed PS02	North Seattle/Puget Sound	Not accessible
Unnamed PS03	North Seattle/Puget Sound	Not accessible
Broadview Creek	North Seattle/Puget Sound	None
Unnamed PS04	North Seattle/Puget Sound	Not accessible
Unnamed PS05	North Seattle/Puget Sound	Not accessible
Unnamed PS06	North Seattle/Puget Sound	None
Unnamed PS07	North Seattle/Puget Sound	None
Unnamed PS08	North Seattle/Puget Sound	None
Unnamed PS09	North Seattle/Puget Sound	Not accessible
Unnamed PS10, 11, 13, 14	North Seattle/Puget Sound	None
Scheuerman Creek	Elliott Bay	Threespine stickleback
Owls Creek	Elliott Bay	None
Unnamed PS18	Elliott Bay	Not accessible
Unnamed PS19	Elliott Bay	Not accessible
Unnamed PS20	Elliott Bay	Not accessible
Unnamed PS21	Elliott Bay	None
Fairmont Creek	Elliott Bay	None
Schmitz Creek	Elliott Bay	None
Mee-kwa-mooks Creek	South Seattle/Puget Sound	None
Pelly Creek	South Seattle/Puget Sound	None
Unnamed PS22	South Seattle/Puget Sound	Dry
Seola Creek	South Seattle/Puget Sound	Dry

6.4.1 Water Quality

Water quality in Puget Sound is affected by many factors, including human activities and ocean currents, as well as physical, chemical, and biological processes. The average tidal range in Puget Sound is 12 to 14 feet (3.7-4.3 m), with an average volume exchange of 8 billion cubic meters per tidal cycle (King County 1994). This relatively high water exchange is a key factor in maintaining good water quality conditions in the offshore areas (Stark et al. 2005). However, nearshore conditions are affected by human activities such as land use, municipal wastewater discharges, combined sewer overflows, storm drain discharges, and shoreline erosion. Because many contaminants present in these discharges tend to adsorb particulate material, the sediment deposited in nearshore areas tends to accumulate contaminants.

Between 1994 and 2003, water temperatures in offshore areas ranged from about 44.6° to 61.8° F (7.0-16.6° C) (as measured at mid-sound stations KSBP01 and LSNT01, located near the northern border of King County and offshore of the Fauntleroy area in Seattle, Stark *et al.* 2005). Average temperatures ranged from 49.6° to 53.8° F (9.8-11.6° C). In general, the offshore areas are well mixed throughout most of the year, with a thermocline developing during the summer months. Higher temperatures generally occur during the summer season along the shallow beach areas. Temperatures at beach stations between 2001 and 2003 ranged from 43.7° to 67.1° F (6.5-19.5° C) (King County 2002, Stark *et al.* 2005).

Salinity varies seasonally, with the lowest measurements generally occurring during the winter and spring months due to contributions from freshwater sources and the highest levels occurring from August to December, which is believed to result from upwelling of saltier deep Pacific water along the outer coast (Stark *et al.* 2005). Salinity ranged from about 22 to 32 on the practical salinity scale (PSS) at the two offshore stations, KSBPO1 and LSNT01 between 1994 and 2003. Lower surface salinities have been recorded in Elliott Bay due to the large freshwater contributions from the Duwamish River (Stark *et al.* 2005).

Dissolved oxygen levels in Puget Sound have remained fairly consistent (Stark *et al.* 2005). Concentrations at all offshore stations and depths ranged from 4.5 to 14.1 mg/L between 2001 and 2003. Dissolved oxygen generally declines with depth up to about 164 feet (50 m) and then remains relatively constant. Average concentrations range from 8.7 to 9.07 mg/L in surface samples and from 6.57 to 6.95 mg/L at a depth of 656 feet (200 m) (Stark et al. 2005, King County 2002). Dissolved oxygen drops below the state water quality standard for marine waters (7 mg/L) in deep water during the late summer and fall due to seasonal influx of deep oceanic water, which contains lower oxygen. Water column stratification, which impedes vertical mixing with oxygenated water from the surface, helps to sustain the low dissolved oxygen concentrations at depth (Stark et al. 2005). Between 2001 and 2003, dissolved oxygen concentrations rarely fell below 5.0 mg/L, the upper limit for biological stress (NOAA 1998). Concentrations below 5.0 mg/L occurred at both outfall and mid-sound stations and occurred at depths greater than 164 feet (50 m) (Stark *et al.* 2005).

Offshore sampling stations generally meet the state water quality standards for fecal coliform bacteria. However, nearshore samples collected along the shoreline frequently exceed the standards. The marine standard for primary contact recreation allows a geometric mean number of no more than 14 cfu/100 mL, with no more than 10% of the samples exceeding 43 cfu/100 mL (Ecology 2004). In 2002 to 2003, all offshore stations met the standard (Stark et al. 2005). However, in 2001, two of three stations located in Elliott Bay met the geometric standard, but did not meet the peak standard (in 4 of 30 samples) and one station exceeded both the geometric mean and the peak standard (in 9 of 30 samples) (King County 2002). Samples collected at the following stations consistently fail the fecal coliform standards:

- Carkeek Park and mouth of Piper's Creek
- Shilshole Bay
- Magnolia beach
- Near the mouth of the Lake Washington Ship Canal
- Inner Elliott Bay
- Fauntleroy Cove.

Fecal coliform data collected by King County from 2001 to 2003 are summarized in Table 6-16 (King County 2002, Stark *et al.* 2005).

Table 6-16

Summary of compliance with state marine water quality standards for fecal coliform bacteria at beach stations

		2001		2002		2003	
Location	Station No.	Geomean	Peak	Geomean	Peak	Geomean	Peak
Piper's Creek	KTHA01	No	No	Yes	No	Yes	No
Golden Gardens	KSLU03	No	No	No 7/12	No	Yes	Yes
Shilshole Bay	KSQU01	No	No	No 12/12	No	No 12/12	No
Magnolia	KSYV02	No	No	No 5/12	No	No 4/12	No
Inner Elliott Bay	LTEH02	No	No	No 12/12	No	No 12/12	No
Inner Elliott Bay	LTAB01	Yes	No	Yes	Yes	Yes	No
Seacrest	LSFX01	Yes	Yes	Yes	Yes	Yes	Yes

		2001		2002		2003	
Duwamish Head	LSGY01	Yes	Yes	Yes	Yes	Yes	Yes
West Seattle	LSHV01	Yes	Yes	Yes	Yes	Yes	Yes
Lincoln Park	LSTU01	Yes	Yes	Yes	Yes	Yes	Yes
Fauntleroy Cover	LSVW01	No	No	No 12/12	No	No 7/12	No
Yes = Samples meet state water quality standards No = Samples exceed state water quality standards For non-compliance, ratio indicates the numbers of exceedances							

Metals—both dissolved and total forms—are frequently detected in Puget Sound water samples, but concentrations are generally low. All of the samples collected by King County in 2001 and 2002 from seven Seattle area beach sites (Carkeek Park, Golden Gardens, Shilshole Bay, West Point—north and south beach, Alki Point, and Normandy Park) were below the acute and chronic toxicity criteria for dissolved metals (Stark *et al.* 2005, King County 2002). King County stopped sampling for metals after 2002.

Puget Sound/Elliott Bay is on the 2004 Ecology 303(d) list of threatened and impaired waterbodies for water and sediment. The 303(d) listings are summarized in Table 6-17.

Table 6-17
Summary of 303(d) listings for Puget Sound/Elliott Bay

	Category		
Media	2[1]	4B[2]	5[3]
Water	Fecal Coliform Bacteria Endosulfan Dissolved Oxygen		Fecal Coliform Bacteria
Sediment	1,2,4-Trichlorobenzene 1,2-Dichlorobenzene 1,4-Dichlorobenzene 2,4-Dimethylphenol 2-Methylphenol	1,2,4-Trichlorobenzene 1,2-Dichlorobenzene 1,4-Dichlorobenzene 2,4-Dimethylphenol 2-Methylnaphthalene	Sediment Bioassay

	4-Methylphenol Acenaphthylene Benzo[ghi]perylene Benzyl Alcohol Bis(2-ethylhexyl) phthalate Butylbenzylphthalate Butylbenzylphthalate Dibenzo[a,h]anthracene Diethyl phthalate Dimethyl phthalate Hexachlorobenzene Hexachlorobutadiene Mercury N-Nitrosodiphenylamine Pentachlorophenol Sediment Bioassay	2-Methylphenol Acenaphthene Acenaphthylene Anthracene Arsenic Benzo[a]anthracene Benzo[a]pyrene Benzo[ghi]perylene Benzofluoranthenes Total (b+k+j) Bis(2-ethylhexyl) phthalate Butylbenzylphthalate Cadmium Chromium Chrysene Copper Dibenzo[a,h]anthracene Dibenzofuran Dibutyl phthalate Diethyl phthalate Di-N-Octyl Phthalate Fluoranthene Fluorene Hexachlorobenzene Hexachlorobutadiene High molecular weight polycyclic aromatic hydrocarbons (HPAH) Indeno(1,2,3-cd)pyrene Lead Low molecular weight polycyclic aromatic hydrocarbons (LPAH) Mercury Naphthalene N-Nitrosodiphenylamine	

		Pentachlorophenol Phenanthrene Phenol Pyrene Silver Total PCBs Zinc	
[1]Water of concern – water body shows evidence of a water quality problem, but pollution level is not high enough to violate the water quality standard, or there may not be enough violations to categorize it as impaired. [2]Water body has a pollution control program in place that is expected to solve the pollution problem. The water body is still impaired, but the pollutant is being addressed. [3]Water body has violated water quality standards and no TMDL or pollution control program has been developed for the pollutant. Source: Ecology 2008			

6.4.2 Sediment Quality

Sediment contamination in Puget Sound offshore of Seattle appears to be limited to a few hotspot areas associated with waterfront activities and/or site-specific discharges, such as combined sewer overflows and/or stormdrain outfalls. Data from King County's marine monitoring program for 2001 to 2003 indicate that concentrations of metals and organic contaminants were well below the Washington state sediment management standards at all stations. Sample locations are summarized in Table 6-18.

Specific areas where sediment contamination has been reported include the sediment offshore of the northwest corner of Harbor Island and at various locations along the Seattle waterfront (PTI and Tetra Tech 1989, USEPA 2005). In 1983, the EPA listed the marine sediments offshore of Harbor Island as part of a Superfund site, due to elevated concentrations of arsenic, copper, lead, mercury, zinc, tributyltin, PCBs, and PAHs (USEPA 2005). Todd Shipyard dredged and capped an area of about 38.9 acres (15.7 ha) on the north side of Harbor Island, removing about 166,000 cubic yards of sediment and 2,700 creosote-treated timber piles. Work was completed in 2005.

Table 6-18 King County marine sediment monitoring locations in Puget Sound offshore of Seattle			
Location	**2001**	**2002**	**2003**
West Point—north beach	√		
Alki beach near CSO storage and treatment facility	√		
Alki offshore of CSO storage and treatment facility	√		
Magnolia beach		√	
Elliott Bay—offshore of Denny Way CSO		√	
Elliott Bay—outer		√	
Shilshole Bay		√	
West Seattle		√	
Golden Gardens beach			√
Normandy Park beach		√	√

King County dredged and capped a 3-acre (1.2 ha) site offshore of the Denny Way combined sewer overflow in 1990 to test the feasibility of capping contaminated sediments in Elliott Bay with clean dredged material from the Duwamish River (Brown and Caldwell 1999). Sediments offshore of the Denny Way combined sewer overflow are contaminated with mercury, silver, PAHs, and bis(2-ethylhexyl)phthalate. King County recently completed the Denny combined sewer overflow control project, which includes a large tunnel to store wastewater during large events, a combined sewer overflow treatment facility along Puget Sound, and a new outfall for the Denny Way combined sewer overflow (King County undated). The project is designed to reduce overflows to Puget Sound from 50 events per year to 4 to 20 treated overflows and one untreated overflow per year, which should greatly reduce the potential for sediment offshore of the outfall to become recontaminated.

In 1992, the Corps capped a 4.5-acre (1.8 ha) site offshore of Pier 53-55 along the Seattle waterfront to contain elevated levels of cadmium, mercury, silver, and organic compounds (Wilson and Romberg 1997). Post-cap monitoring has found that the 3-foot (0.9-m) cap is stable and contaminants are not migrating upwards from the underlying sediments, but elevated concentrations of 4-methylphenol and phenol were found on the surface of the cap in 1996 (Wilson and Romberg 1997).

6.4.3 Shoreline and Aquatic Habitat

The marine nearshore region within central Puget Sound includes several types of distinct habitat areas, including eelgrass meadows, kelp forests, tidal flats, tidal marshes, river and stream mouths and deltas, sand spits, beaches and backshores, high-bank bluffs, and marine riparian zones (Williams *et al.* 2001).

Land use within the nearshore environment in the City of Seattle has greatly modified the aquatic habitat in these action areas (PSWQAT 2000). More than 50% of tidal flats and intertidal areas in major embayments of Puget Sound have been lost since 1850 (PSWQAT 2000). Many estuarine and nearshore areas of Puget Sound have been filled or have had overwater structures installed to provide upland development sites for commercial/industrial and to some extent residential development. Significant portions of nearshore and shoreline habitats have also been altered with vertical or steeply sloping bulkheads and revetments to protect various developments and structures (*e.g.*, railroads, piers) from wave-induced erosion, stabilize banks and bluffs, to retain fill, and to create moorage for vessels (BMSL *et al.* 2001).

It has been estimated that 33% of Puget Sound's shoreline has been modified, with 50% of the main basin of Puget Sound having been altered (PSWQAT 2000). In areas where nearshore habitats currently remain intact or only partially modified, development continues to threaten habitat (WSCC 1999, BMSL *et al.* 2001). Construction of bulkheads and other structures has resulted in habitat loss that has directly affected forage fish for bull trout, salmon, and other piscivorous fish inhabiting Puget Sound.

Bank armoring and inwater structures such as rock jetties and gabions can reduce the mobilization and transport of sediments along the shoreline. The lack of sediment recruitment, and reduced mobilization and deposition along the shore, can result in substantial changes to substrate composition in many marine nearshore and estuary areas. These substrate changes can in turn reduce or eliminate intertidal and subtidal vegetation, including eelgrass beds and kelp forests. However, northern Elliott Bay contains a few areas of intact feeder bluffs that supply sediment to Puget Sound beaches (*e.g.*, Discovery Park). There are additional feeder bluffs near the marina at the south side of Magnolia and along Perkins Lane. These feeder bluffs provide sediment for intertidal and subtidal vegetation including eelgrass beds and kelp forests (City of Seattle 2003). This vegetation provides critical refuge and forage habitat areas for juvenile salmonids, as well as baitfish spawning areas

Factors that have affected the functions of the marine nearshore environment include the loss of habitat within the migratory corridor, degradation of water and sediment quality, alteration of physical processes including bank erosion and alongshore sediment transport and accretion, loss of riparian functions, and introduction of non-native species. Human activities have disrupted the natural processes that create habitat within the nearshore environment. Bank armoring, dredging, filling, and the construction of overwater structures have resulted in direct modification to the nearshore habitat within the Seattle shoreline area.

Although much is known about the importance of riparian areas (transition zones between aquatic habitats and upland areas, such as banks and bluffs) in freshwater systems, relatively little research has been conducted on the functions and values of riparian vegetation in marine systems. Brennan and Culverwell (2004) hypothesize that marine riparian areas provide functions similar to freshwater riparian areas and may provide additional roles unique to marine systems. Riparian corridors provide habitat complexity, predator refuge habitat, food sources in the form of insects dropping into the water and also provide shade to smelt (forage fish) spawning beaches. A loss of riparian vegetation results in a reduction in food resources for salmonids in the nearshore environment. Loss of riparian vegetation along the shoreline may decrease the productivity of deeper water habitats by decreasing detrital inputs. Functional riparian vegetation on Elliott Bay is limited to Magnolia Bluff along the northern shore and represents less than 14% of the bay shoreline. About 3,870 feet (1,179 m) of undeveloped bluff is vegetated with deciduous trees and shrubs. The marine riparian vegetation along the Seattle shoreline consists of 39.5% grass or landscaped areas, 29.1% open area, and 26.5% trees and shrubs. Little marsh habitat exists along the shoreline with only 2.7% of the 29.5 miles (47.4 km) of shoreline having dune grass and other salt-tolerant marsh habitat. Eighty-nine percent of the shoreline is armored, and there are 5.4 million square feet (501,676 sq m) of overwater structures (Anchor Environmental 2004).

Puget Sound nearshore habitats are important for rearing, migration, and growth of juvenile salmon, especially among fish that recently emigrated from rivers (Brennan and Higgins 2004). Juvenile salmonids may be present in nearshore habitats throughout much of the year, although highest densities are likely during late winter to early summer when many juveniles initially enter Puget Sound. Recoveries of coded-wire-tagged salmon demonstrated that salmon from many Puget Sound watersheds utilize nearshore waters adjacent to Seattle (Nelson et al. 2004, Brennan and Higgins 2004). Nearshore habitats provide spawning habitat for forage fish, which are important prey for Chinook salmon and bull trout.

Eelgrass (*Zostera marina L.*) and bull kelp (*Nerocystis luetkeana)* are important in the nearshore ecosystem and provide numerous critical functions including primary production, wave and current energy buffering, and habitat for fish and invertebrates (Williams *et al.* 2001). Studies of primary production indicate that eelgrass productivity can equal or exceed the productivity rates of most other aquatic plants (Thom 1984, Kentula and McIntire 1986, Thom 1990). Limited data show that once eelgrass is established in an area, fish and shellfish increase in the area (Thom *et al.* 1999).

Eelgrass occurs from about +3.28 feet (1 m) to 16.4 feet (5 m) MLLW in the central Puget Sound area (Bulthuis 1994, Thom *et al.* 1998). Kelp grows attached to bedrock or pebble and gravel size substrate in the very low intertidal and shallow subtidal zones. An important factor controlling the distribution of both eelgrass and kelp is desiccation stress (Thom 1978, Thom *et al.* 1998). Eelgrass is found throughout the Seattle shoreline north of the Ship Canal in dense to moderate concentrations. However, eelgrass is not found along the shoreline near Shilshole Marina (King County 2003). Eelgrass along the nearshore of the South Seattle Puget Sound action area is patchy with most eelgrass found around Alki Point and along the northwest shore of the Duwamish Head and categorized as moderately dense to dense (Williams *et al.* 2001). In the North Seattle/Puget Sound action area, kelp occurs along the breakwater of Shilshole Marina and on the north side of West Point. In Elliot Bay, kelp forests are found along 5,577 feet (1,700 m) of shoreline. Kelp was found near the Duwamish Head, along the lower end of Magnolia Bluff, and in patchy locations between Pier 91 and Alki Point (Williams *et al.* 2001).

6.4.3.1 Underwater Sound

High underwater sound levels can have negative physiological and neurological effects on a wide variety of vertebrate species including fishes and birds (Cudahy and Ellison 2002; Fothergill *et al.* 2001; Steevens *et al.* 1999; U.S. Department of Defense 2002; Yelverton and Richmond 1981; Yelverton *et al* 1973). High sound levels can injure or kill fishes, while lower sound levels can cause behavioral changes (Hastings and Popper 2005; Popper 2003; Turnpenny and Nedwell 1994; Turnpenny *et al.* 1994).

Sound pressure levels greater than 180 dB_{peak} can cause injury and mortality to murrelets and listed fish species. Behavioral changes that can affect feeding and migration can occur at sound pressure levels of 150 dB_{rms}. Many factors, such as duration of the exposure, species life history, timing, and ambient levels can all influence potential behavioral changes to fishes and birds.

Elliott Bay is highly urbanized with numerous transportation corridors for ferries, barges, and recreational vessels. Ambient underwater noise levels have been measured in Elliott Bay at Piers 56 and 70. Ambient noise levels were 156 dB_{peak} and 154 dB_{rms} at Pier 56 and 147 dB_{peak} and 132 dB_{rms} at Pier 70 (Laughlin 2006). Ambient noise levels were higher at Pier 56 because the pier is closer to many anthropogenic activities.

6.4.4 Predators in Shilshole Bay

The primary known avian and mammalian predators on juvenile Chinook are glaucous-winged gulls (*Larus glaucescens* and others), harbor seals (*Phoca vitulina*) and California sea lions (*Zalophus californianus*). Gull predation in the lock chamber has virtually been eliminated since implementation of the slow fill procedures in 1999. Before 1999, gulls ate up to one of every eight smolts entrained in the large lock conduits (WDFW 1996). In 2000, anecdotal information has indicated there were only isolated periods when gulls may be preying on sockeye salmon smolts passed over the smolt flumes. One or two noted periods of predation included extreme low tides during the highest smolt passage days.

The abundance of harbor seals and California sea lions in Puget Sound has increased significantly in recent decades. Between 1985 and 1995, significant numbers of adult steelhead were consumed by sea lions. In 1996, NMFS authorized removal of several ‘nuisance’ sea lions and subsequent sea lion predation rates declined to 2% of the adult steelhead run. Concurrent with removal of the ‘nuisance’ animals, NMFS has been running an acoustic deterrent device (ADD) or acoustic harassment device (AHD) in areas near the Locks. The ADD acts as a behavioral barrier to sea lions, emitting sounds in the range of 10 to 15 kHz, a frequency range that appears to exclude most animals from the area below the Locks (Fox *et al.* 1996). Sea lions have not been observed preying on juvenile salmonids near the Locks since 1999. The ADD has been tested on Chinook salmon as they migrate through the fish ladder. No difference was observed in their behavior as they migrated through the fish ladder (B. Norberg, NMFS, pers. comm. 2005).

Harbor seals are present in Puget Sound year-round and are more abundant than sea lions. They commonly prey on salmon, but predation by harbor seals at the Locks has been infrequently observed. Although one or more adults can be seen on an irregular basis by the fish ladder, the number of juvenile Chinook salmon taken by harbor seals is believed to be a very small percentage of the run (Corps 2001).

6.4.5 Fish Present in Elliott Bay

The nearshore waters of Elliott Bay provide habitat for various species of marine fish (Table 6-19). The most abundant fish just north of the Elliott Bay Seawall in the shallow waters include shiner perch, pile perch, striped seaperch, Pacific sand lance, and Pacific herring. Common species in deeper water include English sole, rock sole, starry flounder, and various rockfish and smelt.

Eight species of native anadromous salmonids occur in Elliott Bay. These include Chinook salmon, chum salmon, pink salmon, sockeye salmon, coho salmon, steelhead trout, bull trout, and sea-run coastal cutthroat trout. The emigration and residence timing of juvenile salmonids varies for each species. Very little information is available on the distribution of salmonids immediately adjacent to the seawall.

Table 6-19

Fish present in the nearshore of Elliott Bay

Common Name	Scientific Name	Occurrence
Pacific lamprey	*Entosphenus tridenatus*	Occasional
Spiny dogfish	*Squalus acanthias*	Common
Brown cat shark	*Apristurus brunneus*	Occasional
Sixgill shark	*Hexanchus griseus*	Occasional
Big skate	*Raja binoculata*	Rare
Longnose skate	*R. rhina*	Occasional
Ratfish	*Hydrolagus colliei*	Common
Pacific herring	*Clupea harengus pallasi*	Rare
Northern anchovy	*Engraulis mordax*	Rare
Chinook salmon	*Oncorhynchus tshawytscha*	Common
Chum salmon	*O. keta*	Common
Pink salmon	*O. gorbuscha*	Occasional
Sockeye salmon	*O. nerka*	occasional
Coho salmon	*O. kisutch*	Common
Rainbow trout/steelhead	*O. mykiss*	Common
Sea-run coastal cutthroat trout	*O. clarki*	Occasional
Bull trout/Dolly Varden	*Salvelinus confluentus/S. malma*	Rare
Surf smelt	*Hypomesus pretiousus*	Common
Longfin smelt	*Spirinchus thaleichthys*	Occasional
Lingcod	*Ophiodon elongates*	Occasional
Cabezon	*Scorpaenichthys marmoratus*	Occasional
Kelp greenling	*Hexagrammos decagrammus*	Common
Pacific cod	*Gadus macrocephalus*	Occasional
Pacific hake	*Merluccius productus*	Common
Pacific tomcod	*Microadus proximus*	Common
Walleye Pollock	*Theragra chalcogramma*	Common
Blackbelly eelpout	*Lycodopsis pacifica*	Common
Tube-snout	*Aulorhynchus flavidus*	Common

Common Name	Scientific Name	Occurrence
Threespine stickleback	*Gasterosteus aculeatus*	Occasional
Bay pipefish	*Syngnathus leptorhynchus*	Common
Penpoint gunnel	*Apodichthys flavidus*	Rare
Shiner perch	*Cymatogaster aggregate*	Common
Striped perch	*Embiotoca lateralis*	Common
Pile perch	*Rhacochilus vacca*	Common
Kelp perch	*Brachyistius frenatus*	Rare
Snake prickleback	*Lumpenus sagitta*	Common
Pacific sandlance	*Ammodytes hexapterus*	Common
Brown rockfish	*Sebastes auriculatus*	Occasional
Quillback rockfish	*S. maliger*	Common
China rockfish	*S. nebulosus*	Occasional
Copper rockfish	*S. caurinus*	Common
Yellowtail rockfish	*S. flavidus*	Rare
Black rockfish	*S. mulonops*	Common
Bocaccio	*S. paucispinis*	Rare
Canary rockfish	*S. pinniger*	Rare
Yelloweye rockfish	*S. ruberrimus*	Rare
Prickly sculpin	*Cottus asper*	Occasional
Buffalo sculpin	*Enophrys bison*	Occasional
Pacific staghorn sculpin	*Leptocottus armatus*	Common
Dover sole	*Microstomus pacificus*	Common
English sole	*Parophrys vetulus*	Common
Flathead sole	*Hippoglossoides elassodon*	Occasional
Pacific sanddab	*Citharichthys sordidus*	Occasional
Petrale sole	*Eopsetta jordani*	Occasional
Rex sole	*Glyptocephalus zachirus*	Occasional
Rock sole	*Lepidopsetta bilineata*	Occasional
C-O sole	*Pleuronichthys coenosus*	Common
Sand sole	*Psettichthys melanostictus*	Occasional
Starry flounder	*Platichthys stellatus*	Occasional

6.4.6 Fauntleroy Creek (South Seattle/Puget Sound Action Area)

Fauntleroy Creek receives runoff from a 149-acre (60.23 ha) watershed in the southwestern portion of Seattle (Figure 11). About 23% of the watershed area and 75% of the creek channel length (upper mainstem and tributaries) are in parks and open space. The land use in the watershed is 57% residential and 17% commercial and transportation (roads, parking lots and rights-of-way). The total channel length is about 1.6 miles (2.6 km) long, including six small tributaries, which are fed by numerous groundwater seeps in Fauntleroy Park. The mainstem length is about 0.9 miles (1.4 km) long. The park area surrounding the upper portions of the creek contains wetlands and forest cover. Downstream of the park, Fauntleroy Creek passes through residential areas in open channels and culverts, before reaching Puget Sound near the Fauntleroy Ferry Terminal. Fauntleroy Creek flows year-round with an average estimate of 0.9 to1.3 cubic feet/sec (0.25-0.4 cu m/sec) at the mouth, a two-year storm peak flow estimate of 9.0 cubic feet/sec (0.2 cu m/sec), and a 100-year storm peak flow estimate of 39.8 cubic feet/sec (1.12 cu m/sec) at the Fauntleroy Way Southwest culvert (Hartley and Greve 2005).

6.4.6.1 Water Quality

Nine storm drains discharge stormwater to the upper reaches of Fauntleroy Creek and its tributaries (City of Seattle 2007). No combined sewer overflow outfalls discharge into the stream. In the lower reaches of the creek stormwater enters through surface runoff and through groundwater recharge.

Fauntleroy Creek is on the 2008 Ecology 303(d) list of threatened and impaired waterbodies. The 303(d) listings are summarized in Table 6-20.

Table 6-20

Summary of 303(d) listings for Fauntleroy Creek

	Category	
Media	**2[1]**	**4A[2]**
Water	Mercury	Fecal coliform bacteria

[1]Water of concern – water body shows evidence of a water quality problem, but pollution level is not high enough to violate the water quality standard, or there may not be enough violations to categorize it as impaired.

[2]Water body has an approved TMDL in place and is actively being implemented.

Source: Ecology 2008

Ecology included Fauntleroy Creek on the 2004 303(d) list of threatened and impaired waterbodies as a category 5 waterbody (total maximum daily load required due to demonstrated exceedances of state water quality standards) for fecal coliform bacteria (Ecology 2004). This listing is based on samples collected on June 15 and August 29, 1988, at four sites along Fauntleroy Creek (Kendra 1989) and earlier sampling conducted by King County (formerly Metro). Fecal coliform bacteria in 13 samples collected by Ecology in 1988 ranged from 590 to 2,700 cfu/100 mL, with a geometric mean of 1,300 cfu/100 mL.

Ecology began monitoring water quality near the mouth of Fauntleroy Creek in October 2004. Summary statistics from the preliminary results for conventional water quality parameters are presented in Table 6-21.

Table 6-21

Summary of conventional water quality parameters in Fauntleroy Creek near mouth*

	DO (mg/L)	Temp. (degrees C)	Fecal coliform (cfu/100 mL)	pH	TSS (mg/L)	Turbidity (NTU)
Minimum	9.8	6.5	23	8.0	3	1.5
Maximum	12.4	15.4	390	8.3	33	19
Median	11.1	10.6	87	8.2	10	5.2
Mean	11.1	10.8	145	8.2	13	6.2
5th percentile	9.8	6.9	27	8.0	3	1.5
95th percentile	12.2	15.1	341	8.3	33	13

*15 samples collected between October 2004 and December 2005. Source: Preliminary data Ecology (undated)

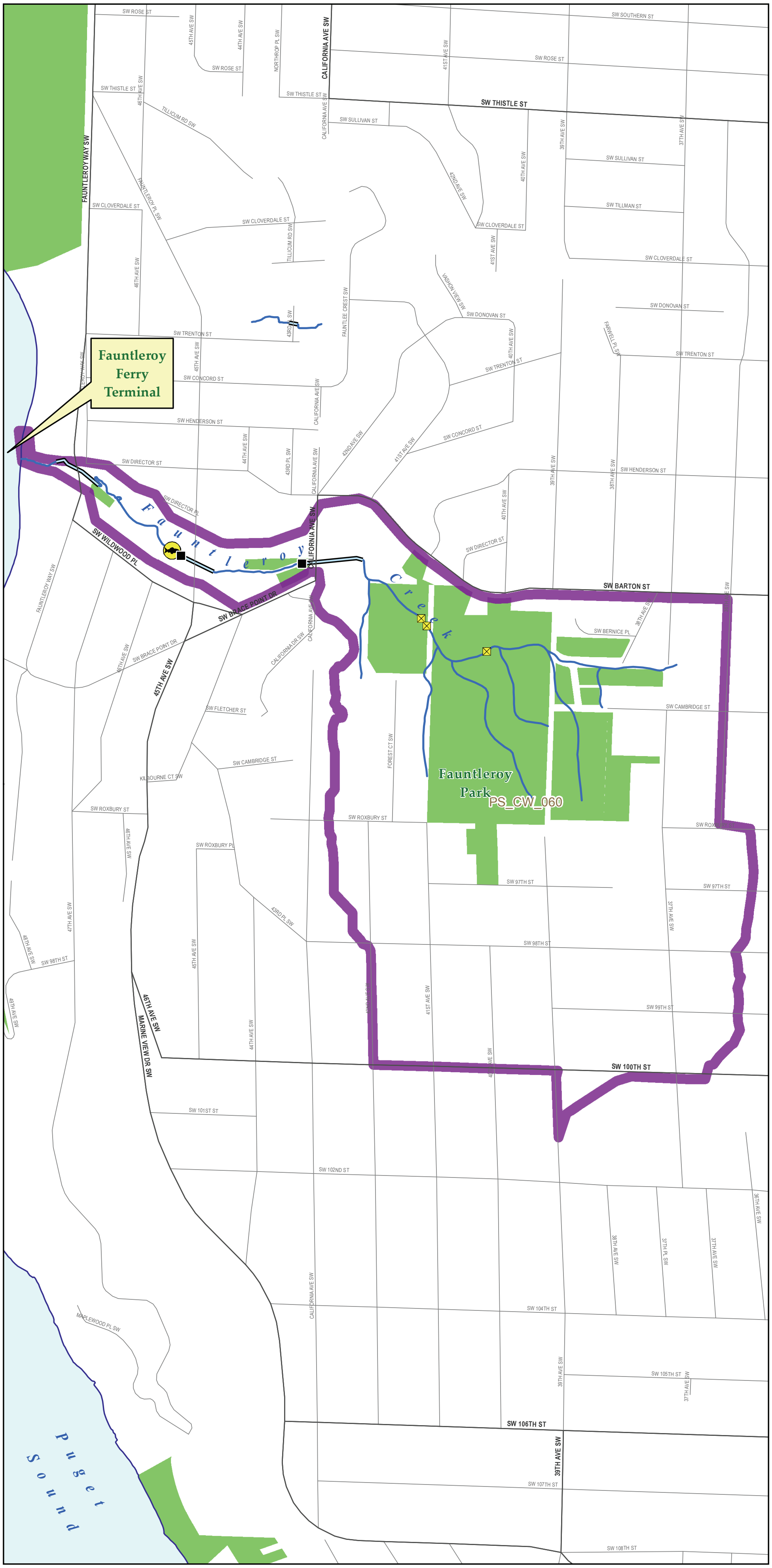
Although fecal coliform levels in the creek have declined since 1988 (590-2,700 cfu/100 mL), Fauntleroy Creek (annual geometric mean of 130 cfu/100 mL in 2004-2005) continues to exceed the water quality standard for extraordinary primary contact recreation (50 cfu/100 mL).

In addition to elevated fecal coliform levels, the area offshore of Fauntleroy Creek frequently experiences odor problems during the summer. Studies have found that the odor problems are caused by hydrogen sulfide generated by decaying seaweed that builds up along the beach from offshore algal beds (WDOH 1991). Seaweed growth is normally limited by the availability of nitrogen, and by mid-summer there is usually insufficient nitrogen to support large growth. However, input from Fauntleroy Creek is believed to support seaweed.

Dissolved oxygen and temperature conditions in Fauntleroy Creek are good. Samples collected between October 2004 and December 2005 consistently met state water quality standards.

Although data are limited, concentrations of toxic materials in Fauntleroy Creek are generally low. Between October 2004 and December 2005, ammonia-nitrogen levels were consistently below toxic levels. Dissolved metals concentrations in Fauntleroy Creek were also low; none of the samples exceeded state water quality standards. Copper and lead levels were either undetected or detected at levels below the acute and chronic toxicity criteria for aquatic resources.

Figure 11. Fauntleroy Creek Watershed



Seattle Biological Evaluation

City of Seattle

FIGURE 11

Fauntleroy Creek Watershed

Drainage Basin

Watershed Boundary

Stream Networks

- Open Channel
- Culvert

Observed Upstream Extent of Adult Salmonids, per 1999-2005 SPU Spawning Survey Data*

- Coho

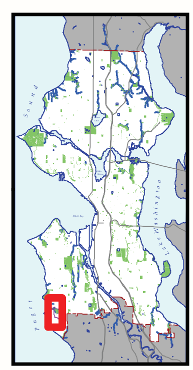
* This information pertains only to creeks.

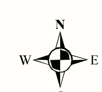
Fish Barriers

- Barrier
- Partial Barrier
- Unknown Barrier

Other

- Residential Street
- Arterial Street
- Park





0 0.0625 0.125
Miles

October 2, 2012

Coordinate System: State Plane, NAD83-91, WA North Zone
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Nutrient levels in Fauntleroy Creek are relatively low. Only one sample (864 µg/L in August 2005) of 15 exceeded the U.S. EPA (1976) water quality criterion (100 µg/L), which establishes a desired goal for the prevention of nuisance plant/algal growth in streams or other flowing waters not discharging directly to lakes or impoundments.

No sediment quality data have been collected for Fauntleroy Creek.

Prespawn mortality rates in Fauntleroy Creek average about 39 percent. This average is lower than rates in other Seattle watercourses (City of Seattle 2007).

6.4.6.2 Shoreline and Aquatic Habitat

Factors limiting aquatic habitat within Fauntleroy Creek include alterations to stream hydrology, reduced floodplain connectivity, restricted habitat access, sedimentation, and lack of channel complexity.

Habitat in Fauntleroy Creek varies in quality between the upstream areas in the park and downstream areas in residential neighborhoods. The channel condition within the park is naturally confined by the ravine and the creek is slightly incised and widening, likely in response to increased streamflows by altered hydrology from urban and residential development. Incision and channel widening are a concern because they make the upper valley walls unstable and erode sand. Erosion of the upper valley walls produces a high volume of sand in Fauntleroy Creek, which can cover spawning areas. Fine sediment sources and a naturally low coarse sediment supply limit potential spawning use of habitat upstream of California Avenue. However, the export of sediment from Fauntleroy Creek benefits the marine environment by the creation and maintenance of shoreline habitat.

The stream within the park has low bank heights, an active floodplain connection and good instream structure (wood and cascade-step pools). These structures help dissipate energy from higher flows. Instream habitat within the park includes long riffles punctuated with short cascade step pools, which have been formed by instream logs. The riparian corridor is continuous and varies in width from 100 to 200 feet (30.5 to 61 m).

The lowermost reaches of the creek, below California Ave., are characterized by a straightened, narrow channel averaging 4.5 feet (1.4 m) wide, with a plane-bed channel type and 35% glide habitat. This section of the creek has been degraded by artificial confinement resulting from extensive fill for roads and culverts and bank armoring. Riparian vegetation downstream of the park is of poor quality dominated by landscaping and invasive species. The lower reaches lack instream habitat structure and as a result of the confinement and heavily armored banks, there is insufficient room to safely add structure.

Fish Use

Coho salmon, Pacific staghorn sculpin, rainbow trout, and an occasional chum are found within Fauntleroy Creek (City of Seattle 2007, Tabor *et al* 2010). Coho spawn in the lower 1,000 feet (305 m) of stream because of the 45th Avenue Southwest culvert, the most downstream fish passage barrier. The culvert prevents salmon use of high quality habitat upstream in Fauntleroy Park. Pacific sandlance were captured in the intertidal area of the creek (Tabor *et al.* 2010).

An average of 26 coho adults enter the watercourse to spawn each fall, although the numbers vary widely (0 to 63 carcasses). Forty percent of the adults are hatchery fish that are either released into the watercourse by Seattle's Salmon-in-the-Classroom program or are strays from nearby hatcheries. Approximately 1,100 coho fry are released into Fauntleroy Creek each year, but juvenile survival is extremely low. Between 37 and 721 fry have been caught in the smolt traps from 2003 to 2006.

Only 400 feet of good spawning habitat is available in Fauntleroy Creek just upstream of Fauntleroy Way SW. Pool habitat is also limited.

6.4.7 Piper's Creek

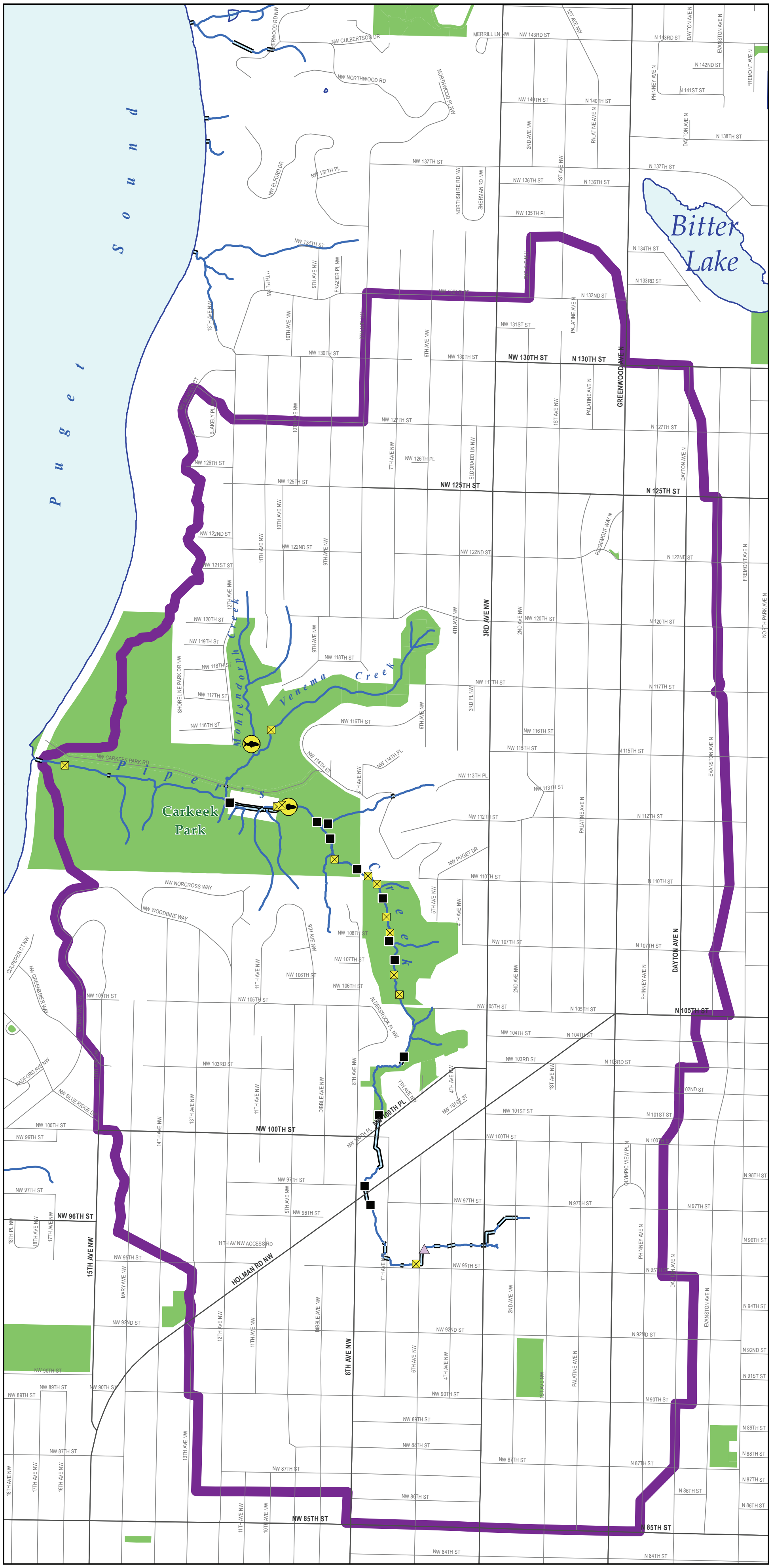
The Piper's Creek watershed is in the North Seattle/Puget Sound Action Area and covers 1,604 acres (649 ha) of northwest Seattle along north Puget Sound (Figure 12). Only 11% of the watershed is located in parks/open space, and the remaining land use is mostly residential (59%) and roads/commercial/industrial (29%). The total channel length is 4.9 miles (7.9 km), with 2 miles (3.2 km) of mainstem and 2.9 miles (4.7 km) of tributary channel. Most of the creek channel is open (90%) and the remaining area is contained in culverts. The creek has 14 tributaries, including a major tributary system that consists of Venema and Mohlendorph creeks. Piper's Creek and its tributaries originate on a residentially-developed plateau. Piper's Creek drains the central and southern portion of the watershed, while Venema and Mohlendorph creeks drain northern areas. From the plateau, the creeks pass into a ravine located mainly within the boundaries of Carkeek Park. The mainstem of Piper's Creek is located almost entirely within Carkeek Park, except for the most upstream sections of the mainstem and some of the tributaries.

Figure 12. Piper's Creek Watershed

Seattle Biological Evaluation

City of Seattle

FIGURE 12



Piper's Creek Watershed

Drainage Basin

- Piper's Creek Watershed Boundary

Stream Networks

- Open Channel
- Culvert

Observed Upstream Extent of Adult Salmonids, per 1999-2005 SPU Spawning Survey Data*

- Coho

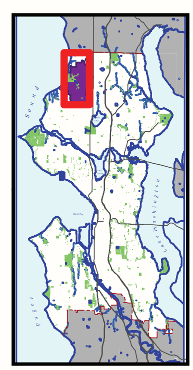
* This information pertains only to creeks.

Fish Barriers

- Barrier
- Partial Barrier
- Unknown Barrier

Other

- Arterial Street
- Residential Street
- Park



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Miles

October 2, 2012

Coordinate System: State Plane, NAD83-91, WA North Zone

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6.4.7.1 Water Quality

Twenty-nine storm drains discharge into Piper's Creek and its tributaries (City of Seattle 2007). No combined sewer overflow outfalls discharge into the stream. Sixteen storm drains discharge into upper Piper's Creek. There are eight outfalls on Venema and Mohlendorph creeks. Two outfalls drain relatively large areas in the watershed: one in the upper reach of Mohlendorph Creek drains an area of 290 acres (18% of watershed), and one drains nearly 575 acres (35% of watershed).

Piper's Creek is on the 2008 Ecology 303(d) list of threatened and impaired waterbodies. The 303(d) listings are summarized in Table 6-22.

Table 6-22

Summary of 303(d) listings for Piper's Creek

	Category	
Media	**2**[1]	**4A**[2]
Water	Dissolved Oxygen pH	Fecal coliform bacteria

[1]Water of concern – water body shows evidence of a water quality problem, but pollution level is not high enough to violate the water quality standard, or there may not be enough violations to categorize it as impaired.

[2]Water body has an approved TMDL in place and is actively being implemented.

Source: Ecology 2008

With the exception of fecal coliform bacteria, which frequently exceeds state water quality standards, during non-stormflow conditions water quality in Piper's Creek is generally good. The creek does experience occasional problems with total suspended solids and turbidity. Ecology included Piper's Creek on the 303(d) list of threatened and impaired waterbodies as a water of concern (*i.e.*, category 2) for turbidity in Venema Creek, a tributary creek to Piper's Creek (Ecology 2004). Increases in turbidity and suspended solids downstream typically result from larger storm flows associated with urbanization in the watershed. Urban stream banks typically erode more easily as riparian vegetation is removed or modified. Upland construction activities and ground disturbances also result in high inputs of turbid water.

Piper's Creek frequently exceeds state water quality standards for fecal coliform throughout the year. Over the past ten years, the annual geometric mean fecal coliform level exceeded the state standard for extraordinary primary contact recreation (50 cfu/100 mL) every year in Piper's Creek (both upstream and downstream of Venema Creek) and in nine of the ten years at the Venema Creek station. Fecal coliform levels in Venema Creek (43-210 cfu/100 mL geometric mean) were generally lower than the levels measured in Piper's Creek (76-630 cfu/100 mL). In addition, the 100 cfu/100 mL limit was exceeded in 15% to 94% of the samples. Under the state water quality standards, no more than 10% of all samples are permitted to exceed 100 cfu/100mL.

Stormwater samples generally contain higher levels of fecal coliform bacteria than non-storm samples. The annual geometric mean for non-storm samples ranged from 43 to 210 cfu/100 mL and from 76 to 630 cfu/100mL in Venema Creek and Piper's Creek respectively, compared with 2,200 cfu/100 mL and 3,800 to 4,100 cfu/100 mL in the stormwater samples.

In 1992, EPA issued a programmatic total maximum daily load for fecal coliform bacteria in the creek based on the 1990 Watershed Action Plan and 1999 update (Piper's Creek Watershed Management Committee 1990, 1999). The Watershed Action Plan recommended specific actions including public education, inspection/enforcement, utility operations and maintenance, and monitoring that should be implemented to reduce nonpoint pollution in the Piper's Creek watershed. Although many of the actions recommended in the 1990 plan have been implemented, recent data (King County undated, SPU undated, and Onwumere 2003), indicate that elevated levels of fecal coliform persist in many locations within the basin.

King County has been collecting monthly samples in Piper's Creek (above Venema Creek, below Venema Creek, and Venema Creek) since about 1988. Samples are analyzed for conventional water quality indicators (temperature, dissolved oxygen, fecal coliform bacteria, pH, total suspended solids, and turbidity), metals, and nutrients. Seattle Public Utilities has also been collecting two to three stormwater samples each year in the creek since about 1999. Conventional water quality parameters from monthly samples collected by King County (undated) between 1979 and 2005 are shown in Table 6-23.

As shown on Figure 13, dissolved oxygen and temperature typically exhibit a seasonal trend with higher temperatures and lower dissolved oxygen concentrations in the warm summer months. Over the 18-year period of record, Piper's Creek downstream of Venema Creek exceeded the temperature standard in one sample and no exceedances occurred in Venema Creek or in Piper's upstream of Venema Creek. Between 1988 and 2005, dissolved oxygen concentrations in Piper's and Venema Creeks exceeded the standard in only 1% to 2% of the samples.

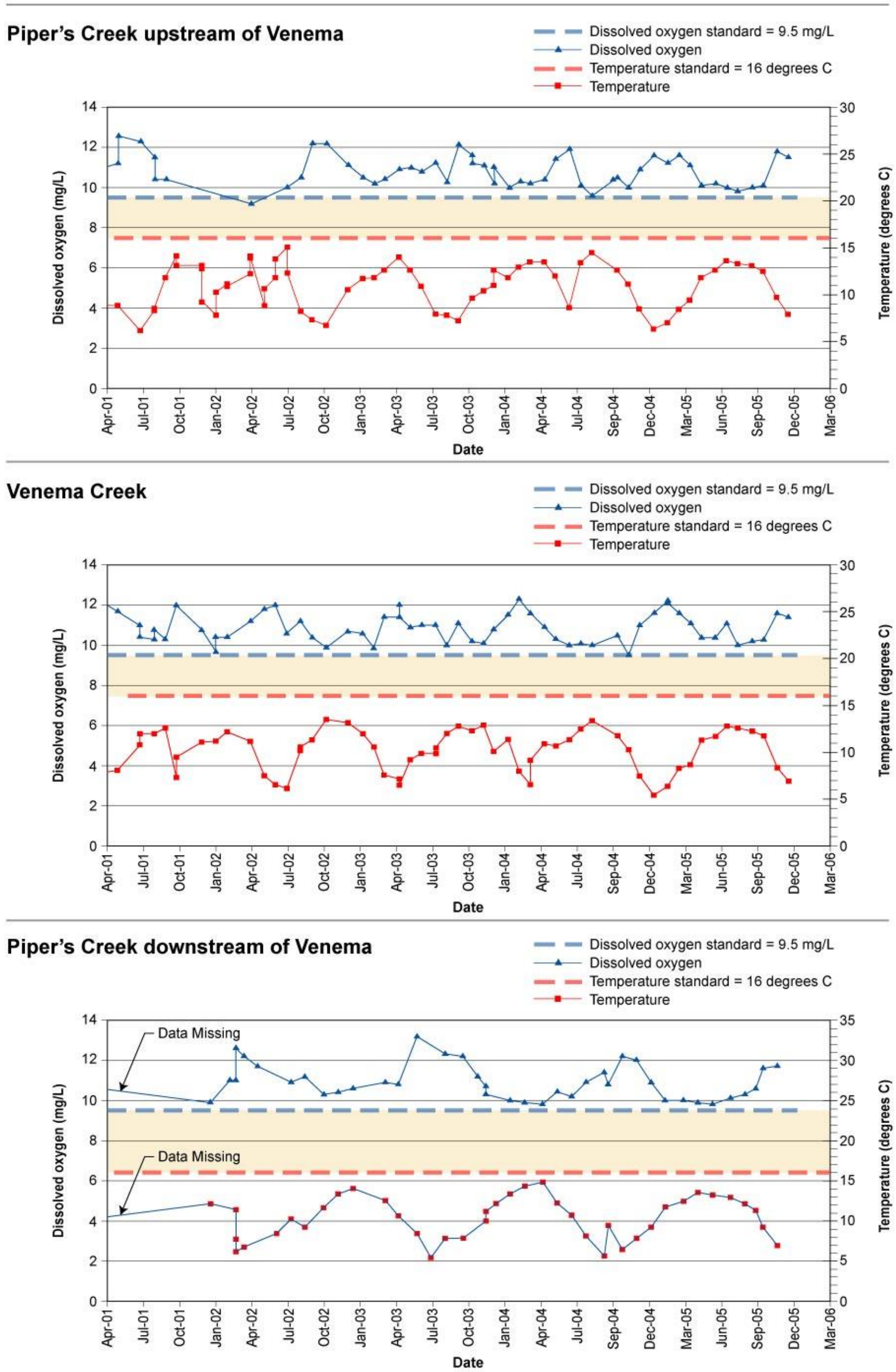
Table 6-23

Summary statistics for conventional water quality parameters in Piper's Creek*

	DO (mg/L)	Temp. (degrees C)	Fecal coliform (cfu/100 mL)	pH	TSS (mg/L)	Turbidity (NTU)
Piper's Creek upstream of Venema Creek (Station KTAH03)						
No. of samples	209	398	412	206	204	203
Minimum	6.6	2.0	1	6.0	0.5	0.2
Maximum	13.1	16.1	37,000	8.4	223	70
Median	10.7	11.4	200	7.9	3.3	1.7
Mean	10.8	10.8	762	7.8	9.7	4.3
5th percentile	9.7	6.0	24	7.1	1.1	0.7
95th percentile	12.2	14.4	3,760	8.2	35.7	15.0
Venema Creek (Station KTAH02)						
No. of samples	210	211	218	207	205	205
Minimum	6.3	2.0	4	6.1	0.01	0.1
Maximum	13.1	14.5	9,700	8.4	166	73
Median	11.0	10.2	70	7.9	3.0	1.3
Mean	11.1	9.7	258	7.8	8.3	3.2
5th percentile	10.0	5.1	12	7.3	0.9	0.5
95th percentile	12.6	13.3	602	8.2	29	9.8
Piper's Creek downstream of Venema Creek (Station KHSZ06)						
No. of samples	254	259	264	251	249	249
Minimum	6.0	1.5	11	6.0	0.5	0.1
Maximum	14.0	16.0	40,000	10.0	425	180
Median	10.9	10.2	250	7.7	3.7	2.0
Mean	10.9	10.0	1,201	7.7	22.4	8.8
5th percentile	9.8	5.0	31	7.0	1.1	0.7
95th percentile	12.7	14.0	5,825	8.2	94.2	37
Source: King County (undated)						

Figure 13

Dissolved oxygen and temperature in Piper's Creek



Reference: Stations KTAH02, KTAH03, and KSHZ06, King County (undated).
Note: The areas between the two dashed lines show the samples that do not meet state water quality standards.

Nutrient levels in Piper's Creek are generally high and exceed recommended water quality criteria. For example, total phosphorus concentrations in Piper's Creek (18 to 720 µg/L in non-storm samples and 3-990 µg/L in stormwater samples) frequently exceed the U.S. EPA water quality criterion (100 µg/L), which establishes a desired goal for the prevention of nuisance plant/algal growth in streams or other flowing waters not discharging directly to lakes or impoundments (USEPA 1976). In addition, total nitrogen concentrations in Piper's Creek (180 to 3,470 µg/L) frequently exceed the U.S. EPA (2000) recommended criterion for streams in the western United States. (340 µg/L for Ecoregion II). These criteria represent conditions in surface waters that are minimally impacted by human activities and are designed to prevent eutrophication and water quality problems associated with nutrient enrichment.

Concentrations of toxic materials in Piper's Creek are generally low. Ammonia-nitrogen levels were consistently below toxic levels. For metals, only dissolved lead exceeded the state water quality standard (in one non-storm sample collected in 2001 downstream of Venema Creek). During storm events, seven of 27 samples exceeded chronic toxicity criterion for dissolved copper, and two samples exceeded the acute toxicity criterion. Water quality is being investigated as a potential contributor to the unusually high rates of coho salmon pre-spawn mortalities reported in urban creeks in the Puget Sound since 1999 (Reed et al. 2003). Between 1999 and 2005, pre-spawn mortality rates in Piper's Creek averaged 58% (McMillan 2006, SPU unpub. data).

6.4.7.2 Shoreline and Aquatic Habitat

Factors limiting aquatic habitat within Piper's Creek include alterations to the stream hydrology, reduced floodplain connectivity, restricted habitat access, sedimentation, and lack of channel complexity.

Habitat in Piper's Creek has the similar degradation patterns as that of other Seattle creeks, although not as severe as those for Thornton and Longfellow creeks. Piper's Creek has been incising and widening (eroding) in response to increased stormwater runoff. Much of the creek carries a large amount of fine sediment (mostly sand). Not surprisingly, the upland developed portions of the watershed have the most degraded channel and riparian conditions, while areas within Carkeek Park contain relatively good habitat. Older grade control structures located in Piper's Creek mainstem, upstream of the King County/Metro sewage pumping station, have helped the channel to restabilize and to reconnect with the floodplain.

The changes in the drainage patterns in the Piper's Creek system resulting from watershed development have an effect on the amount of fine sediment in the system. Steep, eroding tributaries and landslides from upper valley walls supply large amounts of sand and gravel to the channel in mainstem Piper's Creek, and extensive erosion of canyon walls are a major source of sand to Venema Creek. Although tightlining outfalls— by placing pipe from the top of the valley walls directly into the channel—in 1999 to 2000 greatly reduced delivery of sand to Piper's Creek, mass wasting and channel erosion in Venema and upper Piper's channels are the largest components of the existing sediment supply. Upper Piper's Creek produces about 57% of the total mass wasting (sediment) supply while the Venema creek system produces about 29% of the sand in the channel.

The lack of connectivity between the land and stream through bank armoring, particularly in the lower reaches of Venema (35% to 40% armored) and Piper's creeks (26% of the channel), prevents the channel from widening and connecting to the floodplain. Placement of weirs in mainstem Piper's Creek, upstream of the pump station, has resulted in restabilizing portions of the channel, through widening the channel and reconnecting it to the floodplain (Perkins 2002). Both Venema and Mohlendorph creeks are incising in response to higher storm flows (Perkins 2002). The Piper's Creek watershed does contain relatively good riparian vegetation especially in the lower reaches. Much of Piper's Creek is in Carkeek Park and has good cover for shade. However, much of the vegetation is mature alder with few mature conifers. The upper watershed contains fragmented riparian habitat composed mainly of lawns, landscaping, and invasive Himalayan blackberry.

Due to changes in hydrology patterns and lack of connectivity, the Piper's Creek system lacks habitat complexity. In Venema and Mohlendorph creeks, wood and large substrate are insufficient for forming and maintaining habitat. Bank armoring exacerbates these conditions. In Piper's Creek, in-channel refuge habitat is restricted to plunge pools associated with weirs, which composes only about 15% of available habitat.

Fish Use

Piper's Creek is used by cutthroat and rainbow trout, coho and chum salmon and coastrange, prickly, staghorn, and shortnose sculpin (City of Seattle 2007, Tabor *et al* 2010). Of the estimated 2.7 miles (4.3 km) of potentially fish-bearing channel, anadromous fish have access to about 0.6 miles (1 km) including lower Venema and Mohlendorph creeks and Piper's Creek below the pump station. Juvenile use has not been well studied. Pre-spawning mortality averages 58% in the creek.

Barriers to fish passage limit access to upstream areas. The Metro pump station culvert and bypass are the most significant barriers. Returning adult salmon access to the lower river is limited to high tides that connect Puget Sound to the creek channel.

Adult chum salmon numbers ranged between 16 and 398 fish per year (carcass counts) between 1999 and 2005. Coho salmon numbers range between 5 and 122. With the limited access to the stream, redd superimposition is a concern in the creek. The amount of spawning habitat, number of adult salmon, and small amount of habitat accessible contributes to the red superimposition. Coho production is thought to be limited by the more abundant chum population.

Coho prespawn mortality averages about 58% in Piper's Creek, ranging from 18 to 100%. Piper's Creek has the most variable prespawn mortality rate in Seattle watercourses. Chum salmon are also affected, but their mortality rate is only 2 to 4%.

Section 7

Effects of the Action

This section evaluates the potential impacts of City of Seattle projects on Endangered Species Act (ESA)-listed species and their critical habitat, within the Seattle action areas (identified in this SBE), when using the construction methods and conservation measures described in Sections 3 and 4, respectively. Conservation measures area incorporated into construction methods to reduce potential adverse impacts to listed species and/or their critical habitat. Each project will incorporate those construction and conservation measures unique to the activity. Project impacts can be short and long-term, particularly as an affected habitat stabilizes to new project features.

Although the bald eagles are no longer listed under the ESA, they are still regulated under the Bald and Golden Eagle Protection Act. As such, and for the convenience of City of Seattle project managers, all bald eagle information including species occurrences in the action area, potential impacts, and permit information are discussed in Appendix C.

The following summarizes the effects of the construction methods on listed species and designated critical habitat.

All Species

- Climate change

Chinook, Steelhead, and Bull Trout

- Temperature
- Hydrologic alterations
- Channel complexity
- Sediment
- Stream isolation and fish removal
- Electroshocking
- Contaminants
- Underwater noise or sound pressure levels
- Overwater structures
- Vactoring and excavation

- Shoreline hardening, bank stabilization, and habitat enhancement and restoration activity
- Culvert replacement
- Boating activity
- Pesticides

The following is an explanation on how to interpret Table 7-1, below, and other similar tables in this SBE Section 7. Construction methods are combined with conservation measures, to minimize adverse environmental effects, which result in affects on the elements shown in column, which in turn can affect the ESA-listed species referenced in the table heading.

Table 7-1. Effects of action and corresponding methods and conservation measures on Chinook salmon, bull trout, and steelhead for the Seattle Biological Evaluation

Effects of Action	Construction Methods	Conservation Measures
Vegetation removal: riparian area	2. Clearing, grubbing, grading and placement of temporary fill	1, 7, 9, 12-14, 19, 20, 23, 75, 77
Sediment	2. Clearing, grubbing, grading and placement of temporary fill	1, 7, 9, 12-14, 19, 20, 23, 75, 77
	3. Work area isolation and fish removal in streams, large waterbodies and for pipe bypass	31, 32
	4. Pipe, culvert, and outfall installation, removal, and replacement	1-4, 12-18, 30, 78
	5. Vactoring, jetting, and excavating accumulated sediments and debris, sediment test boring, and pipe, culvert, and bridge maintenance	1-4, 15-18, 21, 25-29, 57, 55, 60-62, 65
	6. Bank stabilization	1-4, 9, 15-18, 27-29, 45-55, 57-65, 67, 69-74
	7. Habitat addition and maintenance	1-7, 9-22, 25, 26, 28-30, 57-65, 68, 69, 75-77
	8. Beach nourishment and substrate addition	1, 4, 15, 16, 27, 29, 57-59, 62, 66
	9A. Boat launch improvement, repair, and maintenance	
	9B. Replace ballast, edge armoring and concrete panels; repair concrete panels	1-3, 15, 16, 18, 28, 29, 57-59, 63, 69
	9C. Pressure washing boat ramps	1, 57, 58, 61, 63

Effects of Action	Construction Methods	Conservation Measures
	10. In-water/overwater structure repair and replacement	
	10A. Piling	1, 34, 45-56, 62, 65
	10B. Anchor and chain systems	1, 15, 16, 29, 43, 44, 62, 65
	10C. Superstructure, decking and utilities on fixed structures	1, 3, 4, 7, 12, 15, 16, 18, 19, 25-29, 33, 35, 37-42, 45, 46, 48, 55, 57-59, 62-65
	10D. Floats and Gangways	1-4, 6, 7, 9, 12-19, 25, 26-29, 33, 35-38, 63-65
	10E. Floating log boom	1, 39, 40, 43, 44, 62, 65
	10F. Buoys	1, 43, 44, 62-65
	10G. Fixed breakwaters	1-4, 12-20, 27, 28, 42, 57-59, 62-65, 67, 73, 74
	10H. Highway or road bridge foundation or footing repair	1, 15-18, 57-59, 61, 62, 65, 74
	10I. Removal of plants and animals from pilings for inspection or repair	1, 57, 58, 61-63, 65
	11. Seawall repair and maintenance	1, 3, 4, 15-18, 27-29, 57-59, 61, 62, 65, 74
	12. Site restoration	1, 4, 11, 12, 15, 16, 18, 19, 24, 57, 58, 65
	13. Landscaping and planting	1, 2-7, 9-16, 18-20, 22, 25, 26, 57, 63-65, 67, 72-76, 78
Stream isolation and fish removal	3. Work area isolation and fish removal in streams, large waterbodies and for pipe bypass	31, 32
Pile removal	10. In-water/overwater structure repair and replacement	See above under *Sediment*
Pile driving	6. Bank stabilization 10. In-water/overwater structure repair and replacement	See above under *Sediment*
Overwater structures	9. Boat launch improvement, repair and maintenance 10. In-water/overwater structure repair and replacement	See above under *Sediment*
Vactoring and excavation	4. Pipe and culvert installation, replacement and maintenance 5. Vactoring, jetting, excavating accumulated sediment	See above under *Sediment*

Effects of Action	Construction Methods	Conservation Measures
Shoreline hardening, bank stabilization, habitat enhancement and restoration activity	7. Habitat addition and maintenance 8. Beach nourishment and substrate addition 9. Boat launch improvement, repair and maintenance 10. In-water/overwater structure repair and replacement	See above under *Sediment*
Culvert replacement	3. Work area isolation and fish removal in streams, large waterbodies and for pipe bypass 4. Pipe and culvert installation, replacement and maintenance 5. Vactoring, jetting, excavating accumulated sediments	See above under *Sediment*
Boating activity	9. Boat launch improvement, repair and maintenance 10. In-water/overwater structure repair and replacement	See above under *Sediment*
Pesticides	12. Site restoration	See above under *Sediment*
	13. Landscape and planting	1-7, 9-16, 18-20, 22, 25, 26, 57, 63-65, 67, 72-76, 78

Killer Whales and Stellar Sea Lions

- Pile Driving

The construction methods that result in these effects are shown on Table 7-2:

Table 7-2. Effects of action and corresponding methods and conservation measures on killer whales and Stellar sea lions for the Seattle Biological Evaluation

Effects of Action	Construction Methods	Conservation Measures
Pile driving	10. In-water/overwater structure repair and replacement	53

Designated Critical Habitat

- Water quantity
- Water quality
- Floodplain connectivity
- Forage and prey base
- Natural cover

- Obstructions and barriers
- Predation
- Migratory corridors
- The construction methods that result in these effects are shown on Table 7-4.

Table 7-3. Effects of action and corresponding methods and conservation measures on designated critical habitat for the Seattle Biological Evaluation

Effects of Action	Construction Methods	Conservation Measures
Disturbance and habitat	2. Clearing, grubbing, grading and placement of temporary fill 4. Pipe, culvert, and outfall installation, removal, and replacement 5. Vactoring, jetting, and excavating accumulated sediments and debris, sediment test boring, and pipe, culvert, and bridge maintenance 6. Bank stabilization 7. Habitat addition and maintenance 8. Beach nourishment and substrate addition 9. Boat launch improvement, repair, and maintenance 10. in-water/overwater structure repair and replacement 11. Seawall repair and maintenance 12. Site restoration 13. Landscaping and planting	All conservation measures will minimize impacts to designated critical habitat.

7.1 Effects of the Action on the Species

Some listed species, such as the humpback whale and marbled murrelet, rarely occur within the Seattle action areas.[1] Therefore, the effects of the proposed actions on these species are not addressed in this document. Other species such as the killer whale and Steller sea lion are found within the marine waters of the City of Seattle, although in low numbers. Certain project activities such as pile driving may affect killer whales and Steller sea lions if they are in the area. The effects of the action are described for these two species where applicable (i.e., increased sound pressure levels).

Climate Change

There are many stressors that are affecting fish and wildlife species in the City and Puget Sound area. Some of these stressors have very little information on how or what impact they may have on individual species or populations. One of these stressors includes

[1] These species may be found in the Elliot Bay, North Seattle/Puget Sound, and South Seattle/Puget Sound action areas. However, because these species have been rarely documented within the marine waters of the City, potential impact to these species from proposed activities will be negligible.

climate change. There is now widespread consensus within the scientific community that atmospheric temperatures on earth are increasing (warming) and that this will continue for at least the next several decades (Intergovernmental Panel on Climate Change (IPCC) 2001; Oreskes 2004). There is also consensus within the scientific community that this warming trend will alter current weather patterns and patterns associated with climatic phenomena, including the timing and intensity of extreme events such as heat waves, floods, storms, and wet-dry cycles.

Salmon and their habitat throughout Washington are affected by climate change. Several studies have revealed that climate change has the potential to affect ecosystems in nearly all tributaries throughout the state (Battin *et al.* 2007; ISAB 2007). While the intensity of effects will vary by region (ISAB 2007), climate change is generally expected to alter aquatic habitat (water yield, peak flows, and stream temperature). As climate change alters the structure and distribution of rainfall, snowpack, and glaciations, each factor will in turn alter riverine hydrographs. Given the increasing certainty that climate change is occurring and is accelerating (Battin *et al.* 2007), salmonid habitats will be affected. Climate and hydrology models project significant reductions in both total snow pack and low-elevation snow pack in the Pacific Northwest over the next 50 years (Mote and Salathé 2009) – changes that will shrink the extent of the snowmelt-dominated habitat available to salmon. Such changes may restrict our ability to conserve diverse salmon life histories.

In Washington State, most models project warmer air temperatures, increases in winter precipitation, and decreases in summer precipitation. Average temperatures in Washington State are likely to increase 0.1 to 0.6 degrees centigrade per decade (Mote and Salathe 2009). Warmer air temperatures will lead to more precipitation falling as rain rather than snow. As the snow pack diminishes, seasonal hydrology will shift to more frequent and severe early large storms, changing stream flow timing and increasing peak river flows, which may limit salmon survival (Mantua *et al.* 2009). The largest driver of climate-induced decline in salmon populations is projected to be the impact of increased winter peak flows, which scour the streambed and destroy salmon eggs (Battin et al. 2007).

Higher water temperatures and lower spawning flows, together with an increased magnitude of winter peak flows are all likely to increase salmon mortality. Higher ambient air temperatures will likely cause water temperatures to rise (ISAB 2007). Salmon and steelhead require cold water for spawning and incubation. As climate change progresses and stream temperatures warm, thermal refugia will be essential to the persistence of many salmonid populations. Thermal refugia are important for providing salmon and steelhead with patches of suitable habitat while allowing them to undertake migrations through or to make foraging forays into areas with greater than optimal temperatures. To avoid waters above summer maximum temperatures, juvenile rearing may be increasingly found only in the confluence of colder tributaries or other areas of cold water refugia (Mantua *et al.* 2009).

Climate change is expected to make recovery targets for these salmon populations more difficult to achieve. Habitat action can address the adverse impacts of climate change on salmon. Examples include restoring connections to historical floodplains and freshwater and estuarine habitats to provide fish refugia and areas to store excess floodwaters, protecting and restoring riparian vegetation to ameliorate stream temperature increases, and purchasing or applying easements to lands that provide important cold water or refuge habitat (Battin *et al.* 2007; ISAB 2007).

Direct studies on the effect of climate variability on rockfish are rare, but all the studies performed to date suggest that climate places an extremely important role in population dynamics. Changes in bocaccio populations are governed by rare recruitment events, and these rare events resulted when specific climate conditions occurred at different times in their early life history (NMFS 2009). The coincidence of such climate patterns only occurred 15% of the time. In a generic bioenergetic model for rockfish, productivity of rockfish was highly influenced by climate conditions, such that El Nino-like conditions generally lowered growth rates and increased generation time (NMFS 2009). The negative effect of the warm water conditions associated with El Nino appears to be common across rockfishes. Exactly how climate influences the rockfish in Puget Sound is unknown; however, given the general importance of climate to Puget Sound and to rockfish, it is likely that climate strongly influences rockfish life history and their habitat.

For marine mammals, the above climate changes to salmonids will result in profound effects on marine productivity and food webs. Although no formal predictions of impacts on marine mammals have yet been made, it seems likely that any changes in weather and oceanographic conditions resulting in effects on salmonid population will have consequences for marine mammals.

7.1.1 Puget Sound Chinook Salmon, Steelhead, Bull Trout, and Rockfish

7.1.1.1 Effects of Vegetation Removal: Riparian Area

Removal of trees and vegetation within the riparian zone has several impacts or alterations to watershed conditions and capacity. The primary pathways for negative impacts are through altering stream temperature patterns, hydrologic and sediment regimes, and reducing the structural features that maintain channel complexity.

Removing trees and vegetation from the riparian zone in both marine and freshwater can lead to numerous impacts to listed fish, their habitat, and prey species by altering the vital functions of riparian vegetation (Spence *et al.* 1996; Brennan and Culverwell 2004):

- Microclimate and shading
- Bank, channel, and slope stability
- Sediment control
- Organic litter
- Large woody debris
- Nutrients
- Hydrology
- Fish habitat

Microclimate and Stream Shading

Microclimates are small portions of a stream or marine environment controlled by the interactions of the riparian area and the stream or marine waters (Brennan and Culverwell 2004). Removal of the riparian vegetation can alter the microclimate, specifically water temperatures. Water temperatures significantly affect the distribution, health, and survival of fish, specifically salmonids in streams. Because these fish are ectothermic (cold-blooded), their survival depends on external water temperatures. They will experience adverse health effects when exposed to temperatures outside their optimal range (USEPA 2003). Adverse temperatures can affect growth, behavior, disease resistance, competition, and mortality (Sullivan *et al.* 2000).

Removal of riparian trees and vegetation affects water temperatures primarily two ways: 1) reducing streamside canopy levels and 2) increasing exposure of upland soil surfaces to solar radiation.

The potential for riparian vegetation to mediate water temperatures is greatest for small-to-intermediate size streams and diminishes as streams increase in size, lower in the floodplain (Spence *et al.* 1996). Generally, small and intermediate streams represent most of the total aggregate stream length within a watershed (Chamberlin *et al.* 1991). Given these relationships, maintaining adequate canopy conditions on small- and medium-sized streams (including intermittent ones) is necessary to avoid altering natural temperature regimes.

Groundwater entering streams (especially small streams) is an important determinant of stream temperatures (Spence *et al.* 1996) and provides localized thermal refugia in larger stream systems. Where groundwater flows originate above the neutral zone (52 to 59 feet [16-18 m] below the surface in general) groundwater temperatures vary seasonally, influenced by air temperature patterns (Spence *et al.* 1996).

Within the marine environment, riparian vegetation does not control marine water temperatures like in stream systems, but does affect input to the marine waters which alters the conditions for plants and animals. Marine areas with intact riparian zones have higher species diversity and abundance (Brennan and Culverwell 2004). Removing vegetation can result in dessication of intertidal communities such as surf smelt where high egg mortality has occurred on beaches with little shading (Brennan and Culverwell 2004).

Project activities such as site preparation, clearing and grubbing, bank stabilization, etc. may slightly impact stream temperatures through loss of shade resulting from removal of trees and vegetation within riparian buffers. These impacts to stream temperature will be minimal because of the small amount of riparian buffers lost for such activities and minimization measures implemented to avoid or reduce loss of riparian vegetation during the project. However, the amount of riparian buffers is limited in the Seattle action areas, and any loss of vegetation will increase stream temperatures within the watershed.

Bank, Channel, and Slope Stability

Established riparian vegetation provides effective stability to both stream channels and marine shorelines. Riparian vegetation is responsible for the dissipation of energy associated with flowing water (NRC 2002). In streams and the marine environment, roots, stems, and downed wood provide channel and slope stability decreasing erosion and sedimentation (Knutson and Naelf 1997, Brennan and Culverwell 2004).

Projects that remove riparian vegetation will result in the loss of soil-stabilizing roots that can increase stream or bank erosion.

Sediment Control

Riparian vegetation and downed wood can reduce or control sediment input to streams and marine waters (Spence *et al.* 1996, Brennan and Culverwell 2004). Standing and downed vegetation trap sediments by providing a physical barrier that slows water and allows sediment to settle out. Sediment control also can reduce pollutant loading into streams and marine waters as most pollutants associated with stormwater are absorbed to sediments (Brennan and Culverwell 2004).

Project activities that remove riparian vegetation or drive heavy equipment into the riparian zone can increase sediment input into the water body. Heavy equipment can cause ruts and channelize sediment runoff that riparian vegetation cannot control or remove. Fine sediments not removed by riparian vegetation can also have physical effects on aquatic organisms (see Effects of Sediment below).

Organic Litter and Nutrient Input

Organic detritus is the primary energy source for food webs in river and marine environments (Spence *et al.* 1996, Brennan and Culverwell 2004). The quality, quantity, and timing of organic input to aquatic environments depend on the vegetation type with deciduous trees providing higher quality material.

Dissolved organic matter comes from leaching from entrained litter and large woody debris, algae, invertebrates, and fish excretions (Spence *et al.* 1996). The breakdown of large woody debris by macroinvertebrates is an important source of carbon in the aquatic environment, although this process is not well understood (Brennan and Culverwell 2004). The loss of riparian vegetation results in the loss of detrital input and important nutrients.

Bank armoring projects in the marine environment can increase beach erosion that can result in the loss of organic matter. Increased wave energy lowers the beach profile resulting in a loss of intertidal habitat where organic nutrients accumulate (Brennan and Culverwell 2004).

Large Woody Debris

Large woody debris (LWD) recruitment is a vital function of riparian vegetation. Large woody debris as it enters a stream or marine waters provides numerous functions (Knutson and Naef 1997):

- Dissipation and redirection of water force
- Capture and storage of sediments and organic material
- Streambed or bank stabilization
- Formation of cover from predators and protection during high flows
- Water aeration and mixing
- Facilitation of fish passage in high gradient streams
- Retention of spawned-out salmon and steelhead carcasses
- Contributions to food webs through decomposition
- Input of nitrogen

The importance of LWD to aquatic organisms varies and depends on LWD location (Brennan and Culverwell 2004). In marine waters, LWD in the intertidal may alter organic litter and sediment deposition. Invertebrates break down organic material and contribute to carbon cycling. Large woody debris also provides habitat for invertebrates which are prey species for bird and fishes.

Tree and vegetation removal can alter processes that create and maintain riparian and aquatic habitats, often reducing habitat complexity and aquatic species diversity (Elmore and Beschta 1987, USDA *et al.* 1993, USDA and USDI 1998). However, in many projects, LWD is installed to replace lost riparian function. Changes in habitat features associated with reductions in habitat complexity include decreases in large woody debris, pool quality, channel stability, substrate quality, groundwater inflows, and suitable habitat serving as corridors between habitat patches (MBTSG 1998, Spence *et al.* 1996).

Hardwoods have replaced conifers in many urban riparian areas that humans have altered or managed. Woody debris produced by deciduous vegetation tends to be smaller, more mobile, and shorter-lived than that derived from conifers and does not function as well in retaining sediment (Spence *et al.* 1996). Reduced supply of large woody debris decreases channel stability and leads to a loss of instream cover and pool habitat and decreased retention of sediments, including gravels used by salmonids for spawning, and simplifies channel hydraulics.

In many City projects, while riparian vegetation is removed for access to the stream, stream restoration activities including placement of boulders, large woody debris or other bioengineered techniques are used to increase channel stability and complexity. These techniques, while engineered, provide increased salmonid habitat much faster than what would occur naturally. In addition, site restoration (Method 13) and landscaping and planting (Method 14) activities are used to repair or replant disturbed areas. These activities establish vegetation along the stream faster and reduce the long-term impact of vegetation removal.

Hydrology

Riparian vegetation regulates or controls stream hydrology by intercepting rainfall, contributing to water infiltration, and using water by evapotranspiration (Knutson and Naef 1997). Water stored in the soil is later released to streams through subsurface flows. Riparian vegetation helps to moderate storm-related flows and reduce the magnitude of peak flows.

Hydrologic and sediment regimes are altered by vegetation removal, site disturbance, and soil compaction associated with construction activities (USDA and USDI 1998, Keppeler 1998). The nature and magnitude of these changes are moderated by local climatic, geologic, and topographic characteristics as well as revegetation patterns (Spence *et al.* 1996).

Removal of vegetation typically reduces water loss to evapotranspiration, resulting in increased water yield from the watershed and enhanced base flows (Spence *et al.* 1996, Keppeler 1998). Increases in peak flows following vegetation removal have been reported. They are likely the result from combined effects of vegetation removal and more rapid routing of water from uplands to the stream channel.

Conservation Measures

In delineating the work area, the City will identify and protect environmentally sensitive areas including riparian corridors. Construction areas will be defined on project plans and flagging will be used to mark off areas at the project site. Construction impacts, including clearing and grubbing, will be confined to the minimum area necessary to complete the project. Vegetation will be retained to the maximum extent possible. In addition, when temporary fill is needed to access or work in sensitivy areas, platforms, timber mats, pallets, hog fuel (wood waste), or other biodegradable material will be used to minimize total removal of vegetation. See Table 7-1 for corresponding construction methods and conservation measures for the effects of vegetation removal in the riparian corridor.

7.1.1.2 Effects of Sediment

The following activities may result in sediment inputs in the Seattle action areas:

1. Excavation above the wetted perimeter
2. Restoring streamflow on the reconstructed streambed
3. Disturbance of the bank and riparian area by construction and restoration activities.
4. Discharge of water back into stream following dewatering of upland site or during sediment removal or excavation projects
5. Post-project channel adjustment or stabilization.

Sedimentation Effects to the Aquatic Environment

The introduction of sediment can have multiple effects on channel conditions and processes resulting in effects on listed fish and prey species survival, the food web, and water quality conditions, such as water temperature and dissolved oxygen (Rhodes *et al.* 1994). Fine sediments can influence incubation survival and emergence success (Weaver and White 1985 in MBTSG 1998). Emergence success depends on the quantity and size of the fine sediment within spawning gravels. Table 7-5 summarizes the maximum percentage of fines of different sizes that corresponds to 50% emergence for different salmonids. In general, the smaller the fines (< 0.83 mm) the smaller percentage of fines needed to reduce emergence by 50%.

Sediment can modify stream morphology and function through the following (Bash *et al.* 2001):

- Degradation of spawning and rearing habitat
- Simplification and damage to habitat structure and complexity
- Loss of habitat
- Decreased connectivity between habitats

Biological implications of this habitat damage can include the following (Newcombe and Jensen 1996):

- Underutilization of stream habitat
- Abandonment of traditional spawning habitat
- Displacement of fish from their habitat
- Avoidance of habitat
- Egg/fry mortality

As sediment enters a stream it is transported downstream under normal fluvial processes and deposited in areas of low shear stress (MacDonald and Ritland 1989). These areas are usually behind obstructions, near banks (shallow water) or within interstitial spaces. This episodic filling of successive storage compartments continues in a cascading fashion downstream until the flow drops below the threshold required for sediment to move or all pools have reached their storage capacity (MacDonald and Ritland 1989). As sediment loads increase, the stream compensates by geomorphologic changes such as increased slope, increased channel width, decreased depths, and decreased flows (Castro and Reckendorf 1995). These processes increase erosion and sediment deposition.

In addition, social behavior patterns may be altered by suspended sediment (Berg and Northcote 1985). High concentrations of suspended sediment can also affect survival, growth, and behavior of stream biota that are forage for salmonids (Harvey and Lisle 1998). Suspended sediment may alter the food supply by decreasing abundance and availability of aquatic insects. However, the precise thresholds are difficult to characterize for fine sediment in suspension or in deposits that result in harmful effects to benthic invertebrates (Chapman and McLeod 1987).

Substrate embeddedness is an indicator of the overall habitat condition and is evaluated at the stream-reach scale. Within a reach of a given stream, rearing habitat is considered to be 'functioning' at various levels as follows (NFMS 1996, USFWS 1998):

- Appropriately when reach embeddedness is less than 20%
- At risk when reach embeddedness is 20 to 30%
- At unacceptable risk when reach embeddedness is more than 30%

Table 7-4. Maximum percentage of fines corresponding to 50% emergence for salmonids

Species	Maximum percentage of grains finer than:				Reference
	0.83 mm	**2.0 mm**	**3.35 mm**	**6.35 mm**	
Brook trout		10			Hausle and Coble 1976
Chinook salmon				15, 26	Bjorn 1969
				40	Tappel and Bjornn 1983
				30, 35	McCuddin 1977
Chum salmon				27	Koski 1975; 1981
Coho salmon	7.5, 17				Cederholm & Salo 1979
	21		30		Phillips et al. 1975
	11		36		Koski 1966
Cutthroat trout				20	Irving and Bjornn 1984
Rainbow trout				30	Irving and Bjornn 1984
	12			40	NCASI 1984
Steelhead				25	Bjornn 1969
				39	Tappel and Bjornn 1977
				27	McCuddin 1977
			25		Phillip et al. 1975
Source: Kondolf 2000					

The addition of fine sediment to streams during the summer decreased the abundance of juvenile Chinook salmon is in almost direct proportion to the amount of pool volume lost to fine sediment (Bjornn *et al.* 1977, Bash *et al.* 2001). Similarly, the density of rearing Chinook salmon was inversely related to the abundance of fine sediment, illustrating the importance of winter habitat containing low sediment loads (Bjornn *et al.* 1977). As fine sediments fill the interstitial spaces between the cobble substrate, juvenile Chinook salmon were forced to leave preferred habitat and to utilize cover that may be more susceptible to ice scouring, predation, and decreased food availability (Hillman *et al.* 1987). Deposition of sediment on gravel substrates also may lower winter carrying capacity for bull trout (Shepard *et al.* 1984) and the abundance of aquatic invertebrates, an important food source for young salmonids.

Eggs and alevins are generally more susceptible to stress caused by suspended solids than are adults. Egg survival is dependent on a continuous supply of well-oxygenated water through the streambed gravels (Cederholm and Reid 1987). Accelerated sedimentation can reduce the flow of water and, therefore, oxygen to eggs and alevins. That in turn can decrease egg survival, decrease fry emergence rates (Cederholm and Reid 1987, Chapman 1988, Bash *et al.* 2001), delay development of alevins (Everest *et al.* 1987), and reduce growth and cause premature hatching and emergence (Birtwell 1999). Fry delayed in their timing of emergence are less able to compete for environmental resources than other fish that have undergone normal development and emergence (intra- or interspecific competition) (Everest *et al.* 1987).

Whether eggs/alevins are smothered or fry emergence is impeded is largely determined by sediment particle sizes of the spawning habitat (Bjornn and Reiser 1991). Sediment particle size determines the pore openings in the redd gravel and with small pore openings, more suspended sediments are deposited and water flow is reduced compared to large pore openings.

Several studies have documented that fine sediment can reduce the reproductive success of salmonids. Natural egg-to-fry survival of coho salmon, sockeye and kokanee has been measured at 23%, 23%, and 12%, respectively (Slaney *et al.* 1977). Substrates containing 20% fines can reduce emergence success by 30 to 40% (MacDonald *et al.* 1991). A decrease of 30% in mean egg-to-fry survival can be expected to reduce salmonid fry production to low levels (Slaney *et al.* 1977).

Due to in-water timing restrictions (work windows) for instream construction, sediment will be generated at a time with least impact to fish life-history stage. However, spawning habitat and active redds may be impaired by unavoidable post-construction sediment entering the river from areas disturbed by construction. If this occurs, sediment deposited on redds could result in egg and alevin mortality, particularly where existing levels of fine sediment (less than 6.4 mm [0.25 in]) in the streambed (embeddedness) are high. Fish movement may also be temporarily obstructed by increased suspended sediment due to construction and post-construction sedimentation caused by precipitation.

Conservation Measures

Temporary erosion and sediment control measures are required on all projects to minimize sediment input into the stream and other sensitive areas. These measures include, in part, covering excavated and stockpiled material, placing sediment barriers (silt fences, wattles, *etc.*) around disturbed sites, and placing erosion control measures over disturbed areas. Proper rewatering of streams after construction will also minimize sediment effects downstream of construction sites. A stepwise rewatering of the site will prevent sudden increase in downstream turbidity. See Table 7-1 for corresponding construction methods and conservation measures for the effects of sediment.

7.1.1.3 Effects of Stream Isolation and Fish Removal

Proposed routine project activity may result in impacts to fish from specific construction elements such as the following:

- Capture and transport of fish
- Block nets
- Seines, dip nets and minnow traps
- Electroshocking
- Stream dewatering

Capture and Transport of Fish

To reduce lethal impacts on listed fish species from dewatering the stream, the City of Seattle proposes to capture and relocate all fish from project construction sites before construction begins. The City of Seattle proposes using seines and dip nets, block nets, and electroshocking. Although this effort will reduce the overall impact to endangered, threatened, and proposed species, fish may in some cases experience immediate or delayed injury or death from the use of nets and/or electroshocking techniques. Most of the injuries and death will be due to block nets and electroshocking. Mortality associated with handling stress, seine, and dip nets is unlikely. The City of Seattle proposes releasing all captured fish and aquatic organisms as close to the point of capture as possible. Other considerations for releasing fish will be based on their life-history stage and number of fish captured. Juvenile fish will be released downstream of the site to aid migration out of the system. Adult fish will be released upstream to aid migration to spawning or resting locations. All fish will be released in the best available habitat to reduce or decrease predation and aid recovery.

Block Nets

Before dewatering a stream section, block nets will be placed up- and downstream from the work area to prevent fish entering the stream segment that will be dewatered. The use of block nets poses a mortality risk to fish, even when monitored daily.

In 2000, the U.S. Fish and Wildlife Service studied bull trout sampling efficiency in Washington, capturing 811 bull trout (2,364 salmonids total) with block nets (J. Polos, USFWS, pers. comm. 2001). Total fish mortality was 92 (4% of the total captured). Bull trout accounted for 63% of all mortalities (n=58) and 7% (58 of 811) of all bull trout captured died on the block nets due to impingement. All bull trout mortalities were either fry (n=47) or juveniles (n=11).

To potentially reduce the level of mortality risk, the City of Seattle proposes monitoring block net use in a slightly different manner than that of the U.S. Fish and Wildlife Service study. The U.S. Fish and Wildlife Services' collection methods in the 2000 study resulted in stream flows continually passing through the block nets throughout the night with crews checking nets one time during the night.

Under the proposed action of the Seattle Biological Evaluation—which is mostly maintenance projects—the City of Seattle will install block nets, capture and relocate all fish, divert streamflow around the project area, then remove the block nets all in the same day. On rare occasions, block nets may remain in the stream overnight when the fish are captured and diversion activities require additional time to complete.

However, block nets normally will be installed and removed the same day (during daylight hours). Personnel will be available during the day to remove fish promptly, thus avoiding long-term/lethal impacts of fish impingement on block nets. In addition, stream dewatering will occur during authorized in-water work timing windows which will minimize potential impingement to listed and proposed fish species. Therefore, the impingement of fish will be rare and result in significantly less mortality when compared with methods used for the U.S. Fish and Wildlife Service 2000 study.

Seines, Dip Nets, and Minnow Traps

Seines and dip nets will initially be used to capture and remove any fish trapped between the block nets in the portion of the stream to be dewatered. The use of seines and dip nets is expected to capture about 70% of the fish within the section of stream to be dewatered. However, this is highly site-specific, as sites with large woody debris and undercut banks are difficult to seine or use dip nets.

Minnow traps involve using wire-mesh traps placed in key instream fry habitat overnight before dewatering. Captured fish are then removed and relocated either upstream or downstream based on the fish life history stage. Fry will be transported in large buckets (minimum 5 gallon [19 L]) filled with stream water. The fish and water temperature will be monitored to ensure the health of the fish until they are released. Given the low impact of these capture and relocation techniques, fish are not expected to be injured by the method.

Electroshocking

The capture and handling of Puget Sound Chinook salmon, bull trout, and steelhead through electroshocking is a short-duration activity, occurring intermittently over a single day. However, electroshocking may result in a high risk of mortality and injury including spinal hemorrhages, internal hemorrhages, fractured vertebra, spinal misalignment, and separated spinal columns (Hollender and Carline 1994, Dalbey et al. 1996, Thompson et al. 1997).

Electroshocking has been found to have a high rate of injury to fish. Factors that influence fish injuries include environmental conditions (conductivity of water, depth of water, or substrate), electrical hardware, and the electrical current (Sharber and Carothers 1988). Voltage, pulse shape, and frequency are electrical factors causing fish injuries (Sharber and Carothers 1988, McMichael 1993, Dalbey et al 1996). Table 7-6 summarizes studies on the effects of electroshocking on fish.

Table 7-5. Summary of effects of DC electroshocking on fish

Fish species	Percent with spinal injury	Percent with hemorrhage injury	References
Rainbow trout	22*, 45**	34*, 45**	Thompson et al. 1997
Brown trout	32*, 36**	24*, 35*	Thompson et al. 1997
Rainbow trout			Dalbey et al. 1996
Smooth DC	12		
Half-pulse DC	40		
Full-pulse DC	54		
Brook trout	17	16	Holinder and Carline 1994
Rainbow trout			McMichael 1993
300 v, smooth DC	4	4	
300 v, 30 Hz	22	35	
300 v, 90 Hz	35	53	
400 v, smooth DC	14	17	

Fish species	Percent with spinal injury	Percent with hemorrhage injury	References
Rainbow trout			Sharber et al. 1994
Anode type			
sphere	43		
cable	65		
ring	43		
Pulse frequency			
15 pulses/sec	3		
30 pulses/sec	24		
60 pulses/sec	43		
512 pulses/sec	62		
Burst of waves	8		
Rainbow trout			Sharber and Carothers 1988
Pulse shape			
exponential	44		
square	44		
quarter size	67		
*Shore-based pulsed-DC equipment **Boat electroshocking pulsed-DC equipment			

Spinal injuries in fish ranged from 3% to 67% which depended on the voltage, pulse shape, and frequency used during electroshocking. Smooth DC or low frequency DC (< 30 Hz) electroshocking results in less injury to fish. Hollender and Carline (1994) found most spinal injuries were either rating class 2 (40%) or 3 (40%) (Table 7-7). They also found the spinal injuries involved on average 7 vertebrae, and were usually located in the region of the spinal column between the dorsal and anal fins.

While electroshocking has significant effects on injury to fish, the degree of spinal injury does not affect long-term survival (Dalbey et al. 1996). There is an influence on growth. Rainbow trout with moderate and severe spinal injury (classes 2 and 3) grew little in length and weight after 335 days (Dalbey *et al.* 1996). Thompson *et al.* (1997) speculated that fish in better condition may be more likely to be injured because of more powerful muscle contractions.

Dalbey et al. (1996), Thompson et al. (1997), and Hollender and Carline (1994) all found longer fish had a higher probability of being injured. Incidence and severity of injury were positively correlated with fish length: 40% of rainbow trout longer than 8 inches (20 cm) sustained injury compared with 27% in smaller fish (Dalbey et al. 1996). The injury rate was the following (Hollender and Carline 1994):

- Lowest (12%) for brook trout smaller than 5 inches (12.7 cm)
- Intermediate (26%) for the 5- to 7-inch length (12.7-17.8 cm) group
- Highest (43%) for the 7-inch-and-longer length (17.8 cm) group.

Table 7-6. Rating system to identify and rate severity of electroshocking injuries

Rating class	Internal hemorrhage	Spinal damage
0	None apparent	None apparent
1	Mild hemorrhage with 1 or more wounds in the muscle, separate from the spine	Compression (distortion) of vertebrae only
2	Moderate hemorrhage with 1 or more small wounds on the spine (<= width of 2 vertebrae)	Misalignment of vertebrae, including compression
3	Severe hemorrhage with 1 or more large wounds on the spine (> width of 2 vertebrae)	Fracture of 1 or more vertebrae or complete separation of 2 or more vertebrae
Source: Thompson et al. 1997		

Very few of the fish collected by Thompson et al. (1997) exhibited external signs of injury although a higher percentage of rainbow and brown trout were injured by electroshocking than would have been suspected from external examination. Dalbey et al. (1996) found that rainbow trout X-rayed soon after capture, exhibited no detectable signs of spinal injury, but later showed calcification indicative of old injuries when X-rayed again after 335 days in a pond. Hollender and Carline (1994) found hemorrhages and spinal compressions in the smallest fish were small and difficult to see and might have been overlooked. Therefore, their reported injury rate (average of 22%) may be a conservative estimate. In addition, most studies have focused on injuries exhibited by adults, but stress from electroshocking can be the main problem for juveniles (P. Bisson, U.S. Forest Service, S. Parmenter, California Department of Fish and Game, pers. comm. in Nielson 1998).

The City of Seattle uses Smith Root LR-24 backpack electroshockers that are capable of adjusting voltage (50 to 990 v), pulse shape (smooth, pulsed, or burst), and frequency (1 to 120 Hz) (Smith-Root website at www.smith-root.com). The Smith Root LR-24 electroshockers also have an automatic initial set-up system. This system automatically sets the electroshocker to the current stream conditions. This set-up gives a good starting point to minimize impacts to fish. When proper electroshocking techniques are used, potential fish injury is minimized. Proper electroshocking techniques are identified in the NMFS Electroshocking Guidelines. In addition, all stream dewatering and fish handling will occur during approved in-water work windows, which minimize the potential to injure listed fish. No large (subadults or adults) listed fish species should be in any of the action areas during the in-water work window, especially in City streams. Juvenile listed species may be present in some streams during the in-water work window, but the City has never captured a listed species during stream dewatering (G. Lockwood, City of Seattle, pers. comm. 2006). Rainbow trout are captured in some streams within the action areas (Thornton and Longfellow creeks). These fish have been identified as rainbow trout and not steelhead.

Stream Dewatering

During stream dewatering—including when sandbags are used to focus stream flows—there is a potential that a few fish may avoid being captured and relocated, and thus may die because they remain undetected in stream margins under vegetation or gravels. A gradual dewatering approach, as proposed, should enhance the efficacy of fish removal and thus reduce, but not eliminate, this risk. An estimated 95% of the fish will be removed before total dewatering of the stream. In addition, due to the proposed timing of the activities, the risk to listed fish species should be minimized because of the reduced likelihood of migratory and/or spawning fish being in the stream reach during construction.

Conservation Measures

Method 4 of this Seattle Biological Evaluation is the method to isolate the in-water construction site. This method in the past has been a conservation measure to reduce, minimize, or avoid potential effects to fish. It has now become a routine practice. In addition, this method in conjunction with work timing windows has greatly reduced construction-related impacts to fish. See Table 7-1 for corresponding construction methods and conservation measures for the effects of stream isolation and fish removal.

7.1.1.4 Effects of Pile Removal

Projects proposing to remove creosote-treated timber piles by either full extraction or breaking off or cutting the piles at or below the mudline will result in temporary suspension and a long-term increase in creosote-contaminated sediments within the project area. Puget Sound Chinook salmon, bull trout, and steelhead could be directly exposed to contaminants suspended in the water column or indirectly exposed through the food chain. Listed rockfish can be exposed to contaminants if piles are removed in or near kelp beds. There are 2 potential pathways for increased long-term contamination that could result from this practice:

1. The first pathway is waterborne. Waterborne (surface water and water column) sediment contamination can appear when piles are pulled out or cut. The creosote on the pile's surface has been buried in an anoxic zone and is essentially fresh creosote and highly volatile when re-exposed. Freshly-cut piles generally act in a wicking fashion, pulling the fresh creosote from within the pile and from sediments in the anoxic zone toward the freshly-cut surface. This fresh creosote can be suspended in the water column as well as increase contamination of the sediment.

2. The second pathway consists of droplets of fresh creosote released from the piles into surrounding sediments as piles are being pulled. Because these droplets are heavier than water, they sink to the bottom and very likely are undetectable in the water column.

Creosote contains numerous constituents known to be toxic to aquatic organisms (Eisler 1987, Germain et al. 1993, Brooks 1995, Van Brummelen et al. 1998, Brooks 2000, Johnson et al. 2002). Creosote is composed primarily of PAHs (about 65-85%), with smaller percentages of phenolic compounds (10%), and nitrogen-, sulfur-, or oxygenated heterocyclics (Brooks 1995, EPRI 1995). PAHs are introduced into the environment through industrial discharges, creosote from treated woods, municipal runoff, and atmospheric emissions from incineration and automobile emissions. PAHs are also introduced into the marine ecosystems through accidental spills of fuel oil and other petroleum products.

The general mode of effect associated with acute exposure to PAHs is non-polar narcosis (Van Brummelen et al. 1998). Other major effects include biochemical activation/adduct formation (carcinogenesis), phototoxicity (acute and chronic exposure), and disturbance of hormone regulation. The role of PAHs in endocrine disruption is not well documented. Immunotoxicity as a mode of PAH toxicity has been investigated (Varanasi et al. 1993, Karrow et al. 1999). PAHs have induced tumors in laboratory animals exposed by inhalation and ingestion (Germain et al. 1993). The presence of hepatic (liver) tumors in English sole (*Parophrys vetulus*), a benthic marine fish, has been linked to PAH contamination in sediments collected from industrialized areas around Puget Sound (Krahn et al. 1986, Meyers et al. 1990, Stein et al. 1990, Johnson et al. 2002).

Fish (specifically English sole) residing in Puget Sound with elevated levels of PAHs have been documented to suffer from liver disease and various types of reproductive impairment. This impairment includes inhibited ovarian development, inhibited spawning ability and reduced egg viability (Johnson et al. 2002). Moreover, exposure to PAHs in the water column caused flatfish larvae to become disoriented and to exhibit signs of narcosis, while higher concentrations of PAHs were associated with increased mortality (Johnson et al. 2002).

Schirmer et al. (1999) evaluated the cytotoxicity and photocytotoxicity of intact and photomodified creosote to rainbow trout gill cell cultures. The study found that high creosote doses were necessary to elicit a cytotoxic response in rainbow trout gill cell cultures. The toxic potency of creosote to rainbow trout gill cell cultures was strongly influenced by UV radiation. UV irradiation of either the creosote or the creosote-exposed cell cultures consistently increased the toxicity of creosote to fish gill cells in culture and, at least in the case of the photocytotoxicity of creosote, was attributable to PAHs.

Karrow et al. (1999) reported depression of biological indicators for immune function in rainbow trout that had been exposed to liquid creosote in microcosms. Immune function was evaluated in juvenile Chinook salmon collected from contaminated waterways around Puget Sound and compared with hatchery fish caught upriver (Varanasi et al. 1993). Compared with reference fish from hatcheries located upstream on the Green and Puyallup rivers, fish from the Duwamish Waterway and the Commencement Bay/Puyallup River estuary had elevated concentrations of PCBs and aromatic hydrocarbons in body tissues and stomach contents. The fish from the estuaries exhibited immunosuppression in comparison with the hatchery fish, as indicated by tests of humerol and cellular-mediated immunity.

Studies have shown that high concentrations of toxic chemicals in sediments are adversely affecting Puget Sound biota via detritus-based food webs (NOAA 2000, Johnson et al. 2002). PAHs, introduced into the marine system through sources such as petroleum product spills or creosote treated wood, tend to adsorb to sediments. When sediment is undisturbed, only a portion of parent PAH compounds are readily bioavailable to marine organisms. However, resident benthic organisms may be exposed to PAHs through their diet, through exposure to contaminated water in the benthic boundary layer, and through direct contact with the sediment. PAHs may bioaccumulate in aquatic invertebrates within these benthic communities (Varanasi et al. 1989, Meador et al. 1995). Therefore, benthic invertebrate prey are a significant source of PAH exposure for marine fish. Vertebrate organisms are able to quickly metabolize some of the lighter PAH compounds and readily excrete a percent of the hydrophobic parent compound along with the polar water-soluble metabolites (James et al. 1991, McElroy et al. 1991), which can be passed on to consuming marine fish. While PAHs do not bioaccumulate in vertebrates, some heavier, more carcinogenic PAH compounds and metabolites may persist and are known to cause sub-lethal effects to fish exposed in laboratory studies (NTP 1999) and field studies (Moore and Myers 1994, Myers et al. 1998a, 1998b, O'Neill et al. 1998).

Acute and chronic toxicity have been evaluated in laboratory experiments for a variety of aquatic organisms (i.e., mysids (*Mysidopsis bahia*), oysters (*Crassostrea virginica*), pink shrimp (*Penaeus duorarum*), Mosquito fish (*Gambusia affinis*), Dungeness crab larvae (*Cancer magister*), coho salmon, and rainbow trout (Brooks 1995, BOR 2000).

Application of these laboratory results to real-world exposures is difficult because the release of PAHs into natural waterbodies from treated wood (i.e., environmental exposure) differs significantly from the methods used to introduce pure compounds into essentially sterile laboratory conditions (Poston 2001). The high number of variables contributes to a high level of uncertainty in understanding the risk for exposure and the potential effects.

Environmental exposure to creosote and PAHs depends on the age of the treated wood, methods used to treat the product, a host of environmental parameters, and dilution by the receiving waterbody. Chinook salmon, bull trout, steelhead, rockfish, and prey fish species could become exposed to creosote and its associated contaminants (i.e., PAHs) when old pilings are removed. They will be directly exposed to these constituents while they are suspended in the water column. Given the chemical composition and characteristics of creosote (i.e., in general this chemical and associated compounds are hydrophobic and will adsorb to particulate matter in the water column and later settle out into bottom sediment [Johnson et al. 2002]) the waterborne creosote concentrations should be negligible within a week of re-suspension (J. Davis, USFWS, pers. comm. 2004). Levels of creosote and PAH exposure would probably not be high enough to cause direct cytotoxicity or tumor induction but may cause immune suppression in Chinook salmon, bull trout, steelhead, rockfish, and prey fish species, resulting in increased disease susceptibility.

Puget Sound Chinook salmon, bull trout, steelhead, and rockfish could be indirectly exposed to contamination through the food chain. Creosote and associated chemicals remaining in sediments at the site and wherever they settle out after suspension are likely to persist for many years given their resistance to biological breakdown. Creosote and its chemical constituents have a half-life of about 3 years in biological components (e.g., water, soils). The length of persistence will depend on the concentration of chemicals added to the environment during the removal of the piles, which is currently unknown. As creosote and associated chemicals are known to bioaccumulate in invertebrates, Puget Sound Chinook salmon, bull trout, steelhead, and rockfish are expected to be exposed to creosote/PAH compounds through the food chain. Over the long-term, with the treated timber piles removed and, therefore, the source of creosote removed or capped by the sediment falling into the hole left by the extracted pile, the following happens:

- The concentration of creosote in the sediment will decrease
- Water quality will improve
- The pathway of exposure for fish through contamination of prey will be reduced.

We anticipate that direct exposure, in the water column, and indirect exposure, through the food chain, will affect individuals. These effects could result in reduced reproductive success (e.g., inhibited ovarian development, inhibited spawning ability, and reduced egg viability) and reduced survival (e.g., impacts resulting in cytotoxicity, tumors, immune suppression, etc.). However, we expect that a significant impairment of breeding, feeding or sheltering activities or the normal behaviors associated with these activities will be difficult to discern at the individual level. At this point, impairment may only be detectable at the population level (i.e., declines in population). In the long term, removal of creosote piles is expected to improve water quality for Puget Sound Chinook salmon, bull trout, steelhead, rockfish, and their prey species by decreasing concentrations in the water column and chronic contamination of benthic invertebrates.

Conservation Measures

If treated piles are fully extracted or if they are cut below the mudline, the City will cap the holes or piles with appropriate material such as clean substrate (sand and/or gravel) or pile caps. This ensures that chemicals from the existing piles do not leach into the adjacent sediments or the water column. See Table 7-1 for corresponding construction methods and conservation measures for the effects of pile removal.

7.1.1.5 Effects of Pile Driving

Projects involving the installation or proofing of steel piles will result in effects to Puget Sound Chinook salmon, bull trout, steelhead, rockfish, and prey species through underwater sound pressure levels. During pile installation, either an impact or a vibratory hammer pile driver will be used. In some circumstances both pile drivers may be used. An impact hammer is a large piston-like device that is usually attached to a crane. A vertical support holds the pile in place and a heavy rod moves up and down, striking the top surface of the pile. A vibratory hammer has a set of jaws that clamp onto the top of the pile. The pile is held by the jaws while the hammer vibrates the pile. The vibrations liquefy the surrounding sediments and the combined weight of the hammer and pile cause it to sink to the desired depth. Piles that are installed with a vibratory hammer often must be 'proofed.' Proofing involves striking the pile with an impact hammer to determine the load-bearing capacity of the pile and usually involves multiple strikes. Juvenile and adult Puget Sound Chinook salmon and steelhead, sub-adult and adult bull trout, and juvenile and adult rockfish may be affected from in-water impact and vibratory pile driving. Juvenile rockfish may be affected by in-water impact and vibratory pile driving especially when pile driving occurs near kelp beds. Adult rockfish may be affected because of the overall distance that sound travels in water.

Data from studies of blasting indicate that the shape of the sound pressure wave is an important factor in determining whether an organism may be physically injured by the pressure wave (Hastings and Popper 2005). Pressure waveforms where the initial peaks are steep and rise quickly are considered more likely to cause potential injury compared to pressure waveforms with slower rise times on the initial peak (Yelverton et al. 1975; Wardle et al. 2001; Hastings 2002).

High underwater sound pressure levels (SPLs) are known to have negative physiological and neurological effects on a wide variety of vertebrate species including fish and birds (Yelverton et al. 1973, Yelverton and Richmond 1981, Steevens et al. 1999, Fothergill et al. 2001, Cudahy and Ellison 2002, USDOD 2002). High underwater SPLs are known to injure and/or kill fish by causing barotraumas (pathologies associated with high sound levels including hemorrhage and rupture of internal organs), as well as causing temporary stunning and alterations in behavior (Turnpenny et al. 1994, Turnpenny and Nedwell 1994, Popper 2003, Hastings and Popper 2005). Risk of injury appears related to the effect of rapid pressure changes, especially on gas-filled spaces in the bodies of exposed organisms (Turnpenny et al. 1994).

High underwater SPLs can also cause several behavioral responses that have not been well studied. Broadly, the effects of elevated underwater SPLs on organisms range from death to no effect. Over this continuum of effect, there is no easily identifiable point at which behavioral responses transition to physical effects. A number of technical acoustic descriptors are used throughout this section (Table 7-8).

From a point source in a uniform medium (such as water), sound spreads outward following common laws of Transmission Loss physics (i.e., spherical or cylindrical spreading laws). Transmission Loss physics implies that intensity and pressure vary inversely with the square of the distance from the source. With spherical spreading, SPLs diminish by about 6 dB when the distance is doubled. For cylindrical spreading, SPLs diminish by about 3 dB with every doubling of distance. Sound transmission in shallow water is highly variable and site specific. Refraction can result in either reduced or enhanced sound transmission in shallow water (Richardson et al. 1995). Therefore, a practicable spreading loss (Davidson 2004) provides a more accurate analysis on reduction of SPLs through water. The practicable spreading model uses a 4.5 dB reduction with every doubling of distance from the source.

Table 7-7. Acoustic concepts and terminology

Term	Definition
Sound	Vibrations in air, water, etc., that stimulate the auditory nerves and produce the sensation of hearing. The perception of a sound depends on 2 physical characteristics: 1) amplitude and 2) frequency. Both can be measured.
Amplitude	Measure of the acoustic energy of sound vibrations. Sound amplitude is measured on a logarithmic scale in units called decibels.
Frequency	Rate of oscillation or vibration of sound measured in cycles per second, or hertz (Hz). Ultrasonic frequencies are those that are too high to be heard by humans (greater than 20,000 Hz). Infrasonic sounds are too low to be heard by humans (less than 20 Hz).
Decibel (dB)	Numerical expression of the relative loudness of a sound. The reference scale for underwater sound is 1 micro-pascal (µPa) and is expressed as "dB re: 1µa". A pascal (Pa) is the pressure resulting from a force of 1 newton exerted over an area of 1.2 square yards (1 m^2).
Sound pressure levels (SPL)	Sound pressure that is expressed in dB. In this document, underwater SPLs are referred to in units of dB. Peak pressure (peak): The highest level or amplitude or greatest absolute SPL during the time of observation. SPLs expressed as peak are used in discussing injury or mortality to fish. Sound exposure level (SEL): A metric that incorporates both SPL and duration. SEL is calculated as 10 times the logarithm of the integral, with respect to duration, of the mean-square sound pressure, referenced to μPa^2-sec. Using this metric, 0-dB SEL corresponds to a continuous sound whose rms sound pressure equals the reference pressure of 1 µPa at the duration of 1 s (Morfey 2001) Root mean square (rms): The root square of energy divided by the duration. SPLs expressed as rms are commonly used in discussing behavioral effects. Behavioral effects—which often result from auditory cues and effects on hearing—may be better expressed through averaged units rather than by peak pressures.

Term	Definition
Impulse	Measure of the total energy content of the pressure wave. Positive impulse is the integral of pressure over time measured from the arrival of the leading edge of the pressure wave until the pressure becomes negative.
Transmission loss (TL)	Loss of sound energy, expressed in dB, as sound passes through a medium like water. Several factors are involved: the spreading of the sound over a wider area (spreading loss), losses to friction (absorption), scattering and reflections from objects in the sound's path, and interference with 1 or more reflections of the sound off of surfaces (for underwater sound, the surfaces are substrate and air-water interface).

Impact Pile Driving: Underwater Noise Effects Resulting in Injury or Mortality

Injury and mortality in fishes has been attributed to impact pile driving (Stotz and Colby 2001, Stadler 2002, Fordjour 2003, Abbott et al. 2005, Hastings and Popper 2005). As described above, injuries to fishes include barotraumas, hemorrhages and ruptures of internal organs, swim bladders, and eyes (Yelverton et al. 1973, Yelverton and Richmond 1981, Turnpenny and Nedwell 1994, Hastings and Popper 2005). Death from barotrauma can be instantaneous, occurring within minutes after exposure, or several days later (Abbott et al. 2002).

The potential for injury to fish or any other aquatic organism from pile driving depends on the type and intensity of the sounds produced. These are greatly influenced by a variety of factors, including the type of hammer, the type of substrate, and the depth of the water. Firmer substrates require more energy for pile driving, and produce more intense sound pressures. Biologically, key variables that factor into the degree to which an animal is affected include size, anatomical variation and location in the water column (Gisiner et al. 1998). Any gas-filled structure within an animal is particularly susceptible to the effects of underwater sound (Gisiner et al. 1998). Examples of gas-filled structures in vertebrate species are swimbladders, bowel, sinuses, lungs, etc. As a sound travels from a fluid medium into these gas-filled structures, there is a dramatic drop in pressure that can cause rupture of the hollow organs (Gisiner et al. 1998).

Sound energy from an underwater source readily enters the bodies of animals because the acoustic impedance of aquatic animal tissue nearly matches that of water (Hastings 2002). This has been demonstrated in fish with swimbladders (such as salmonids). As a sound pressure wave passes through a fish, the swimbladder is rapidly compressed due to the high pressure and then rapidly expanded by the underpressure component of the wave. At the high SPLs associated with pile driving, the swimbladder may repeatedly expand and contract, hammering the internal organs that cannot move away since they are bound by the vertebral column above and the abdominal muscles and skin that hold the internal organs in place below the swimbladder (Gaspin 1975). This pneumatic pounding can also rupture capillaries in the internal organs, as observed in fish with blood in the abdominal cavity, and maceration of kidney tissues (Abbott et al. 2002, Stadler 2002).

Physical injury to aquatic organisms may not result in immediate mortality. If an animal is injured, death may occur several hours or days later, or injuries may be sublethal. Necropsy results from Sacramento blackfish (*Othodon microlepidotus*) exposed to high SPLs showed fish with extensive internal bleeding and a ruptured heart chamber were still capable of swimming for several hours before death (Abbott et al. 2002). Sublethal injuries can reduce osmoregulatory efficiency and increase energy expenditure (Gaspin et al 1976, Govoni et al. 2008) and can effect equilibrium and interfere with the ability to carry out essential life functions such as feeding and predator avoidance (Gaspin 1975; Turnpenny et al. 1994; Hastings et al. 1996; Popper 2003).

Yelverton et al. (1973) and Yelverton and Richmond (1981) exposed many fish species, various birds and terrestrial mammals to underwater explosions. Common to all species exposed to underwater blasts were injuries to air and gas-filled organs, as well as eardrums. These studies identified injury thresholds in relation to size of the charge, the distance at which the charge was detonated, and the mass of the animal exposed. For fish, Yelverton et al. (1973) and Yelverton and Richmond (1981) found that the greater the mass (weight of the fish), the greater impulse level needed to cause an injury. Conversely, a smaller mass would sustain injury from a smaller impulse.

At Bremerton, Washington, approximately 100 surfperch (*Cymatogaster aggregata*, *Brachyistius frenatus* and *Embiotoca lateralis*) were killed during impact driving of 30-inch (76 cm) diameter steel pilings (Stadler 2002). The size of these fish ranged from 2.7 to 6.9 inches (70-175 mm) FL. Dissections revealed that the swimbladders of the smallest of the fish (3.1 inch [80mm] FL) were completely destroyed, while those of the largest individual (6.7 inches [170 mm] FL) were nearly intact. Damage to the swimbladder of *C. aggregata* was more severe than to similar-sized *B. frenatus*. These results are suggestive of size and species-specific differences and are consistent with those of Yelverton et al. (1975), who found size and/or species differences in injury from underwater explosions.

The most noticeable and documented effects of pile driving have been fish kills. However, it is important to note that not all fish killed by pile driving float to the surface and they are therefore likely undetected (Teleki and Chamberlain 1978; WSDOT 2003). At the Port of Vancouver, British Columbia, divers found that a large number of dead fish, including salmonids, had sunk to the bottom (WSDOT 2003). Teleki and Chamberlain (1978) found that up to 43% of the fish killed by underwater explosions sank to the bottom. With few exceptions, fish kills are reported only when dead and injured fish are observed at the surface. Thus, the frequency and magnitude of such kills are likely underestimated.

Small fish that are subjected to high SPLs may also be more vulnerable to predation, and the predators themselves may be drawn into the potentially harmful field of sound by following injured prey. The California Department of Transportation reported that the stomach of a striped bass killed by pile driving contained several freshly consumed juvenile herring. It appears this striped bass was feeding heavily on killed, injured, or stunned herring that swam into the zone of lethal sound pressure.

Implications and Extent of Underwater Sound Resulting in Injury or Mortality

Examination of the current literature indicates that physical damage to non-auditory tissue is best evaluated through the use of an energy index that is indicative of mechanical effects to the tissue that is independent of whether the pressure is positive or negative. This can be estimated using cumulative SELs; however, the most relevant data (Yelverton et al. 1975; Wiley et al. 1981; Stuhmiller et al. 1996) are not reported in cumulative SELs, and the raw data necessary to calculate SELs is not contained in these reports.

Using data from an unpublished study of the effects of underwater explosions on fishes, Hastings (Hastings 2007) determined that a SEL as low as 183 dB (re: 1 μPa2-sec) was sufficient to injure the non-auditory tissues of juvenile spot (*Leiostomus xanthurus)* and pinfish (*Lagodon rhomboides*) with an estimated mass of 0.5 grams. While previous studies (Yelverton et al. 1975; Stuhmiller et al. 1996) demonstrated a log-log relationship between the mass of a fish and the SEL from an impulsive sound required to induce injury, data on the cumulative SEL required to injure the non-auditory tissues of larger fishes are not available.

Popper et al. (2005) and Song et al. (2008) investigated the seismic effects of exposing three species of fish to airgun shots at a mean received level of 205-209 dB_{peak} and an approximate received mean of 176-180 dB SEL. The inner ears of these fishes were examined and no physical damage to the sensory cells was found (Song et al. 2008). The authors noted that the onset and degree of temporary threshold shift (TTS) varied among species, with broad whitefish (*Coregonus nasus*) showing no effect after cumulative SEL exposures up to 187 dB. Northern pike (*Esox lucius*) and lake chub (*Couesius plumbeus*) (a hearing specialist) showed TTS after exposure to cumulative SELs as low as 185 dB and 184 dB, respectively (Popper et al. 2005). This work indicates that substantial differences exist in the effects of high SELs on the hearing thresholds of different species; fish with poorer hearing (the pike) showed little hearing loss, while the fish with the best hearing (the lake chub) had the most loss (Popper et al. 2005). The authors also note that the sounds of airguns are characterized by relatively rapid onset, broad frequency ranges and high peak levels, making them more similar to sounds from pile driving and explosions than to ship noise or sonar (Popper et al. 2005).

In 2004, the California Department of Transportation (Caltrans) and Federal Highway Administration (FHWA) established an inter-agency Fisheries Hydroacoustic Working Group (FHWG) to develop a better understanding of the issue of pile driving and its potential effects to listed fishes. The group was comprised of transportation and resource agencies, underwater acoustics experts and fish biologists. In support of the FHWG, Drs. Marti Hastings and Arthur Popper were contracted to prepare a report titled "Effects of Sound on Fish" describing what was known about the effects of sound (including those from pile driving activities) on fishes and to identify areas of uncertainty (Hastings and Popper 2005). In this report, SEL was presented as a metric that allows for comparison and accumulation of multiple transient sound events having different pressure levels and temporal characteristics. The authors proposed the use of SEL to correlate physical injury to fishes exposed to elevated levels of underwater sound produced during pile driving. The authors considered SEL superior to the previous metric (*i.e.* peak SPL) used to evaluate pile driving effects, because it allows one to sum the energy produced with multiple pile strikes. However, the fact remained that due to the integral nature of a SEL metric, brief and high peak pressure transients may not exceed the SEL criteria, but could be damaging. Carlson et al. (2007) states that it is imperative to utilize criteria that address both peak pressure and cumulative SEL.

Subsequently, the FHWG developed and agreed upon "interim criteria" for evaluating the potential for physical effects (i.e., injury) from underwater SPLs associated with pile driving (FHWG 2008). These criteria are based on the information above and represent threshold values of the dual metrics proposed by (Carlson et al. 2007) (peak pressure and cumulative SEL) for assessing the risk of direct injury, including TTS, and account for the repeated strikes required to drive a pile. Injury is therefore expected if either: 1) the peak pressure of any strike exceeds 206 dB; or 2) the SEL, accumulated over all pile strikes exceeds 187 dB (re: 1 μPa^2-sec) for fishes 2 grams or larger and 183 dB (re: 1 μPa^2-sec) for fishes smaller than 2 grams. The number of pile strikes is used to determine the cumulative SEL by applying the following equation:

Cumulative SEL = Single-strike SEL + 10*log(number of pile strikes)

The number of pile strikes is estimated per continuous work period. This approach assumes that there will be a break of at least 12 hours between work periods. A break of this duration is typical for most pile driving operations, and is thought to allow for fish to recover from exposure to high SPLs.

Impact Pile Driving: Underwater Noise Impacts Resulting in Behavioral Disruption

This section addresses only those effects that could result in behavioral disruption. It summarizes existing information and its application to effects on Puget Sound Chinook salmon, bull trout, steelhead, and rockfish.

Most of the sound energy of impact hammers is concentrated at frequencies between 100 and 800 Hz. Salmonids can detect sounds at frequencies between 10 Hz (Knudsen et al. 1997) and 600 Hz (Mueller et al. 1998). Salmonids are thought to have optimal hearing at frequencies of 150 Hz (Hawkins and Johnstone 1978). Therefore, impact pile installation produces sounds within the range of salmonid hearing.

Popper (2003) notes that behavioral response of fishes to loud sounds could either include swimming away from the sound source (decreasing potential exposure to the sound); or staying in place (becoming vulnerable to possible injury). Responses to sound could also affect behavior more extensively, resulting in fish leaving a feeding ground (Engas et al. 1996) or an area where it would normally reproduce. Feist et al. (1992) found that impact pile driving of concrete piles affected juvenile pink and chum salmon distribution, school size, and schooling behavior. In general, on days when pile driving was not occurring, the fish exhibited a more polarized schooling behavior (moving in a definite pattern). When pile driving was occurring, the fish exhibited an active milling schooling behavior (moving in an eddying mass). Fish appeared to change their distributions about the site, orienting and moving towards an acoustically-isolated cove side of the site on pile driving days more than on non-pile driving days. The effect of these responses may range from insignificant to permanent, long-term effects if feeding or reproduction is impaired.

Turnpenny et al. (1994) attempted to determine a level of underwater sound that would elicit behavioral responses in brown trout, bass, sole, and whiting. With brown trout an avoidance reaction occurred above 150 dB_{rms} and other reactions (e.g., a momentary startle) were noted at 170-175 dB_{rms}. The report references Hastings' "safe limit" recommendation of 150 dB_{rms} and concludes that the Hastings' “safe limit” provides a reasonable margin below the lowest levels where fish injury was observed. In an associated literature review, Turnpenny and Nedwell (1994) also state that the Hastings' 150 dB_{rms} limit did not appear overly stringent and that its application seemed justifiable. Additionally, observations by Feist et al. (1992) suggest that sound levels in this range may also disrupt normal migratory behavior of juvenile salmon.

Fewtrell (2003) held fish in cages in marine waters and exposed them to seismic airgun impulses. The study detected significant increases in behavioral responses when SPLs exceeded 158 – 163 dB_{rms}. Responses included alarm, faster swimming speeds, tighter groups, and movement toward the lower portion of the cage. The study also evaluated physiological stress response by measuring plasma cortisol and glucose levels and found no statistically significant changes. Conversely, Santulli et al. (1999) found evidence of increased stress hormones after exposing caged European bass to seismic survey noise.

Clearly, there is a substantial gap in scientific knowledge on this topic. The study by Fewtrell presents, at least, some experimental data on behavioral responses of fishes to impulsive sounds above 158 dB_{rms}. Given the large amount of uncertainty, a SPL in excess of 150 dB_{rms} will cause temporary behavioral changes to salmonids and rockfish. They are not expected to cause injury. Sound pressure levels above 150 dB_{rms} could result in alteration of normal foraging, and migrating behavior in listed fish species. Should

SPLs lead salmonids or rockfish in avoiding an area, or altering their migration timing, it could represent a significant disruption in foraging and migratory behavior.

Vibratory Pile Driving: Review and Assessment of Existing Information and Data

Adverse effects in the form of physical injury or mortality, or behavioral disruption to Puget Sound Chinook salmon, bull trout, steelhead and rockfish from vibratory pile driving is not expected. This assumption is based on the significant differences, discussed here, in the underwater sounds produced by vibratory driving of piles when compared with those from impact driving of piles.

Vibratory pile installation of hollow steel piles and sheet piles consistently produce sounds above 150 dB_{rms}, and sometimes above 180 dB_{peak}. However, the sounds from vibratory hammers differ from those of impact hammers not only in intensity, but in frequency and impulse energy (total energy content of the pressure wave). Most of the sound energy of impact hammers is concentrated between 100 and 800 Hz—the frequencies thought most harmful to aquatic animals—while the sound energy from the vibratory hammer is concentrated around 20 to 30 Hz. Additionally, during the strike from an impact hammer, sound pressure rises much more rapidly than during the use of a vibratory hammer (Carlson et al. 2001, Nedwell and Edwards 2002). Depending on the location of the vibratory installation, SPLs may not exceed ambient sound levels. Vibratory installation of steel piles in a river in California resulted in sound pressure levels that were not measurable above the background noise created by the current (Reyff 2006).

Just as these two sounds differ, so do the observed behavioral responses of fish to them. Most of the energy in the sounds produced by vibratory hammers is at the frequency of vibration, around 20 to 30 Hz, near the range of infrasound (less than 20 Hz). Fish have been shown to avoid infrasound (Knudsen et al. 1997). The duration of exposure to the sounds produced by vibratory installation, coupled with the time of year, species life history, and use of the action area are important factors that must be considered when determining whether exposure to these types of sound would result in behavioral responses that would rise to the level of adversely effecting listed species.

Impact Installation of Concrete and Wood Piles

Concrete piles are typically installed with impact hammers combined with wood pile caps that prevent damage to the pile (Illingworth and Rodkin 2007). In general, SPLs associated with concrete piles are lower than similarly-sized steel pile, and are characterized by a longer rise time than those of steel piles. Rise time appears to be an important factor in whether or not a sound pressure wave is likely to cause physical injury. No information is available that shows where installation of concrete piles has caused injury or mortality in aquatic organisms.

The effects of impact installation of wood piles are not well documented or understood. Carlson et al. (2001) conducted hydroacoustic monitoring during impact installation of wood piles. This monitoring demonstrated that impact installation of 12-inch diameter wood piles can result in SPLs of 195 dB_{peak}. Limited data (Rodkin and Donavan 2004) indicates that impact installation of wood piles results in a slower accumulation of energy and generally lower sound pressure levels compared to installation of steel piles. Therefore, one might assume that installation of wood piles may be less injurious than installation of steel piles.

It is possible that impact installation of wood piles could result in behavioral responses potentially affecting Chinook salmon, steelhead, bull trout, and rockfish migratory and foraging patterns. The sound generated by impact installation of wood piles includes a very low frequency component which may be due to lateral movement of the pile after it is hit with the hammer (Carlson et al. 2001). Although the majority of the energy of the impulse for wood piles in this study was contained at frequencies around 200 Hz and higher (Carlson et al. 2001), the low frequency component is within the range shown to trigger a behavioral response (Knudsen et al. 1997). These behavioral responses could disrupt normal feeding and/or migratory behavior. There may be a long-term effect if feeding is impeded (Popper 2003). Another possibility is that fish may "freeze" and stay in one place, increasing the potential for physical effects such as hearing loss and injury. The normal "fright" response of many fishes is to freeze (Popper 2003).

Factors to consider in evaluating the potential behavioral effects of concrete and wood pile installation include the duration of the work, diurnal timing, and location (e.g., near a forage fish base). Because the sound pressure wave generated from impact pile driving of concrete and wooden piles is different from steel piles, and since no fish kills have been documented during their installation, significant physical effects to fish are not expected to occur from installation of concrete and wood piles.

Reducing Underwater Sound Pressure Levels

A sound attenuation system, such as a pile 'cap,' bubble curtain, or combination of both, may be used to reduce SPLs and to lengthen rise times.

Pile caps are typically wood, or nylon discs placed between the pile hammer and the top of the pile. Caps have long been used by pile driving contractors to protect the pile from damage. Effectiveness varies depending on the material used. In 2006, Washington State Parks compared effectiveness between 4 pile cap materials: wood, nylon, Combest and Micarta (Laughlin 2006). Hydroacoustic monitoring during impact installation of 12-inch (30.5 cm) steel piles with the 4 cap types showed that wood caps reduced SPLs more than caps made from the other materials (average reduction with the wood cap was 24 dB). Use of a wood cap also lengthened rise times. For example, on 1 pile, the rise time was 1.8 msec without the wood cap and was 37.7 msec with the wood cap. Other materials did not lengthen rise times to this degree. (Laughlin 2006)

Use of a bubble curtain can be an effective method for reducing SPLs from pile driving. The degree of effectiveness depends on the design as well as the site conditions. Spacing of the bubble manifolds, air pressure, tidal currents, and water depth are all factors influencing effectiveness. Improper installation and operation can also decrease bubble curtain effectiveness in reducing SPLs (Visconty, Anchor Environmental, pers. comm. 2004, Pommerenck 2006).

Studies on the effectiveness of bubble curtains on reducing sound pressure waves have found varied results (see Table 7-9).

Table 7-8. Bubble curtain effectiveness for different projects

Study	Bubble Curtain Effectiveness
Longmuir and Lively (2001)	> 17dB
Laughlin (2006)	17 dB
Vagel (2003)	18 to 30 dB
Reyff (2003)	0 to 2 dB attenuation in SPLs (due to strong currents) 5 to 10 dB reduction in peak dB 3 to 5 dB reduction in rms
Visconty, Anchor Environmental (pers. comm. 2004)	0 dB reduction – improperly installed bubble curtain (not on ground) < 12 dBm average 9 dB
Reyff et al. (2002)*	23 to 24 dB reduction in peak 22 to 28 dB reduction in rms
Houghton and Smith (2005)	10 to 15 dB

* Evaluated the effectiveness of an isolated pile using a bubble curtain system. The isolated pile was 12.5 feet (3.8 m) in diameter with the interior coated with 1-inch (2.54-cm) closed cell foam. In this type of bubble curtain system, the isolated pile surrounds the actual driven pile, and contains the bubble flow.

Bubble curtains may also minimize injury to fish by changing the shape of the impulse wave. A bubble curtain and a fabric barrier system were both used during a pile installation demonstration project at the San Francisco – Oakland Bay Bridge (Caltrans 2001). The bubble curtain did not attenuate peak SPLs, but changed the shape of the impulse wave, resulting in a more gradual accumulation of energy at the start of pile driving. The overall effect of this on fish is unknown, because fish were still killed and injured with the use of the bubble curtain, although in smaller numbers than without a bubble curtain. The fabric curtain system was found to effectively reduce dB_{rms} values, but no specific numbers in dB reduction were given (Caltrans 2001). The fabric barrier is estimated to reduce SPLs by 10 to 5 dBs [Figure 4-8 in (Caltrans 2001)].

Impact installation of large (7.9 feet [2.4 m] diameter) piles with an isolation casing combined with an air bubble curtain resulted in significant sound pressure attenuation on a project in California. During impact pile driving in the San Joaquin River an attenuation system consisting of an isolation casing with a bubble curtain on the inside achieved much less attenuation (between 6-9 dB) (Pommerenck 2006). However, this project had problems correctly implementing the system.

Conservation Measures

The following conservation measures to minimize impacts will be implemented when installing piles:

- Plastic, cement, or timber piles should be used instead of steel piles
- Vibratory driver should be used as much as possible depending on the load capacity
- Bubble curtain or other noise attenuation method (wood blocks, nylon blocks, etc.) shall be used during impact installation or proofing of steel piles

- Hydroacoustic monitoring is required during installation of 12-inch or larger piles.

See Table 7-1 for corresponding construction methods and conservation measures for the effects of pile driving.

7.1.1.6 Effects of Overwater Structures

Overwater structures in both marine and freshwater alter important habitat controlling factors (light regime, wave energy, substrates, and water quality) that support salmonids, rockfish, and prey species biological and ecological functions such as predator-prey relationships, behavior, spawning, rearing and refugia (Simenstad et al. 1999, Carrasquero 2001, Nightingale and Simenstad 2001a). The nearshore habitat in marine waters and the edge or littoral habitat in freshwater are the most vulnerable areas altered by humans (Brown 1998, Barwick et al. 2004). Incremental impacts of shoreline development through the construction of docks and piers result in cumulative losses of habitat diversity and complexity (Barwick et al. 2004). Direct effects of shoreline development include physical structure alterations of bottom substrate modifications, removal of coarse woody debris, loss and fragmentation of aquatic vegetation, and simplification of shoreline habitat through bulkhead construction (Kelty and Bliven 2003, Scheuerell and Schindler 2004).

A variety of overwater structures line the marine waters of the Seattle action areas. These structures range from residential boat docks to large industrial and commercial piers like ferry terminals and piers along the Seattle waterfront. The effects of docks and piers in marine waters include behavioral responses to fish migration, alteration of light regimes, hydrology and wave energy attenuation, substrate and sediment transportation and distribution, changes in vegetation and macroinvertebrate density and diversity, and water quality changes (Simenstad et al. 1999, Nightingale and Simenstad 2001a, Haas et al. 2002),

In freshwater, most of the overwater structures are public and residential boat docks. However, in the Lake Washington Ship Canal, large commercial piers have been constructed to moor large boats (fishing, sightseeing, etc.), houseboats, and smaller pleasure crafts. The effects of these docks and piers are similar to those in marine waters. Overwater structures in freshwater effect predator-prey interactions, riparian and aquatic vegetation loss, alterations of light regimes, changes in migration, wave energy alterations, and water quality effects (Kahler et al. 2000, Carrasquero 2001).

Activities during construction of piers, docks and associated bulkheads result in permanent loss or destruction of aquatic and riparian vegetation and woody debris (Kahler et al. 2000, Haas et al. 2002, Kelty and Bliven 2003). Installation of pilings disturbs the substrate and vegetation. The presence of pilings lessens the chance of vegetation regrowth. Pilings, especially in marine waters, alter currents and sediment deposition, which affects vegetation growth (Kelty and Bliven 2003, Williams et al. 2003a).

Overwater structures result in sharp underwater light contrast that affect plant communities, macroinvertebrates and fish populations. Under-pier light energy loss falls below the threshold amounts needed for photosynthesis affecting macrophyte and phytoplankton primary projection (Simenstad et al. 1999, Kahler et al. 2000, Carrasquero 2001, Nightingale and Simenstad 2001a, Williams et al. 2003a). These photosynthesizers are an important part of the marine nearshore habitat and the estuarine and nearshore food webs that support juvenile salmonids and other fish in the nearshore (Simenstad et al. 1999, Nightingale and Simenstad 2001a). Submerged aquatic vegetation and marsh grasses provide important habitat, filter nutrients and sediments, provide nursery habitat for fish, and stabilize bottom sediments (Kelty and Bliven 2003). Increased shading due to overwater structures reduces plant shoot density, biomass, and growth (Kelty and Bliven

2003). Although the area of vegetation loss associated with any individual dock may be relatively small, cumulative impacts and fragmentation of vegetation beds may be significant along highly developed shorelines (Shafer and Robinson 2001). Dock height, width, construction material, and orientation to the sun are primary factors in determining shade effects to vegetation (Nightingale and Simenstad 2001a, Shafer and Robinson 2001, Kelty and Bliven 2003, Williams et al. 2003a).

Fish migration along the shoreline in marine waters and freshwater shows behavioral responses upon encountering docks and piers (Nightingale and Simenstad 2001a). Migrating salmonid responses to docks and piers include migration delays due to disorientation, school dispersal, and migration directional changes (Nightingale and Simenstad 2001a). Salmon fry have been found to migrate along the edges of the shadows of overwater structures rather than penetrate them (Williams et al. 2003a), although this may be species dependent (Williams et al. 2003a). In marine and freshwater environments, as Puget Sound Chinook salmon increased in size, they moved further offshore and did not migrate under overwater structures (Ratte and Salo 1985, Tabor et al. 2006).

Artificial lights on nighttime movement and habitat use has also been documented (Nightingale and Simenstad 2001a; Celedonia et al. 2009). Changes in underwater light regimes at night can alter fish migration and increase predation. Increased risk of predation occurs by changes in migratory behavior, activity and location of predators (Nightingale and Simenstad 2001a). In the Ship Canal, Chinook salmon were found to be associated with artificial light spending extended periods near artificial lights (Celedonia et al 2009). At the University and I-5 Bridges, Chinook salmon migrated along the light/shadow edge at night. Tracking of Chinook salmon showed little activity in the shadow beneath the bridges and migration through the shadow was rapid.

For marine waters, studies of potential increases in predation of salmonids have not documented any increase in predation associated with overwater structures in the marine environment (Ratte and Salo 1985, Shreffler and Moursund 1999, Nightingale and Simenstad 2001a). Williams et al. (2003a) studied potential salmon predators at Washington State ferry terminals in Puget Sound, and while predators were slightly more abundant at the terminals as compared to unmodified shores, they found no evidence that predation increased at the terminals. In freshwater, predation has been observed near overwater structures (Carrasquero 2001). Overwater structures provide cover for predators and prey, but predators have the advantage because complex habitat that juvenile salmonids need to avoid predators is missing (Barwick et al. 2004). In Lake Washington and the Ship Canal, salmonid predators such as smallmouth and largemouth bass can be found directly under piers (Tabor et al. 2004c, 2006).

In an experimental study of juvenile Chinook salmon, Kemp et al. (2005) found that juvenile Chinook salmon strongly avoided overwater cover. The fish responded to visual cues related to either the presence of an overwater structure or the area of darkness it created. Similarly, Tabor et al. (2006) watched schools of juvenile Chinook salmon as they migrated along the shores of Lake Washington. As the fish approached a pier, they altered their migration by heading out to deeper water where they either went under or swam around the pier, or on a few occasions, fish appeared to turn around and head in the direction from which they came. These changes in migration patterns may lead to increased energetic demands to the juveniles or increased risk of predation (Kemp et al. 2005).

In freshwater, overwater structure can increase the rate of predation on juvenile salmonids by 1) reducing prey refuge habitat by modifying the shoreline habitats that are critical in all predator-prey interactions; 2) providing concealment structures for ambush predators such as bass and sculpin; 3) creating enough artificial structure to reduce bass home range sizes; 4) providing artificial lighting that allows for around-the-clock foraging by predators; 5) potentially increasing migration routes for smolts and rearing fry, thus increasing exposure to predators; and 6) potentially increasing the bass population by increasing the amount of potential spawning habitat (Kahler et al. 2000).

Docks and piers are often associated with boat traffic. Boating impacts include impacts to submerged aquatic vegetation from prop wash, contamination from fuel discharges, erosion of shoreline due to increased wave action, and resuspension of bottom sediments and turbidity (Kelty and Bliven 2003). Docked boats can also increase light attenuation under the dock or pier, increase turbidity and physical disturbance from propeller wash, scour, and scarring if the propeller hits the substrate (Haas et al. 2002). Water quality impacts such as frequent exposure to petroleum, household cleaners, pesticide products as well as sewage increases with boat usage around docks and piers (Williams et al. 2003a).

Conservation Measures

To minimize, reduce or avoid overwater structure impacts, conservation measures will be implemented during overwater structure repair or replacement. These conservation measures include the following:

- Minimize/reduce pier and overall footprint of structure to reduce shading impacts
- Grating will be installed on more than 50% of the structure
- In marine waters, all piers and floats should be at least 4 feet (1.2 m) above marine vegetation at the MLLW elevation.

See Table 7-1 for corresponding construction methods and conservation measures for the effects of overwater structures.

7.1.1.7 Effects of Vactoring and Excavation

The potential mechanisms by which vactoring and excavation could affect listed fish species include direct mortality, injury by entrainment, sublethal effects (stress, gill damage, and increased susceptibility to disease), and behavioral responses (disruptions to feeding or migration) (Pacific International Engineering 2001). Long-term ecosystem effects of vactoring and excavation generally include changes in the volume and area of habitat, periodic changes to primary and secondary production (food web effects), and changes in hydrodynamics and sedimentology (Nightingale and Simenstad 2001b).

The following are biological effects to listed fish species from vactoring and excavation:

1. Temporary reductions in water quality from suspended sediment associated with vactoring and excavation could reduce or preclude foraging in the affected area
2. Temporary loss of benthic organisms and other prey due to disturbance of the sediment substrates
3. Potential exposure to contaminated sediments or water.

Water Quality

Vactoring and excavation will only occur within streams that are dewatered before removing any sediment. Therefore, vactoring and excavation will not impact water quality.

Within Puget Sound, fine sediment removal will create a sediment plume that may not disperse rapidly because of tidal fluctuations, especially during incoming tides. This could create poor water quality (i.e., decreased dissolved oxygen levels) that might preclude listed fish from accessing foraging and rearing habitat. Excavating activities disturb and suspend sediment, discoloring the water, reducing light penetration and visibility, and changing the chemical characteristics of the water. The size of the sediment particles and tidal currents are typically correlated with the duration of sediment suspension in the water column. Larger particles, such as sand and gravel, settle rapidly, but silt and very fine sediment may be suspended for several hours. Lasalle (1988) described a downstream plume that extended 900 feet (274 m) at the surface and 1,500 feet (457 m) at the bottom. Lasalle (1988) also noted a 70% increase in sediment levels as the bucket descended through the water.

Excavating effects on water quality (suspended sediments and chemical composition) can hurt salmonids. Suspended sediments can have an adverse effect on migratory and social behavior as well as foraging opportunities (Bisson and Bilby 1982, Sigler et al. 1984, Berg and Northcote 1985). Servizi (1988) observed an increase in sensitive biochemical stress indicators and an increase in gill flaring when salmonids were exposed to high levels of turbidity. Gill flaring allows the fish to create sudden changes in buccal cavity pressure, which is similar to a cough (see section *7.1.1.2 Effects of Sediment* above).

Chemical composition of the water with suspended sediments is also affected by excavating activities. Estuarine sediments are typically anaerobic and create an oxygen demand when suspended in the water column, which in turn decreases dissolved oxygen levels (Hicks et al. 1991, Morton 1976). A review of the processes associated with dissolved oxygen reduction (Lunz and LaSalle 1986, Lunz et al. 1988) suggested that dissolved oxygen demand of suspended sediment is a function of the amount of material placed into the water, the oxygen demand of the sediment, and the duration of suspension. The dissolved oxygen reductions appear to be most severe lower in the water column, and usually the condition reverses with adequate tidal flushing (LaSalle 1988). Most research to date indicates that excavating-induced dissolved oxygen reductions are short-term phenomena and do not cause long-term problems in most estuarine systems (Slotta et al. 1974, Smith et al. 1976, Markey and Putnam 1976).

Decreases in dissolved oxygen levels have been shown to affect swimming performance levels in salmonids (Bjornn and Reiser 1991). The decrease of swimming performance due to decreases in dissolved oxygen can be expected to affect the ability of salmonids to escape potential predation or could affect its ability to forage on motile fish. Lasalle (1988) found a decrease in dissolved oxygen levels from 16% to 83% in the mid- to upper water column and nearly 100% close to the bottom. Smith et al. (1976) found dissolved oxygen levels below 2.9 mg/l during excavating activities in Grays Harbor. Hicks (1999) observed salmon avoidance reactions when dissolved oxygen levels dropped below 5.5 mg/l.

Excavating can be conducted using mechanical equipment such as a barge-mounted crane fitted with a clamshell bucket or with an environmental bucket. An environmental bucket, which closes, vents and seals the bucket from leaking, causes very limited, short-term localized turbidity. No long-term effects would result from this turbidity.

Benthic Organisms

Vactoring and excavation will disrupt benthic habitat, temporarily eliminating benthic organisms and will reduce foraging opportunities for listed fish species. This may cause fish to migrate into deeper waters where there is greater vulnerability to predation or into habitat where there are fewer foraging opportunities.

Disruption of the channel bottom and entrainment by vactoring or excavation has a negative impact on benthic biota and forage fish. Removal of sediment in a stream physically disturbs the channel bottom, eliminating or displacing established benthic communities, thus reducing prey availability to salmonids or their forage species. Filter-feeding benthic organisms can suffer from clogged feeding structures, reduced feeding efficiency, and increased stress levels (Hynes 1970). Sediment removal may also suppress the ability of some benthic species to colonize a vactored or excavated area, thus resulting in loss of benthic diversity and food sources for prey species.

Contaminants

Sediment removal within Elliot Bay, Duwamish Waterway, and Lake Washington has the potential for short-term suspension of chemicals if excavation occurs in contaminated sediments. Very little information is known about the toxicity of contaminants to listed fish species. Preliminary work with freshwater toxicity levels indicates that they are sensitive to contaminants. Hansen et al. (2000) found effects to bull trout from cadmium as low as 0.089 µg/L, which is much lower than EPA's chronic water quality criterion of 0.9 µg/L. Collier et al. (2000) suggest that current sediment quality criteria (established by EPA) for PCBs, TBT, and PAHs for juvenile salmonids may be inadequate to prevent damaging their disease resistance, causing DNA damage, or reducing their prey base. Research by Hansen et al. (2000) has shown that measured LC50s for bull trout from cadmium and zinc were less than the national water quality criteria. Cook et al. (1999) demonstrated that bull trout were 3 times more sensitive to certain contaminants than lake trout using egg dose-dependent mortality data to 2,3,7,8-tetrachlorodibenzo-p-dioxin and PCBs. Although preliminary, most of the bull trout toxicity work has concluded there are effects to bull trout at levels lower than the existing water quality standards, and bull trout will be impacted by increases in contaminant levels in the water column. West et al. (2001) detected PCBs in 100 percent of rockfish collected in Sinclair Inlet and Elliott Bay. PCB correlations existed with the age of the rockfish. While no rockfish-specific PCB threshold is available, concentrations of PCBs found in rockfish exceeded concentrations shown to cause adverse sublethal effect in salmonids. Other effects of contaminants to listed fish are described above in section *7.1.1.5 Effects of Pile Removal*.

Conservation Measures

Conservation measures for vactoring and excavation are those that minimize sediment input into the stream (i.e., CSECP, minimizing heavy equipment and stream crossing sedimentation) and habitat degradation. See Table 7-1 for corresponding construction methods and conservation measures for the effects of vactoring and excavation.

7.1.1.8 Effects of Shoreline Hardening, Bank Stabilization, and Habitat Enhancement and Restoration Activities

Shoreline Hardening: Bulkheads

Bulkheads can have a variety of impacts on the aquatic environment due to construction, maintenance, or existence (Kahler et al. 2000). Some of these effects include:

- Temporary increases in turbidity associated with construction
- Disruption of migratory and rearing behavior of juvenile salmonids
- Removal of vegetation
- Reduction or elimination of sediment recruitment to the lake or shoreline
- Elimination of shallow-water habitat
- Reflection of wave energy along the shoreline that increases scour of sediment
- Permanent removal of woody debris.

These impacts result in numerous effects to salmonids and rockfish including reduced prey abundance, decreased habitat complexity, decreased shallow water, loss of vegetation, increased predation, increased chemical contaminates, and increased high energy environment (Kahler et al. 2000). Williams and Thom (2001) state that possibly the most significant effect of hardened shoreline stabilization is a direct impact to regional geomorphology via impoundment of potential natural sediment sources (Macdonald et al. 1994). Structures located above the natural beach grade can cut off sediment supply from a feeder bluff or upper beach. They will cause direct onsite impacts to habitat structure (e.g., shift to a lower elevation, higher energy, hard substrate shoreline), as well as indirect impacts within the coastal drift cells (Downing 1983).

The placement of hardened structures along natural shorelines can influence erosion processes that alter the structure and function of native habitats at areas both near and far from site of impact. This effect appears to be consistent throughout protected bay and estuarine habitats, as well as outer coast environments. For example, in a field survey of the entire developed ocean coasts of South Carolina, North Carolina, and New Jersey, Pilkey and Wright (1988) showed that dry beach width was significantly narrower in front of stabilized seawalls and areas with a higher degree of stabilization correlated to narrower beaches. Limited quantitative understanding of interactions between shoreline processes and hardening structures continues to fuel debate over the cumulative effects of shoreline armoring on beaches and adjacent properties (Pilkey and Wright 1988). However, most evidence suggests biological communities do respond locally to physical changes.

Structural modifications may directly alter shoreline geomorphology including tidal elevation relative to MLLW, gradient, channel characteristics (depth, width, cross-sectional area, sinuosity), and sediment character and quality. Geomorphology affects rates of tidal inundation and exchange, and is responsible for most of the distinguishing physical and chemical features of tidal systems. Placement of structures below the OHW mark often results in a permanent loss of habitat, reducing the availability and extent of intertidal foraging, spawning, and refuge areas. Changes in the physical composition and volume of substrates have predictable effects on biological resources (Macdonald et al. 1994, Dethier 1990, Thom et al. 1994). Long-term, chronic impacts may reduce intertidal habitat area, bottom complexity, and associated soft-bottom plant and animal communities.

Hardened shorelines with vertical or recurved slopes (like rock jetties) alter hydrology by deflecting wave energy downward, scouring the bottom sediment at the toe and periphery (Engineering Science 1981, Zabawa and Ostrom 1982). This ultimately results in elevation loss and habitat change. Added turbulence and scour may prevent vegetation establishment and alter the floral assemblage (Watts 1987, Thom 2002). Loss of sediment supply can erode beach profiles and lower the beach gradient. This change will result in loss or impairment of species and communities adapted for using higher elevations and particular substrates.

Hardened shorelines built below the MHHW line can steepen the natural shoreline, an effect created by the steep face of the structure, and can eventually, after several years, result in an increase in the mean water depth and a corresponding loss of the shallow, intertidal habitat preferred by juvenile salmonids as a migration and foraging corridor (Douglass and Pickel 1999). During periods of high tide, the water along the submerged face of the bulkhead will be deeper, with a steeper slope, than the shallow-water habitat found along a natural, gradually sloping beach.

Over time, shoreline hardening is expected to alter the physical characteristics of beach and nearshore biotic communities. These changes in turn can alter distribution and abundance of fish within the action area.

Bank Stabilization

Bank stabilization techniques in a dynamic river environment reduce the potential for channel complexity by limiting channel migration and recruitment of large woody debris and gravel. Rivers continuously transport eroded material downstream from areas of erosion to areas of deposition. Transport varies with discharge and is therefore episodic (Kondolf 1994). Armoring streambanks limits lateral channel changes and gravel recruitment (Schmetterling et al. 2001).

Bank hardening may also sequester onsite gravel sources from capture by the active river system and cause downcutting due to increased flow velocities. Downcutting may extend well upstream or downstream, and result in the perching of historic depositional gravel layers above the OHW, thereby reducing gravel capture rates within the system.

A net loss of gravel recruitment to the system may ultimately result in the loss of sufficient gravels to support successful salmon spawning. The cumulative effect of gravel isolation may lead to the loss of enough sources that the waterway becomes gravel-limited. Overall, streambank stabilization will reduce the potential for side channel formation and lateral channel migration in the floodplain, which are natural processes contributing to habitat complexity. These processes contribute to undercut banks and overwater cover that help provide important summer habitat for salmonids (Brusven et al. 1986, Beamer and Henderson 1998).

The placement of riprap above and below the OHW will permanently degrade the streambed substrate in streams within the action area. Placement of riprap on top of the streambed may injure or kill Puget Sound Chinook salmon, bull trout, and/or steelhead juveniles that hide in interstitial spaces. Riprap installation results in the following:

- Removal of native sediments
- Installation of different sized sediments (riprap)
- Reconstruction (stabilization) of the streambank slope.

Such activities can be characterized as channelization. Bolton and Shellberg (2001) describe channelization as the deliberate or indeliberate alteration of one or more of the interdependent hydraulic variables of slope, width, depth, roughness or size of sediment load. Thus the effects of the habitat alteration related to the installation of riprap can be evaluated as channelization.

Channelization has immediate and direct effects on stream processes because it involves direct modification of the river channel. These effects result in both physical and biological changes that lead to various alterations of biological systems. The changes affect benthic macroinvertebrates, fish, and aquatic riparian vegetation from algae and macrophytes to riparian shrubs and trees.

A typical sequence of events that occurs after the placement of a channelization activity leads to immediate changes in physical aspects of the channel. These physical changes lead to longer-term biotic responses that extend over space and time (Simpson et al. 1982 in Bolton and Shellberg 2001). The biological effects may be in response to the physical changes in depth, shade, sediment temperature, altered hydrology, isolation of floodplain habitats, etc. Or they may be in response to changes in nutrient cycling and changes in population of various trophic (nutrition) levels that get transmitted throughout a biological system. Streamflow, stream velocity, channel morphology, vegetation and channel substrate are all affected by channelization activities. The physical nature of stream channels reflects a continuous readjustment of the interrelated variables of discharge, slope, channel width and depth, flow velocity, channel roughness and sediment characteristics (Brookes 1988).

Some studies have looked at the biological effect of specific structures and bank stabilization techniques, such as riprap, spur dikes, and revetments. Hjort et al. (1984) looked at fish and invertebrates along revetments and natural channel areas of the Willamette River, Oregon. They found different numbers and species of fish and invertebrates in natural stream areas compared with riprap banks. Fewer fish species used riprap areas than used natural areas. Fish found in revetment areas tended to be ones that fed on algae or diatoms growing on the stones or fed on bottom-dwelling invertebrates. Invertebrates found in the revetments were species that preferred a very stable bottom and either clung to stones or hid in crevices. More fish species were found in areas with natural banks due to the greater diversity of habitat in these areas.

Li et al. (1984) compared larval, juvenile and adult fish use of natural and channelized habitats in the Willamette River, Oregon. They concluded that continuous revetments are not good larval fish habitat. The combination of proximity to fast water, steep bank slopes, greater water depth, and cooler temperatures does not provide suitable habitat for larval fish. Spur dikes have a greater diversity of habitats than continuous revetments and appear to be intermediate in habitat quality between natural banks and continuous revetments. Low-angle beaches that develop between spur dikes can provide good larval fish habitat. Natural banks have the greatest diversity of habitats within secondary channels, fast and slack water areas and backwaters. And, as expected, natural banks have the most diverse fish species composition.

Peters et al. (1998) looked at seasonal fish densities in Washington at sites with various bank stabilization structures. They conducted a survey of typical bank stabilization methods and found that 496 of 667 projects used riprap or riprap with deflectors. Only 29 projects used bioengineering or large woody debris. Of all project types (riprap, riprap with large woody debris, rock deflectors, rock deflectors with large woody debris and large woody debris) they surveyed, only sites stabilized with large woody debris consistently had higher fish densities in spring, summer and winter than the control sites without any stabilization structures. Riprap sites consistently had lower densities than control sites. At all sites, fish densities were generally positively correlated with increasing surface of large woody debris and increasing amounts of overwater riparian cover with 12 inches (30 cm) of the water surface.

The effects of streambank alteration are not limited to the wetted stream channel itself. Connectivity longitudinally (up and downstream), laterally (floodplain and uplands) and vertically (groundwater, hyporheic, and phreatic) are major features of stream corridors (Stanford and Ward 1992). The temporal nature of the system adds a fourth dimension (Ward 1989). These linkages mean that the effects of channelization can be transmitted over areas far beyond an actual work zone. Impacts include changes in hydrology, biology, morphology, and water quality (Brookes 1988).

Lateral connectivity is altered by channelization activities including dredging and filling, channel lining, and bank stabilization. The cessation of overbank flooding and the flood-pulse (Junk et al. 1989) effect is suspected to decrease floodplain productivity and biodiversity (Bayley 1995).

Longitudinally, connectivity is most clearly affected by diversion structures that either store or remove water, sediment, and nutrients from the river (Ward and Stanford 1995).

Diversions can have a significant effect on the quantity and timing of flow in the river, water temperature, and sediment and nutrient loads (e.g., Lillehammer and Saltveit 1984, Ligon et al. 1995).

Many observations indicate that downstream flooding is a common—but not inevitable—response to channelization. If the channelization decouples the timing of peak flows merging at confluences, downstream flooding may be decreased. Draining and filling of wetlands and swamps in floodplains reduces the storage capacity of the system and leads to more downstream flooding (Brookes 1988).

Onsite effects of channelization typically increase channel slope and water velocity. As a result, more sediment is eroded and transported downstream where it is deposited in areas that have not had transport capacity altered. Morphologically, this leads to incision or widening of the channel onsite and aggradation (filling) of the channel downstream when the sediment is deposited.

Water quality effects are highly site-specific. They are controlled by watershed land use, extent of channelization, and length of the recovery period (Brookes 1988). Shields and Sanders (1986) reviewed studies on the effects of excavation and diversion on water quality. They found water quality changes were due to increased sediment inputs and decreased shade. Most of the measured water quality parameters increased by 50% to 100% during construction compared with pre-construction values. Little (1973) reported that during and after channelization, large amounts of suspended sediments are typically released and deposited downstream where they adversely affect aquatic life. If the channelized reach is very long, reduced shade may increase temperatures downstream (Duvel et al. 1976). Few studies have directly addressed the effects of channelization on water quality components such as oxygen, nutrients, and ions (Brookes 1988).

Typically, changes due to human activities in the channel migration zone reduce habitat diversity, which affects the numbers and kinds of animals the habitat can sustain (Schneberger and Funk 1972, Hahn 1982, Simpson et al. 1982). As the physical habitat changes, stresses are placed on individual plants and animals. These stresses—depending on the tolerance of the species and individual—may limit growth, abundance, reproduction, and survival (Lynch et al. 1977). Biologically important parameters that change following channel activities include water temperature, turbidity, flow velocity, variable water depths, hydrologic regime, a decrease or change in vegetation, changes in storage of organic matter and sediment, and changes in the size and stability of channel substrate (Hahn 1982). These changes can decrease habitat connectivity and the exchange of energy and matter between habitats. The direction of change varies by site and circumstance. Specific structures proposed to be installed and potential impacts to listed fish are shown in Table 7-10:

Table 7-9. Typical structures for bank stabilization

Structure	Function	Effect
Groins and/or barbs	Roughness elements that extend from the bank into the water to direct flow away from an eroding bank. Groins and barbs are similar except groins are larger and tend to deepen and narrow the stream.	Groins and barbs direct water away from one side of a stream to the opposite side which can increase bank erosion, thus increasing the need for additional bank stabilization methods.
Structure	**Function**	**Effect**
Drop structures and porous weirs	Low-elevation weirs that span the entire width of the channel designed to spill and direct flow away from an eroding bank, dissipate energy and provide grade stabilization. Drop structures are not porous and are usually constructed with logs or concrete.	Drop structures not installed correctly may result in increased scour downstream of the structure that may create a fish passage barrier. A fish barrier may also result if the upstream-to-downstream water surface elevation is excessive.
Log toes	Structural features that prevent erosion at the toe of a streambank. Log and rootwad toes provide a natural approach to toe protection.	They are very effective at controlling bank erosion, but can also increase water velocities that can result in further downstream erosion. As with most hardened bank structures, log toes result in lost opportunities for sediment supply and recruitment of large woody debris.
Coir logs	Long, sausage-shaped bundles of coir (coconut fiber), bound together with additional coir or synthetic netting. They provide biodegradable stabilization to streambanks.	They decompose over 7 to 12 years and provide good moisture-retention properties. Coir logs are also placed on top of streambanks on exposed soils to control sediment input into streams.
Riprap	Bank armoring consisting of rock for controlling bank erosion. Riprap is very effective at controlling bank erosion but results in a permanent lost opportunity for sediment and large woody debris recruitment.	Riprap has very little aquatic-habitat value or cumulative effect on channel forming processes. Riprap tends to increase water velocities downstream, which results in increased bank protection measures.

Habitat Enhancement and Restoration Activities

Large Woody Debris. Installing large woody debris into bank stabilization and habitat enhancement and restoration project designs will provide shade, cover, and contribute to habitat complexity. Large woody debris is central to determining channel morphology and biological condition in many Pacific Northwest streams (Spence et al. 1996). Pool formation, gravel and organic material retention, velocity disruption, and cover for fish from predators are all strongly reliant on large woody debris. Other than natural mortality, sources of large woody debris recruitment to streams include bank erosion, blow down, and transport from upstream (Gurnell et al. 1995). The replanting of native vegetation provides a future source of large woody debris recruitment.

Boulders and Boulder Clusters. Boulders and boulder clusters increase and restore structural complexity, hydraulic diversity, and fish habitat. Placement of boulders and boulder clusters creates a diversity of water depth, substrate, and velocity. Boulders confine and direct flow, creating bed and bank scour and depositing sorted bed material that provides cover and spawning habitat (WDFW 2004).

Depending on the design, spacing, and location of boulders, they may have a backwater effect on the upstream reach of the channel. This backwater effect can cause upstream deposition, and possible increase in a floodwater state. If not properly designed and installed, increased bank erosion may occur.

Boulder placements typically pose a low risk to existing habitat. Potential impacts would include temporary loss of habitat value associated with sediment movement and depositions through scour and slower water velocities. If upstream backwater effects occur resulting in sediment deposition, sediment may need to be excavated to obtain the desired effects of boulder installation.

Weirs or Groins. Groins are large roughness elements that project into the channel of a stream from the bank and extend above the high-flow, water-surface elevation. The main function of a groin is to redirect flow away from a streambank to reduce flow velocities near the bank to increase sediment deposition. Barbs are similar to groins except they are not as high profile and have less effect on the cross-section shape of the stream (WDFW 2003).

Weirs are low-elevation structures that span the entire width of the stream channel. Two main types of weirs are 1) drop structures and 2) porous rock weirs. Drop structures are designed to create substantially more backwater. They can be constructed with rock, logs, sheet piles, or concrete. Porous weirs are constructed of loosely arranged boulders that redirect flows away from the bank and toward the center of the channel.

Groins and barbs constrict the channel by blocking a portion of the channel. This can increase erosion on the opposite bank as the water is pushed toward that side of the stream. Groins and barbs also push the thalweg of the stream away from the bank. This may result in downstream channel adjustment and increased erosion of the stream substrate or banks. Groins and barbs prevent channel migration, which reduces sediment and large woody debris recruitment into the stream. Existing spawning habitat may be lost due to increased erosional forces as the channel is constricted and the thalweg is pushed away from the bank. Incorporating large woody debris into groins and barbs will minimize these effects.

Drop structures are designed to spill and direct flow away from an eroding bank, dissipate and redistribute energy, and provide grade stabilization. Drop structures constrict flows to a specific location in the channel that creates a scour hole, plunge pool at the constriction point. If not properly installed, a fish barrier may result from the difference in surface elevations. Existing spawning habitat may be lost due to installation of drop structures, but some spawning habitat may be formed by sediment deposition at the downstream portion of the plunge pool.

Porous weirs are similar to drop structures but are not as rigid and are designed to have spaces between the boulders to allow fish and sediment to pass through the structure. Porous weirs are designed to redirect flow away from the bank and to provide channel roughness. Redirection of flow is caused by constricting flow between boulders, which increases erosive forces downstream and sediment transport. Porous weirs may affect spawning habitat similarly to drop structures.

Conservation Measures

Numerous conservation measures will be incorporated into shoreline and nearshore habitat modification and bank stabilization projects. Conservation measures incorporated into projects are intended to create salmonid and/or prey species habitat or decrease hard bank and shoreline structures. The main conservation measures include:

- Reduce sediment input into the stream
- Avoid fuel/oil contamination of the site from equipment operation
- Reduce bulkhead impacts by removing the bulkheads from the water and installing them behind the OHW or the MHHW line.
- Increasing habitat complexity around the bulkheads with large woody debris, cove installation, and riparian vegetation.
- Increasing habitat complexity in riprap by including large woody debris, and filling interstitial spaces with habitat mix.

See Table 7-1 for the construction methods and conservation measures for the effects of shoreline hardening, bank stabilization and habitat enhancement and restoration.

7.1.1.9 Culvert Replacement

The overall impact of a proposed culvert project on listed fish species is expected to be beneficial because it will restore spatial and temporal connectivity of waterways within and between watersheds where movement is currently obstructed. Connectivity will permit listed fish species to access areas critical for fulfilling life-history requirements, especially foraging, spawning and rearing.

The constricted flows at culverts or bridges are largely due to poor installation or undersized structures. In many instances high water velocities amplified by undersized culverts have created large scour pools at the culvert discharge point, altering the stream elevation below the natural gradient. Over time, culverts become elevated above the stream and create a physical barrier to fish passage. In other cases, water also drains under and around culverts, and migrating fish attempting to follow these flows can become stranded or impinged against the culvert or road fill.

In addition to allowing for fish passage for all age classes, the replacement or removal of fish-blocking culverts should result in more naturally maintained stream hydraulics, including bedload movement, sediment transport, and passage of moderately-sized woody debris, leading to more natural stream dynamics and stream geometry. The new structures should result in fewer maintenance needs and better performance during high precipitation events, resulting in near-normal sediment and bedload movement and debris conveyance.

Each culvert replacement will also include restoration of the streambed within and immediately downstream and upstream of the culvert. Stream restoration will include the placement of large woody debris, boulders, and spawning gravels with the goal of increasing habitat complexity of the aquatic environment currently lacking at many culvert sites. Placement of these materials should aid in improving the habitat value for listed fish species and their prey species.

With the onset of fish removal and construction activities, listed fish species will experience short-term adverse affects due to fish removal and relocation procedures before or along with stream dewatering and isolation of the project work area. This will disrupt normal fish behavior and in some instances, cause mortality. Construction impacts will have localized effects to the riparian corridor. The effects of sediment to the aquatic environment during construction are expected to be minimal due to the construction occurring in dewatered streams and other sediment control measures being implemented at each construction site. However, rain during and after construction will likely mobilize sediment into the stream, even with sediment control measures in place, because those measures are not always effective at precluding sediment deposition into streams (Rashin et al. 1999).

Sedimentation and turbidity will occur from heavy equipment operation on access roads and excavation/fill areas by exposing, destabilizing, and/or compacting streambanks, streambeds, and riparian soils. Access roads will be built from the existing road to the stream in a direct line to the stream diversion and discharge point or to the structure, as needed. Heavy equipment operation in streambeds will only occur during dewatered periods. Additional sedimentation may occur from excavating the roadfill (above the wetted perimeter), backfilling, clearing and restoring the riparian area, maintenance, and repairing streambeds following high-flow events.

After construction, periodic spikes in sediment input are expected during the first winter season in response to precipitation events that may mobilize unstable sediments from upland locations. Sedimentation may also occur throughout the site recovery period until fill slopes stabilize.

See Table 7-1 for construction methods and conservation measures for the effects of culvert replacement.

7.1.1.10 Effects of Boating Activity

Adding or improving boat launches, docks, and piers may increase levels of boating activity. Boating activities can cause several impacts on listed salmonids and aquatic habitat. For example, the following can occur with boating (Mueller 1980, Asplund 2000):

- Engine noise
- Prop movement
- Physical presence of boat hulls may disturb or displace nearby fish.

Boat traffic increases the following:

- Turbidity and up-rooting of aquatic plants in shallow waters
- Aquatic pollution (through exhaust, fuel spills, or release of petroleum lubricants)
- Shoreline erosion.

These boating impacts affect listed fish several ways. Turbidity may injure or stress fish. The loss of aquatic macrophytes may expose salmonids and rockfish to predation, decrease littoral productivity, or alter local species assemblages and trophic interactions. Despite a general lack of data specifically for salmonids and rockfish, pollution from boats is thought to potentially cause short-term injury, physiological stress, decreased reproductive success, cancer, or death. Further, pollution may also affect fish by impacting potential prey species or aquatic vegetation. Shoreline erosion can change hydraulic flow patterns, increase sedimentation and turbidity, reduce aquatic and riparian vegetation, and steepen bank and nearshore gradient.

See Table 7-1 for construction methods and conservation measures for the effects of boating activity.

7.1.1.11 Effects of Pesticides

While there is a healthy volume of literature regarding pesticide effects to aquatic species, in some cases, data are lacking for a specific pesticide on particular salmonid and rockfish species and their prey, including diverse life-stages. 'Pesticides' in this document refer to all chemicals used to control unwanted insects (insecticides), weeds (herbicides), or other activity such as killing roots in pipes. No chemical fertilizers are used to establish plant restoration.

Pesticide Application

The application of pesticides in proximity to Puget Sound, lake and river systems can result in the transport of potentially toxic chemicals (active ingredients or adjuvants) to surface waters (USGS 1999) that may harm ESA-listed species. Pesticides can impair the essential biological requirements of salmonids and rockfish if they undermine the physical, chemical, or biological processes that collectively support a productive aquatic ecosystem (Preston 2002) or affect the physiological or behavioral performance of salmonids and rockfish in ways that will reduce growth, survival, migratory success, or reproduction.

The degree, or likelihood, of effects to ESA-listed salmonids rockfish from the discharge of pesticides to surface waters vary spatially and temporally, according to factors that have been simplified into the following categories:

1. Likelihood of Exposure. If listed fish do not occupy habitat that has been chemically modified, the likelihood of effects could be limited to loss of prey base.
2. Water Quality Conditions. Dissolved oxygen levels and temperature affect salmonids and rockfish susceptibility to pesticide exposure.
3. Lifestage of the Salmonid. Salmonids occupy freshwater as incubating eggs/alevins, newly emerged fry, and rearing parr and smolts, and as returning adults. Each lifestage has a different susceptibility or tolerance of exposure to pesticides.
4. Levels of other Contaminants. Concurrent discharge or background levels of other contaminants can magnify effects through mixture toxicity resulting from discharges associated with the use of the chemical.
5. Concentration and relative toxicity of the chemical.

Pesticides can impair the essential biological requirements of salmonids and rockfish if they undermine the physical, chemical, or biological processes that collectively support a productive aquatic ecosystem (Preston 2002). The alteration of watershed characteristics by pesticides can include: 1) disruption of the growth of riparian deciduous vegetation, 2) reduction of delivery of leaves and intermediate-sized wood, and 3) alteration of hydrologic and sediment delivery processes (Spence et al. 1996). Moreover, aquatic plants and macroinvertebrates are generally more sensitive than fish to the toxic effects of pesticides. The application of pesticides can affect the productivity of the stream by altering the composition of benthic algal communities, the food source of macro-invertebrates. Benthic algae are important primary producers in aquatic habitats, and are thought to be the principal source of energy in many mid-sized streams (Minshall 1978, Vannote et al. 1980, Murphy, 1998). Pesticides, specifically herbicides, can directly kill algal populations at acute levels or indirectly promote algal production by increasing solar radiation reaching streams by disruption of riparian vegetative growth. The disruption of riparian vegetative growth carries with it other consequences for salmonid habitat, such as loss of shade, bank destabilization, and sediment control. Therefore, pesticides can potentially impact the structure of aquatic communities at concentrations that fall below the threshold for direct impairment in salmonids. The integrity of the aquatic food chain is an essential biological requirement for salmonids, and the possibility exists that pesticide applications will alter the productivity and watershed characteristics of streams and rivers.

Pesticides can cause significant shifts in the composition of benthic algal communities at concentrations in the low parts per billion (Hoagland et al. 1996). Based on the data available, pesticides have a high potential to elicit significant effects on aquatic microorganisms at environmentally relevant concentrations (DeLorenzo et al. 2001). In many cases however, the acute sensitivities of algal species to pesticides are not known. In addition, Hoagland et al. (1996) identify key uncertainties in the following areas: 1) the importance of environmental modifying factors such as light, temperature, pH, and nutrients, 2) interactive effects of pesticides where they occur as mixtures, 3) indirect community-level effects, 4) specific modes of action, 5) mechanisms of community and species recovery, and 6) mechanisms of tolerance by some taxa to some chemicals. Pesticide applications have the potential to impair autochthonous (indigenous) production and, by extension, undermine the trophic (food) support for stream ecosystems.

Prey Base Effects and Bioaccumulation

It is becoming increasingly evident that the indirect effects of contaminants on ecosystem structure and function are a key factor in determining a toxicant's cumulative risk to aquatic organisms (Preston 2002). Adverse effects to salmonid and rockfish prey base can occur from exposure to some substances. Aquatic plants and macroinvertebrates are generally more sensitive than fish to the acutely toxic effects of pesticides. Therefore, chemicals can potentially impact the structure of aquatic communities at concentrations that fall below the threshold for direct biological impairment in salmonids and rockfish. The integrity of the aquatic food chain is an essential biological requirement for salmonids and rockfish, and the reasonable likelihood pesticide applications will reduce the productivity of Puget Sound, lakes, streams and rivers is a significant effect.

Pesticide effects to salmonid and rockfish prey base typically occur through 2 primary mechanisms: 1) effects to the amount and/or type of food supply, or 2) by exposure via food organisms. Depending on the exposure scenario, effects to aquatic invertebrate communities can be very short-term, or take months or years to fully recover. Exposure via food organisms is likely to be much more episodic and short-term. Norris et al. (1991) provide a summary and literature review of pesticide effects to salmonids. The amount and/or type of food supply can be altered by pesticides in complex and subtle ways, particularly if the aquatic system is exposed to a combination of pesticides.

Pesticides can alter the prey base by direct mortality of aquatic invertebrates (Beschta et al. 1995). Pesticides can cause direct mortality of aquatic invertebrates, or trigger extensive drift of aquatic invertebrates out of the affected area (Spence et al. 1996). If grazing invertebrates are reduced or eliminated from a stream reach, primary production release may occur (such as algal blooms), altering trophic structure.

Pesticides are often not highly toxic to salmonids, as they are generally designed to interfere with physiological systems unique to plants. However, low concentrations of pesticides may exert significant effects on salmonid prey items by affecting algal or aquatic plant communities (Pratt et al. 1997), or directly on salmonids through sublethal effects of the pesticide (Spence et al. 1996). In addition, some pesticides, such as triclopyr esterare, are moderate to highly toxic to aquatic invertebrates (SERA 2003), and adjuvants and surfactants present in pesticide commercial formulations can greatly enhance toxicity (SERA 1997, Stark and Walthall 2003).

Salmonid and rockfish pesticide exposure through food organisms can occur through incidental exposure of terrestrial insects that subsequently become prey items for fish (Norris et al. 1991), or indirectly through invertebrate ingestion of organic material delivered to the aquatic system (Urban and Cook 1986). Pesticides that are more lipophilic (fat soluble) will tend to partition into organic material in or on soil. Runoff can mobilize organic material into Puget Sound and streams where it is consumed by insects and crustaceans. Little data are available on the risk of exposure via this pathway, but risk is likely to be highly variable depending on conditions at the time of application, such as seasonal timing.

Bioaccumulation in fish is partially mediated by the presence of pesticides in food items and sediment residues, but also includes bioconcentration, defined as passive uptake from the water column (Klaassen et al. 1986). The lipophilicity of the pesticide and fat content of the organism are the primary factors determining the extent of bioaccumulation. Pesticides with high lipophilicity tend to partition out of the water column and into food items, with the degree of partitioning proportional to the organism fat content. Concentration up the food chain (biomagnification) occurs when repeated exposure through consumption of contaminated prey items results in high concentrations of pesticides in predators, such as salmonids. For bioaccumulation to occur, a pesticide must have sufficient lipophilicity and persistence, and relatively low acute toxicity.

The possibility exists of effects from additive, antagonistic or synergistic effects from multiple applications. The relative risk of these types of effects depends on the volume and timing of their delivery, and background water quality conditions. Within the zones of possible exposure periods described above, the greatest likelihood of additive/synergistic effects from applications would occur anytime precipitation causes significant subsurface or overland flow delivery to aquatic systems. The volume and types of pesticides delivered would depend on the relative success of the pesticide to inhibit off-target delivery. As precipitation levels rise, subsurface and overland flow will increase, thus pesticide delivery to nearby streams is reasonably likely to occur.

Conservation Measures

Conservation measures included during pesticide application are intended to minimize improper application. A licensed applicator must oversee that pesticides are being applied properly. In addition, pesticides must be used for the intended purpose of killing, removing, or controlling unwanted species. See Table 7-1 for corresponding construction methods and conservation measures for the effects of pesticides.

7.1.2 Killer Whales and Steller Sea Lions

7.1.2.1 Effects of Pile Driving

As with Chinook salmon, bull trout, and steelhead, pile driving and its associated SPLs can injure and affect the behavior of killer whales and Steller sea lions. In-water construction activities, specifically pile driving, may result in elevated sound levels that can affect killer whales and Steller sea lions by causing actual injury, which may result in temporary or permanent hearing loss. NMFS is currently (2011) developing comprehensive guidance on sound characteristics likely to cause injury and behavioral disruption to listed marine mammals.

For in-water acoustic thresholds, the injury threshold is 190 dB_{rms} for Steller sea lions and 180 dB_{rms} for killer whales. The behavioral threshold for impulsive noise (e.g., impact pile driving) is 160 dB_{rms} and for non-pulse noides (e.g. vibratory pile driving) is 120 dB_{rms}. The 120 dB_{rms} threshold may be adjusted if background levels are at or above this level. In-air acoustic thresholds have also been determined. There is no threshold for injury. The in-air behavioral threshold for all types of disturbance is 200 dBrms for Stellar sea lions. See NMFS' website for most current information (http://www.nwr.noaa.gov/Marine-Mammals/MM-consults.cfm).

Sound can also disrupt important biological functions. Killer whales use sound underwater for important life functions that include communicating, finding prey, and navigating. The intensity and persistence of certain sounds (both natural and anthropogenic) in the vicinity of the whales has the potential to interfere with these important biological functions. For instance, the constant production of anthropogenic sound in frequencies that overlap those of biological significance to whales has the potential to mask acoustic signals the species rely upon. It is well documented that killer whales use sound for echolocation (hunting, navigating) and when communicating (Dahlheim and Awbrey 1982, Ford 1989, Barrett-Lennard et al 1996, Ford et al 2000). To accomplish these functions, whales use a wide range of frequencies and have well developed hearing across a broad frequency range of from 1 to 120 kHz or more. Their hearing is most sensitive in the range of 18 to 42 kHz, with peak sensitivity at 20 kHz (Szymanski et al 1999).

The potential for disturbing killer whale and Steller sea lion movements and behavior in Elliott Bay and Puget Sound will be greatly reduced by the suspension of in-water pile driving activities when marine mammals are present in the vicinity.

Conservation Measures

An active monitoring program and a protocol to suspend pile driving if marine mammals enter the vicinity is a conservation measure under the Seattle Biological Evaluation (see CM #53 in **Section 4, Conservation Measures**). CM #53 will provide a reasonable degree of certainty that killer whales and Steller sea lions are not exposed to high intensity sound from pile driving at levels that may cause behavioral disruption.

7.2 Effects of the Action on Critical Habitat

7.2.1 Puget Sound Chinook Salmon Critical Habitat

Critical habitat for Puget Sound Chinook salmon within the City of Seattle action areas is limited to the nearshore of Puget Sound, Lake Washington, the Ship Canal, and the Duwamish River. No streams, other than the Duwamish River, are designated as critical habitat. This section describes the effects of the actions (see Table 7-1) on the Primary Constituent Elements (PCEs) present within the action areas. PCEs are physical or biological features that are essential to the conservation of the species. There are 6 Chinook salmon critical habitat PCEs. See **Section 5, Status of the Species**, for a description of each PCE:

- Puget Sound Chinook Salmon PCE #1: Freshwater spawning sites
- Puget Sound Chinook Salmon PCE #2: Freshwater rearing sites
- Puget Sound Chinook Salmon PCE #3: Freshwater migration corridors
- Puget Sound Chinook Salmon PCE #4: Estuarine areas
- Puget Sound Chinook Salmon PCE #5: Nearshore marine areas
- Puget Sound Chinook Salmon PCE #6: Offshore marine areas.

Within each of these PCEs are certain features or elements that are required to support the biological processes for which Chinook salmon use the habitat. Some of these features or elements include water quantity and quality, natural cover, floodplain connectivity, and lack of obstructions.

7.2.1.1 Puget Sound Chinook Salmon PCE #1: Freshwater Spawning Sites

This PCE is not found within the Seattle action areas. Thornton Creek does contain Chinook salmon freshwater spawning sites, but it is not designated critical habitat.

7.2.1.2 Puget Sound Chinook Salmon PCE #2: Freshwater Rearing Site

Freshwater rearing sites require the following features:

- 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
- 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.

Juvenile Chinook salmon migrating to Puget Sound rear and forage in Lake Washington and the Ship Canal. Most juvenile Chinook salmon use the lake for 1 to 5 months before outmigrating through the Locks. While rearing in Lake Washington, juvenile Chinook salmon are shoreline oriented, using shallow water areas. As juveniles reach a larger size, they disperse to deeper water and begin migration towards the Locks.

Water Quantity

Within the Seattle action areas, designated critical habitat PCE #2 for water quantity relies on upstream influences. Lake levels for Lake Washington and the Ship Canal are controlled by the Locks and are not allowed to fluctuate by more than 2 feet. Inflow to Lake Washington comes from 2 major tributaries, the Sammamish and Cedar rivers. Numerous smaller tributaries also provide water into Lake Washington including Thornton and Taylor creeks. Flows in the Lower Green/Duwamish River are controlled by Howard Hansen Dam.

No proposed projects will remove water from Lake Washington or the Ship Canal. Water quantity will not be reduced by proposed projects. The projects covered under this Seattle Biological Evaluation are tasks that will not be large enough to change the hydrologic regime of Lake Washington, the Ship Canal, or the Duwamish River.

Floodplain Connectivity

No designated critical habitat within the Seattle action areas contains freshwater rearing sites with floodplain connectivity. The Ship Canal is highly urbanized with bulkheads, docks, piers, and other shoreline structures built to protect the commercial infrastructure of the area. The water level in the Ship Canal is controlled by the Locks and fluctuates 2 feet throughout the year. The lowest water level occurs in December and the highest in May. Because of this infrastructure, no floodplain connectivity currently exists. Future project designs may involve increasing shallow water and riparian habitat that could provide some, but minimal, floodplain function, but without huge economic costs, increasing floodplain connectivity would not be feasible.

Water Quality

Water quality within Seattle's designated critical habitat PCE #2 varies with each action area (see *6.1.1, 6.2.1, 6.3.1,* and *6.4.1 in* **Section 6, Environmental Baseline**). Although Lake Washington is highly urbanized, its water quality is very good. This is due to the high quality of water entering the lake as well as the removal of wastewater that entered the lake until the 1960s. Localized water quality problems such as elevated concentrations of metals, bacteria, nutrients, and organic compounds have been found near major stormdrain and combined sewer overflows during storm events.

Water quality in the Ship Canal is generally good due to the high quality of inflowing water from Lake Washington. However, the Ship Canal experiences seasonal temperature and dissolved oxygen problems, as well as occasional problems with fecal coliform bacteria levels. See section *7.2.1.3 Puget Sound Chinook Salmon PCE #3: Freshwater Migration Corridors*.

Construction activities for the proposed projects may result in temporarily decreased water quality. In-water activities, clearing and grubbing, and other bank or shoreline activities will result in short-term increased sediment plumes that may last less than 2 hours. Use of heavy equipment and other construction vehicles poses a risk of petroleum products spilling into the water. Riparian vegetation removal will result in increased sediment input and decreased shade, which can increase water temperatures. Removal of riparian vegetation results in a longer term impact (5 to 10 years) to water temperatures as new vegetation gets established and grows to a size to shade the stream.

Projects that remove creosote-treated timber piles by either full extraction or breaking off the piles at or below the mudline will result in temporary suspension and a long-term increase in creosote-contaminated sediments within the project area.

Forage and Prey Base

Puget Sound Chinook salmon in Lake Washington are opportunistic feeders, consuming a wide variety of prey items and switching quickly to an abundant prey source. In Lake Washington, 2 major prey resources are chironomids and zooplankton. Chironomids are extremely abundant in the nearshore areas of Lake Washington throughout most of the year and zooplankton become abundant in the summer.

Projects along the shoreline of Lake Washington and the Ship Canal that involve the installation, replacement, or maintenance of bulkheads, piers, or hardened shoreline structures will result in simplified shoreline habitat that will reduce forage and prey base species for Puget Sound Chinook salmon. Habitat features such as large woody debris and increased shallow water habitat and riparian vegetation will increase juvenile shallow water rearing habitat.

Natural Cover

Designated critical habitat in the action areas contains very little natural cover. Lake Washington and the Ship Canal are highly urbanized with bulkheads, docks, piers, and other shoreline structures. Large woody debris and other restoration activities to minimize or offset effects associated with hardened shorelines and over-water structures are utilized as much as possible. Within designated critical habitat in Lake Washington, future projects will improve natural cover by placement of large woody debris, removal or set-back of bulkheads, and increasing shallow water habitats.

7.2.1.3 Puget Sound Chinook Salmon PCE #3: Freshwater Migration Corridors

Freshwater migration corridors must be free of obstruction and offer 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.

Water Quantity, Water Quality and Natural Cover

These are discussed above in section *7.2.1.1. Puget Sound Chinook Salmon PCE #2: Freshwater Rearing Site.*

Obstructions and Barriers

Currently, the only permanent obstruction or barrier to Puget Sound Chinook salmon within the action areas is the Locks within the Ship Canal. The Locks divide the marine and freshwater habitats in the Ship Canal. Passage is possible through the Locks via the fish ladder, large lock, small lock, the saltwater drain, and the smolt passage flumes. Adult salmonids migrating to freshwater primarily pass via the fish ladder and the 2 lock chambers. Juveniles are thought to primarily pass via the smolt passage flumes.

Water temperatures in summer and early fall may be too high and may impede fish migration in Lake Washington and the Ship Canal. Water temperatures along the Ship Canal and in south Lake Union range from 60.8º to 73.4º F (16º to 23º C) between June and September (see Section 6.2.1). In addition, dissolved oxygen regularly drops below 6 mg/L during the summer months when the water temperatures are above (68º F to 70º F [20º C to 21º C]).

Water temperatures in the Duwamish River have increased in the past couple of years with temperatures in the summer exceeding 64º F (18º C). High temperatures and low dissolved oxygen can impede juvenile and adult migration through the area.

Docks, both large and small, and other overwater structures are present along the shorelines of Lake Washington and the Ship Canal. These structures may inhibit juvenile salmonids migrating along shallow-water habitats, but have not been found to impede migration. Tabor et al. (1996) found that docks in Lake Washington altered the migration patterns of Puget Sound Chinook salmon, with some juvenile salmon reversing the direction in which they were migrating upon encountering a dock.

None of the proposed actions will result in a permanent obstruction or barrier to Puget Sound Chinook or other salmonids. Construction activities may result in short-term temporary sediment plumes that may impede salmonid migration. However, mitigation measures, like sediment booms or curtains, will be implemented to minimize sedimentation effects. Other construction-related impacts such as clearing and grubbing, may remove some riparian vegetation that could result in decreased shade within the action area. Because only large waterbodies (Lake Washington and the Ship Canal) are designated as critical habitat, the temporary loss of riparian vegetation—until planted vegetation grows to significant size—will not result in increased water temperatures. Pile installation will result in increased SPLs that can impede or prevent salmonid migration. This short-term effect will be minimized through conservation measures such as work timing windows and the use of bubble curtains.

Project designs for projects involving docks and overwater structures will improve existing obstruction and barrier conditions in the long-term. Designs for docks and other overwater structures improve migration corridors for salmonids by minimizing nearshore overwater structure impacts through the use of narrower piers, grating, and the installation of fewer piles. Shoreline restoration and modification projects along the shores of Lake Washington and the Ship Canal will remove bulkheads, retaining walls, and other hard structures and replace them with structures to increase shallow water and habitat complexity that will benefit salmonid migration corridors.

7.2.1.4 Puget Sound Chinook Salmon PCE #4: Estuarine Areas

Estuarine areas must be free of obstruction and excessive predation and offer the following other features:

- Water quality
- Water quantity
- Salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater
- Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels
- Juvenile and adult forage, including aquatic invertebrates and fish, supporting growth and maturation.

The Duwamish River within the City of Seattle Lower Green/Duwamish River Action Area is an all tidally influenced, brackish water environment. This transition zone is very important to outmigrating juvenile Chinook salmon. High densities of juvenile Chinook salmon can be found in this transition zone as juveniles are migrating to Puget Sound.

In the Ship Canal, the estuary has been highly altered due to the construction of the canal and the lowering of Lake Washington and rerouting of the Cedar River system (see **Section 5, Status of the Species**). The Locks structure and its operation influence the physical characteristics of Salmon and Shilshole bays. Juvenile and adult Chinook salmon are forced to move abruptly from one salinity regime to another. Normally juveniles and adults would spend time in the brackish water interface between salinity regimes (acclimation period) before moving into another salinity regime. Because of the Ship Canal, however, little brackish water is available for this.

Obstructions and Barriers

The Duwamish River, like Lake Washington and the Ship Canal, is also highly urbanized with bulkheads, docks, piers, and other shoreline structures. These structures, while not being total obstructions or barriers to migrating Chinook salmon, may impede migration by altering migration patterns by moving juvenile Chinook away from the nearshore into deeper water. Proposed projects under the Seattle Biological Evaluation will improve existing obstruction and barrier conditions in the long-term by increasing shallow water habitat and improving shoreline habitat through modifications of bulkheads, docks, and piers. See section *7.2.1.3 Puget Sound Chinook Salmon PCE #3: Freshwater Migration Corridors*.

Predation

Predators of juvenile Puget Sound Chinook salmon within the Ship Canal action area, upstream of the Locks, include cutthroat trout, bull trout, prickly sculpin, smallmouth bass, largemouth bass, and northern pikeminnow. Below the Locks and in the Duwamish River, cutthroat trout, staghorn sculpin, bull trout, and resident Chinook salmon (blackmouth) are the most prevalent predators. Predation rates have been influenced by the extensive modification of the littoral zone habitats, increase in the population size of predator species, effects of increased water temperature on predator consumption rates, and the introduction of non-native piscivorous fish. Predation of Chinook salmon will be greatest in areas where they aggregate. Within the Ship Canal, juveniles may be most vulnerable to predation as they migrate from Lake Washington to the Locks, pass through the Locks, aggregate below the Locks, and as they rear in the relatively small estuary.

Other predators below the Locks include gulls, harbor seals, and California sea lions. Predation rates of these species on Puget Sound Chinook salmon have been reduced due to changes in operation of the Locks and by removal of nuisance animals and electronic measures to deter predation. The City of Seattle has no control over these measures at the Locks.

Proposed projects for the City of Seattle will help reduce predation in the estuarine environment. While the City does not operate the Locks, future projects in the Ship Canal and the Duwamish River will increase shallow water habitat and habitat complexity important for Puget Sound Chinook salmon survival.

Water Quality and Salinity

Water quality in the Duwamish River has been adversely affected by discharges from public and private storm drains, combined sewer overflows, industrial and municipal wastewater discharges, contaminated groundwater, and spills and leaks that discharge directly to the river from waterfront or overwater activities. Specific water quality concerns included increased water temperatures in the summer and minor decreases in dissolved oxygen. Since 1970, water temperatures have increased about 2º C and have exceeded the salmon migration blockage threshold of 70º F [21º C] during summer.

Salinity is a concern within the Ship Canal. Little brackish water exists around the Locks. Some saltwater is found upstream of the Locks, but is flushed back downstream of the Locks by the saltwater drain. During the summer, a saltwater layer or wedge forms along the bottom of the Ship Canal. This layer combines with summer thermal stratification to make the bottom layers of the water column anoxic. See Section 6, Environmental Baseline.

Proposed projects under the Seattle Biological Evaluation will not affect the salinity concentrations within the Ship Canal and Duwamish River. See section *7.2.1.2 Puget Sound Chinook Salmon PCE #2: Freshwater Rearing Site*.

Water Quantity, Natural Cover, and Forage and Prey Base

Water quantity within the Duwamish River estuary is controlled by upstream river systems and future projects will not result in the removal of any water or alter the hydrology of the system. Natural cover with the Duwamish River is limited due to the highly urbanized system. As with Lake Washington and the Ship Canal, future projects will increase natural cover by increasing shallow water and habitat complexity through installation of large woody debris and other habitat features. As in Lake Washington, juvenile Chinook salmon in estuarine areas are opportunistic foragers, feeding on epibenthic and pelagic invertebrates, insects, and small fish. Chinook salmon turn to preying on fish at approximately 6 inches (150 mm) length. Future projects within Puget Sound will not alter the forage or prey base for Chinook. See section *7.2.1.2 Puget Sound Chinook Salmon PCE #2: Freshwater Rearing Site.*

7.2.1.5 Puget Sound Chinook Salmon PCE #5: Nearshore Marine Areas

Nearshore marine areas must be free of obstruction and offer the following features:

- Water quality and quantity conditions
- Forage, including aquatic invertebrates and fish, supporting growth and maturation
- Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels.

Obstructions and Barriers

The Puget Sound nearshore marine area is highly urbanized like the Duwamish River, Lake Washington, and the Ship Canal. Designated critical habitat and proposed project impacts will be similar to that described in section *7.2.1.3 Puget Sound Chinook Salmon PCE #3*.

Water Quality

Water quality in Puget Sound is affected by many factors, including human activities and ocean currents, as well as physical, chemical, and biological processes. The nearshore conditions are affected by human activities such as land-use activities, municipal wastewater discharges, combined sewer overflows, stormdrain discharges, and shoreline erosion. Because many contaminants present in these discharges tend to adsorb to particulate material, the sediment deposited in nearshore areas tends to accumulate contaminants. Areas of concern include the northwest corner of Harbor Island and various locations along the Seattle waterfront.

Future projects covered by this Seattle Biological Evaluation are activities that will not affect water quality within Puget Sound.

Water Quantity

Future projects covered by this Seattle Biological Evaluation are activities that will not affect water quantity within Puget Sound.

Forage and Prey Base and Natural Cover

The City of Seattle's future projects will not affect the Puget Sound forage and prey base. Projects will be designed to increase natural cover and shallow water habitat. See section *7.2.1.2 Puget Sound Chinook Salmon PCE #2* above.

7.2.1.6 Puget Sound Chinook Salmon PCE #6: Offshore Marine Areas

Offshore marine areas must have the following features: Water quality conditions that offer forage, including aquatic invertebrates and fish, supporting growth and maturation.

No projects will be constructed within the offshore marine designated critical habitat. However, because of the link between nearshore and offshore habitats, there is a potential that future projects may result in a very small change in offshore habitat, but this would be very unlikely.

7.2.2 Coastal-Puget Sound Bull Trout Critical Habitat

Coastal-Puget Sound bull trout designated critical habitat within the City of Seattle action areas include the Puget Sound nearshore, Lake Washington, the Ship Canal, and the Duwamish River. No streams are designated as critical habitat. All critical habitats in the action areas are considered foraging, migration, and overwintering habitat. There are 9 bull trout critical habitat PCEs (see **Section 5, Status of the Species**, for a complete description of each PCE:

- Coastal-Puget Sound Bull Trout PCE #1: Springs, seeps, groundwater, subsurface water connectivity
- Coastal-Puget Sound Bull Trout PCE #2: Migration habitats
- Coastal-Puget Sound Bull Trout PCE #3: Abundant food base
- Coastal-Puget Sound Bull Trout PCE #4: Complex river, stream, lake, reservoir, and marine shoreline aquatic environments
- Coastal-Puget Sound Bull Trout PCE #5: Water temperatures
- Coastal-Puget Sound Bull Trout PCE #6: Substrate for egg, fry, young-of-the-year and juvenile survival
- Coastal-Puget Sound Bull Trout PCE #7: Natural hydrograph
- Coastal-Puget Sound Bull Trout PCE #8: Sufficient water quality and quantity
- Coastal-Puget Sound Bull Trout PCE #9: Low levels of occurrence of nonnative predators.

7.2.2.1 Coastal-Puget Sound Bull Trout PCE #1: Groundwater Sources

Springs, seeps, groundwater sources, and subsurface water connectivity are important habitat features for bull trout because they provide cool water refugia. Water temperatures in Lake Washington and the Ship Canal during the summer exceed bull trout temperature thresholds. While bull trout are not expected to be in Lake Washington or the Ship Canal during the summer months, groundwater sources would provide cool water refuge for bull trout. Cool water refugia provide locations that contribute to water quality and quantity.

Proposed projects will not alter any springs, seeps, or other groundwater sources within Lake Washington or the Ship Canal. The Lake Washington and Ship Canal shorelines are highly developed and any proposed projects will improve the aquatic habitat along the shoreline, which could increase groundwater connectivity in these action areas.

7.2.2.2 Coastal-Puget Sound Bull Trout PCE #2: Migratory Habitats

Bull trout need migratory habitats 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.

The only permanent obstruction or barrier to bull trout within the action areas is the Locks within the Ship Canal action area. The Locks divide the marine and freshwater habitats in the Ship Canal. Adult and subadult bull trout migrating to freshwater or the marine waters pass via the fish ladder and the 2 lock chambers.

Water temperatures in summer and early fall are too high and impede bull trout migration in Lake Washington and the Ship Canal. Water temperatures along the Ship Canal and in south Lake Union range from 60.8º to 73.4º F (16º to 23º C) between June and September (see *6.2.1* in Section 6, Environmental Baseline). In addition, dissolved oxygen regularly drops below 6 mg/L during the summer months when the water temperatures are above 68º to 70º F [20º C to 21º C]. Water temperatures in the Duwamish River have increased in the past couple years with temperatures in the summer over 64.5º F [18º C]. High temperatures and low dissolved oxygen can impede bull trout migration through the area.

Docks, both large and small, and other overwater structures are present along the shorelines of Lake Washington, the Ship Canal, the Duwamish River, Elliott Bay, and Puget Sound. These structures may inhibit bull trout migrating along shallow-water habitats, but have not been found to impede migration.

None of the proposed actions will result in a permanent obstruction or barrier to bull trout. Construction activities may result in short-term temporary sediment plumes that may impede bull trout migration. However, conservation measures such as work timing windows usually result in construction activities being conducted in summer and early fall when water temperatures are too high for bull trout. In addition, other conservation measures, like sediment booms or curtains, will be implemented to minimize sedimentation effects. Pile installation will result in increased SPLs that can impede or prevent bull trout migration. This short-term effect will be minimized through conservation measures such as work timing windows and the use of bubble curtains.

Project designs for projects involving docks and overwater structures will improve existing obstruction and barrier conditions in the long-term. Designs for docks and other overwater structures improve migration corridors for bull trout by minimizing nearshore overwater structure impacts through the use of narrower piers, grating, and installation of fewer piles. Shoreline restoration and modification projects along the shores of Lake Washington, the Ship Canal, the Duwamish River, Elliott Bay, and Puget Sound will remove bulkheads, retaining walls, and other hard structures, when possible, and replace them with structures to increase shallow water and habitat complexity that will benefit bull trout migration corridors.

7.2.2.3 Coastal-Puget Sound Bull Trout PCE #3: Abundant Food Base

Bull trout require an abundant food base including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish. Because bull trout are apex predators, as adults and subadults they feed primarily on fish including various trout and salmon species, whitefish, yellow perch, and sculpin. In Elliott Bay and Puget Sound, bull trout also feed on ocean fish, such as surf smelt and sandlance. In freshwater, juvenile bull trout prey on terrestrial and aquatic insects, macrozooplankton, amphipods, mysids, crayfish, and small fish.

Bull trout prey resources are not expected to be appreciably impacted by the proposed projects and activities. Some localized impacts to macroinvertebrates will occur during project construction, but these impacts will be temporary and macroinvertebrates will recolonize disturbed areas quickly. Conservation measures will be used for all in-water work to reduce impacts to macroinvertebrates and forage fish from turbidity, sedimentation, and other water quality issues. Fish mix to increase macroinvertebrate production will be installed to cover riprap and fill interstitial spaces. Riparian plantings will increase terrestrial macroinvertebrate input. In the long-term, the bull trout food base should benefit from many City projects.

7.2.2.4 Coastal-Puget Sound Bull Trout PCE #4: Complex River, Stream, Lake, and Marine Shoreline Aquatic Environments

Bull trout require shorelines with features such as woody debris, side channels, pools, and undercut banks to provide a variety of depths, velocities, and instream structures.

Designated critical habitat in the Elliott Bay, Lake Washington, and the Ship Canal contains very little natural cover. Elliott Bay, Lake Washington, and the Ship Canal are highly urbanized with bulkheads, docks, piers, and other shoreline structures. When possible, the City is removing or pulling back bulkheads, and reducing overwater structure impacts within the Ship Canal and in Lake Washington. Large woody debris and other restoration activities are installed or constructed to minimize or offset effects associated with hardened shorelines. Within designated critical habitat in Lake Washington, future projects will increase habitat complexity by placement of large woody debris, removal or set-back of bulkheads, and increasing shallow water habitats.

7.2.2.5 Coastal-Puget Sound Bull Trout PCE #5: Water Temperature

Bull trout have been documented in streams with temperatures from 32 to 72º F (0-22º C) but are found more frequently in temperatures ranging from 36 to 59º F (2-15º C) with adequate thermal refugia available for temperatures at the upper end of this range. Water temperatures within Lake Washington and the Ship Canal during the summer often reach or exceed 72º F (22º C). These temperatures result in a barrier to bull trout entering the Ship Canal. Similar temperatures are found in the Duwamish River, with temperatures exceeding the salmon migration blockage threshold of 69.8º F (21º C). These temperatures in Lake Washington, the Ship Canal, and the Duwamish River limit the use of these waters by bull trout in summer and early fall. Proposed projects covered by this Seattle Biological Evaluation will not result in increased stream temperatures for these waterbodies. Some riparian trees may be removed, but this will not result in increased water temperature.

Maximum water temperatures in Elliott Bay and Puget Sound are about 62º F (16.7º C) offshore and 67º F (19.5º C) along the nearshore. While nearshore temperatures may be too warm for bull trout, prey species, such as Chinook salmon, at this time are not dependent on the nearshore, and, therefore, bull trout will not have to utilize the nearshore. City projects will not affect Elliott Bay or Puget Sound water temperatures.

7.2.2.6 Coastal-Puget Sound Bull Trout PCE #6: Substrate for Egg and Incubation Success

Bull trout do not spawn within any of the Seattle action areas.

7.2.2.7 Coastal-Puget Sound Bull Trout PCE #7: Natural Hydrographs[2]

Within the City's action areas, water quantity for designated critical habitat relies on up-stream influences. As noted, lake levels for Lake Washington and the Ship Canal are con-trolled by the Locks and are not allowed to fluctuate by more than 2 feet. Inflow to Lake Washington comes from 2 major tributaries, the Sammamish and Cedar rivers. Many smaller tributaries also flow to Lake Washington, including Thornton and Taylor creeks. Flows in the Lower Green/Duwamish River are controlled by the Howard Hansen Dam.

No proposed projects will remove water from Lake Washington, Ship Canal, or the Duwa-mish River. Water quantity will not be reduced by proposed projects. Increases in imper-vious surface may increase stormwater runoff, but these projects will not be large enough to change the hydrologic regime of Lake Washington, the Ship Canal, or Duwamish River.

[2] Bull trout require a natural hydrograph with peak, high, low, and base flows within historic ranges, or if regulated, operate under a biological opinion that addresses bull trout. They can also survive in a hydrograph that supports bull trout by minimizing daily fluctuations and departures from the natural cycle of flow levels corresponding with seasonal variation.

7.2.2.8 Coastal-Puget Sound Bull Trout PCE #8: Sufficient Water Quality and Quantity

Within the Seattle action areas, water quantity relies on upstream influences. See description under Coastal-Puget Sound Bull Trout PCE #7 for information on water quantity within the action areas. See description under Puget Sound Chinook Salmon PCE #2 for information on water quality with the action areas.

7.2.2.9 Coastal-Puget Sound Bull Trout PCE #9: Sufficiently Low Levels of Occurrence of Nonnative Predatory Species

Lake Washington and the Ship Canal both have abundant nonnative predator species, especially smallmouth and largemouth bass (see Section 6 – Environmental Baseline for complete description). However, bull trout that have been found within Lake Washington and the Ship Canal are larger subadults and adults that would not be preyed upon by nonnative species.

The proposed project will not result in an increase in the occurrence of nonnative predatory species. Smallmouth and largemouth bass are structure oriented within Lake Washington and the Ship Canal. Future projects will reduce habitat for predator fish by increasing light penetration under piers and docks which lessens or decreases the sharp shadow gradients that exist under piers.

7.2.2.10 Conservation Measures

All conservation measures incorporated into this document will avoid, minimize, or reduce impacts to critical habitat.

7.2.3 Killer Whale Critical Habitat

Southern Resident Killer Whales critical habitat is limited within the Seattle action areas to Elliott Bay and Puget Sound. There are 3 killer whale critical habitat PCEs.

See Section 5, Status of the Species, for a complete description of each PCE:

- Southern Resident Killer Whale PCE #1: Water quality
- Southern Resident Killer Whale PCE #2: Prey species
- Southern Resident Killer Whale PCE #3: Passage conditions.

7.2.3.1 Southern Resident Killer Whale PCE #1: Water Quality

Water quality in Puget Sound is affected by many factors such as human activities and ocean currents. The relatively high water exchange is a key factor in maintaining good water quality conditions in the offshore areas. However, nearshore conditions are affected by human activities such as land-use activities, municipal wastewater discharges, combined sewer overflows, stormdrain discharges, and shoreline erosion. Temperature, dissolved oxygen, and salinity values are fairly consistent throughout the year. Total and dissolved forms of metals are frequently found in Puget Sound waters, but concentrations are generally low.

Construction activities in Elliott Bay or Puget Sound may result in temporarily decreased water quality in the nearshore. In-water activities such as bank or shoreline stabilization or restoration may result in short-term increases in sedimentation. Use of heavy equipment and other construction vehicles pose a risk of petroleum products spilling into the water. However, these activities will impact the nearshore and should not result in water quality impacts to offshore, killer whale critical habitat.

7.2.3.2 Southern Resident Killer Whale PCE #2: Prey Species

Killer whale need prey species of sufficient quantity, quality and availability to support individual growth, reproduction and development, as well as overall population growth. They eat a variety of marine organisms ranging from fish to squid to other marine mammal species. Fish, preferably salmon, are the major food source for Southern Resident killer whales. Chinook salmon comprise approximately 65% of the prey. Other salmonids consumed include pink, coho, chum, sockeye salmon, and steelhead.

City projects in all action areas will result in a variety of impacts to both listed and unlisted salmonids. Construction impacts including stream dewatering, grading, vegetation clearing, etc. may result in increased turbidity, sedimentation, and stream temperatures that may temporarily affect salmonid feeding and rearing. Conservation measures are incorporated into the project to avoid, reduce, and minimize project effects to salmonids. Most projects include habitat restoration or improvement activities—such as increasing large wood, habitat complexity, and removing barriers—that increase or improve spawning and rearing habitat. In the long-term these projects will benefit salmonid populations. Therefore, City projects will, over the long-term, improve or maintain the quantity, quality, and availability of killer whale prey species.

7.2.3.3 Southern Resident Killer Whale PCE #3: Passage Conditions

For killer whales, passage conditions must allow for migration, resting, and foraging. Most City projects within Elliott Bay and Puget Sound will not result in activities that affect the migration, resting, and foraging of killer whales. A few projects will include pile driving, both impact and vibratory, resulting in increased sound and SPLs that may impede the migratory, resting, and foraging behavior of killer whales. However, conservation measures will be included in these projects that suspend pile driving activities when marine mammals are in the project vicinity. Because of these conservation measures, killer whale migration, resting, and foraging activities will not be affected by City projects covered under this Seattle Biological Evaluation.

7.2.3.4 Conservation Measures

Marine mammal monitoring will occur during all pile driving activities in Elliott Bay and Puget Sound. All pile driving activities will be suspended if marine mammals are seen in the project vicinity and will not resume until all marine mammals have left the area.

Section 8

Cumulative Effects

Under federal guidelines, a biological evaluation must describe and analyze the effects of actions that are cumulative to the primary action. Cumulative effects are impacts on the environment that result from the incremental impact of future actions when added to other past, present, and reasonably foreseeable future actions regardless of which agency or person undertakes the action. For this SBE, 'cumulative effects' are the effects of future local, state or private activities that are reasonably certain to occur within the Seattle action areas (see Figure 1).

Federal actions are not included in the cumulative effects analysis because the effects of those actions would be considered in any future Section 7 consultations. This cumulative effects analysis does not address future work within the Seattle action areas that would be authorized by a federal agency (*e.g.*, work requiring a Corps Section 10 or 404 permit), funded by a federal agency (*e.g.*, projects receiving funding from the Federal Highway Administration, U.S. Department of Housing and Urban Development, *etc.*), or carried out by a federal agency (*e.g.*, Corps' modification of the Hiram M. Chittenden Locks).

Cumulative effects within the seven action areas for this SBE may include impacts from the following:

- Expansion of transportation networks may result in environmental impacts
- Increases in population growth that may result in increases in impervious surfaces, contaminant releases, and pesticide use and subsequent releases
- Along the Puget Sound waterfront, increases in water-based actions, water-based businesses and waterfront businesses (such as barge shipping, fishing, cement production, shipbuilding and repair, marine construction, aircraft manufacturing, sand and gravel operations, and recreational boating) may result in environmental impacts
- Global and regional changes to climate may cause variations in environmental impacts

All these activities, which may have an incremental impact and/or compounding effect when experienced together, may result in impacts to ESA-listed fish and wildlife species. The following are direct and indirect effects resulting from these cumulative actions:

- Increased sedimentation

- Altered hydrology including increased surface water peak flows and reduced groundwater flows
- Increased impervious surface
- Loss or further degradation of functional riparian habitats

These effects may be lessened by the application of updated regulatory regimes that focus on protecting riparian areas, decreasing stormwater runoff, and controlling the harmful effects of erosion and drainage during construction. Seattle's Department of Planning and Development has programs and services that educate and provide technical assistance and incentives to produce long-term, environmentally sustainable benefits to the city. Some of these programs include Greenhouse Gas Assessment; Shoreline Alternative Mitigation Plan; Shoreline Master Program; Stormwater, Grading and Drainage Code; and City Green Building. These and other programs will help improve the environment as well as meet the City's increasing population demands.

As of early 2015, the City of Seattle population estimate of is approximately 662,400 (http://www.seattle.gov/dPd/cityplanning/populationdemographics/default.htm). In the next 20 years, the population is projected to increase about 17.5% or by 98,700 residents (City of Seattle 2005). Population increases may result in changing impervious surfaces through construction of more buildings and paved or concreted surfaces. A related potential impact is the pressure to move the urban growth boundary as a result of increased housing costs. The political will to hold to the urban growth boundary will be important in focusing greater impacts on the City of Seattle rather than sprawl into the rural areas. While holding to the current urban growth boundary will provide better ecological functioning overall, it puts added pressure on the urban areas and requires increased emphasis on the protection of water quality and riparian and aquatic habitat.

Development increases impervious surfaces. Most physical, chemical, and biological characteristics of stream quality were found to degrade with more impervious surfaces (May *et al.* 1996). The effect of increases in impervious surfaces can result in higher peaks in water flow during rains and less infiltration to ground water, resulting in lower groundwater flows to waterbodies during dry periods. It also may increase the quantity of pollutants entering surface waterbodies instead of being filtered by the soils during infiltration. The City of Seattle is already highly urbanized and little new impervious surface can be built. Nonetheless, updated land-use regulations, building standards, and construction regulations help minimize or mitigate adverse impacts to areas critical to ESA-listed species through prohibiting actions or by dictating timing and methods of an action. Increased residential and commercial development also may result in increased use of chemical fertilizers or pesticides, which can enter Puget Sound, Lake Washington, and streams within the seven action areas. Outreach and education programs conducted by local governments and utilities may be effective at minimizing this increase. In addition, the City has an Environmental Action Agenda that includes protection and improvements to surface water quality and Seattle's aquatic habitats.

The action areas along Puget Sound are major urban industrial waterways that support water-based commerce, waterfront businesses and water transportation networks, such as marine container and barge shipping, fishing, rail and highway transportation, concrete production, shipbuilding and repair, marine construction, aircraft manufacturing, sand and gravel operations, and recreational boating, to name a few. The Puget Sound shoreline is continually changing as new waterfront facilities and uses occur. The increased operation of the waterway's facilities may increase the use of the water-based transportation network and its connection to the land-based transportation network. Puget Sound contains several onshore oil facilities, tanker ports receiving large numbers of tanker and barge trips annually, large industrial developments, tanker and other shipping routes, bypass traffic into southern British Columbia, and other coastal and urban developments. The increase in vessel traffic will increase the potential for water pollution from vessel-related activities (*e.g.*, oil, transmission fluid, gasoline, and diesel fuel spills).

Regulation by agencies, such as the Washington State Department of Ecology (Ecology) and the U.S. Coast Guard, mitigate or minimize adverse effects to water quality, including those caused by vessels operating in Puget Sound. For example, regulations prohibit bilge and sewage discharge and require that any hazardous material spilled (*e.g.*, diesel fuel, gasoline, oil, and transmission fluid) be reported to Ecology and the U.S. Coast Guard.

Lately it has become important to consider global climate change as a possible component of cumulative effects. The City has introduced locally and nationally a Climate Protection Initiative to reduce global warming, improve air quality, and review the rise in sea-level and its potential and effects. Locally, there have been increases in the number of days of warm temperatures in some surface waters, such as in the Ship Canal. In addition, rainfall frequency and intensity may be impacted by global climate change. These changes may carry incremental environmental impacts, such as affecting the timing of salmon migration and survival or reproductive viability. More discussion is provided at the end of this section.

The City of Seattle is taking numerous actions to offset adverse cumulative effects and to benefit the environment. One such action is to promote healthy people and communities by creating healthy livable urban centers and promoting sustainable practices. In addition the Green Seattle Initiative was initiated for restoring the urban forest, increasing open space, and promoting the greening of the 'built environment.' A second action is the Plan to Protect Seattle's Waterways, which is a comprehensive strategy being implemented to reduce overflows and discharge of pollutants from combined sewers and the storm drain system. Other offsetting actions for adverse effects to growth include:

- Increasingly well-informed and targeted regulations
- Educating citizens
- Creating environmentally-friendly areas

Local, state, and federal regulators are striving to develop effective regulations and guidelines to manage the environment. These include Seattle's Environmental Critical Area ordinance, which mitigates for development and the related Seattle Shoreline Master Program. In addition, many agencies and nonprofit groups are educating citizens on topics such as using environmentally-friendly products, planting native vegetation and removing invasive plants, car-pooling, mass transit, biking, walking, and creating and improving fish and wildlife habitats. Environmentally-friendly trends include construction of more natural surface water drainage systems through designs that allow longer surface water contact with the soil and, thus, more infiltration and pollutant soil filtering. Other actions include removal of stream blockages and the restoration of stream, lake, and Puget Sound shorelines to benefit salmon and other riparian and aquatic species. While many of these actions will require permitting with the Corps and, therefore, consultation with the Services, they will help avoid and minimize the cumulative effects of ongoing activities within the Seattle action areas.

Climate Change

There is now widespread consensus within the scientific community that atmospheric temperatures on earth are increasing and that this will continue for at least the next several decades (IPCC 2007, p. 749). There is also consensus within the scientific community that this warming trend will alter current weather patterns and patterns associated with climatic phenomena, including the timing and intensity of extreme global events such as heat-waves, floods, storms, and wet-dry cycles.

Recent observations and modeling for aquatic habitats in the Pacific Northwest suggest that salmonids and other native cold-water species will be negatively affected by ongoing and future climate change. Rieman and McIntyre (1993, p. 8) listed several studies which predicted substantial declines of salmonid stocks in some regions related to long-term climate change. Battin et al. (2007) modeled impacts to salmon in the Snohomish River Basin related to predictions of climate change. They suggest that long-term climate impacts on hydrology would be greatest in the highest elevation basins, although site specific landscape characteristics would determine the magnitude and timing of effects. Streams which acquire much of their flows from snowmelt and rain-on-snow events may be particularly vulnerable to the effects of climate change (Battin et al. 2007, p. 6724). In the Pacific Northwest region, warming air temperatures are predicted to result in receding glaciers, which in time would be expected to seasonally impact turbidity levels, timing and volume of flows, stream temperatures, and species responses to shifting seasonal patterns.

Battin et al. (2007, p. 6720) suggest that salmonid populations in streams affected by climate change may have better spawning success rates for individuals that spawn in lower-elevation sites, especially where restoration efforts result in improved habitat. Higher elevation spawners would be more vulnerable to the impacts of increased peak flows on egg survival. They further note that juvenile salmonids spending less time in freshwater streams before out-migrating to the ocean would be less impacted by the higher temperatures and low flows than juveniles that rear longer in the streams.

Changes in climate have been identified that are occurring now or will occur over the next 50 to 100 years (Glick et al. 2007, p. iii; Mote et al. 2005, p. 4). The predicted changing precipitation patterns are expected to result in more frequent severe weather events and warmer temperatures (Mote et al. 2005, p. 13). Glaciers in the Cascades and Olympics Mountains have been retreating during the past 50-150 years in response to local climate warming. Regional warming can result in reduced winter snowpack, earlier occurrence of peak runoff, and reduced summer flows. If the current climate change models and predictions for Pacific Northwest aquatic habitats are relatively accurate, salmonids in the Puget Sound region are likely to be impacted through at least one or more of the following pathways:

- Changes in distribution of salmonids within a watershed, such as reduced spawning habitat, and/or seasonal thermal blockage in the migratory corridors associated with increased stream temperatures
- Disturbance or displacement of eggs, alevins, juveniles, and adults during winter flooding events
- Short-or long-term changes in habitat and prey species due to stochastic events during winter floods

- Changes in flow/out-migration timing in the spring for salmonids and their prey species
- Increased migration stressors from lower stream flows and high stream temperatures during spawning migrations

Section 9

Essential Fish Habitat

In addition to ESA, actions under this SBE are subject to the Magnuson-Stevens Fishery Conservation and Management Act (MSA), which requires Essential Fish Habitat (EFH) consultation with the National Marine Fisheries Service (NMFS).

9.1 Essential Fish Habitat

The MSA established procedures to preserve EFH for species regulated under a federal fisheries management plan. Federal agencies, such as the Corps of Engineers, are required under the MSA to consult with the NMFS regarding actions that are authorized, funded, or undertaken by that agency that may adversely affect EFH. This includes the Corps-permitted projects and Corps-permitted maintenance activities covered under this SBE. Other federal agencies may use the SBE to conduct EFH consultation with the NMFS.

EFH means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity (MSA Section 3). For the purpose of interpreting this definition the following terms apply:

- 'Waters' include aquatic areas and their associated physical, chemical, and biological properties used by fish. Where appropriate, waters may include aquatic areas historically used by fish.
- '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
- 'Spawning, breeding, feeding, or growth to maturity' covers a species' full life cycle (50 CFR 600.110)
- 'Adverse effect' means any impact that reduces the quality and/or quantity of EFH, and may include direct (*e.g.*, contamination or physical disruption), indirect (*e.g.*, loss of prey or reduction in species fecundity), site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810).

Any reasonable attempt to encourage the conservation of EFH must take into account actions that occur outside that habitat such as upstream and upslope activities that may have an adverse effect on EFH. Therefore, EFH consultation with NMFS is required for any federal agency action that may adversely affect EFH, regardless of its location.

The procedures identified under the MSA are designed to identify, conserve, and enhance EFH. Under the MSA federal agencies must follow this process:

- Federal agencies must consult with NMFS on all actions, or proposed actions, authorized, funded, or undertaken by the agency, that may adversely affect EFH (section 305(b)(2))
- NMFS must provide conservation recommendations for any federal or state activity that may adversely affect EFH (section 305(b)(4)(A)).

Federal agencies must provide a detailed response in writing to NMFS within 30 days after receiving EFH conservation recommendations. The response must 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 shall explain its reasons for not following the recommendations (section 305(b)(4)(B)).

9.2 Identification of Essential Fish Habitat

Under the MSA, the Pacific Fisheries Management Council (PFMC) has designated EFH for federally-managed fisheries within the waters of Washington, Oregon, and California.

Designated EFH for groundfish and coastal pelagic species encompasses all waters along the coasts of Washington, Oregon, and California that are seaward from the MHW line, including the upriver extent of saltwater intrusion in river mouths to the boundary of the U. S. economic zone, approximately 230 miles (370.4 km) offshore (PFMC 1998a,b).

Freshwater EFH for Pacific salmon includes all those streams, lakes, ponds, wetlands, and other waterbodies currently or historically accessible to salmon in Washington, Oregon, Idaho, and California, except areas upstream of certain impassable human-made barriers (as identified by the PFMC 1999), and longstanding, naturally-impassable barriers (*i.e.*, natural waterfalls in existence for several hundred years) (PFMC 1999).

In estuarine and marine areas, designated salmon EFH extends from the nearshore and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone offshore of Washington, Oregon, and California, north of Point Conception to the Canadian border (PFMC 1999).

Detailed description and identification of EFH are contained in the fishery management plans for groundfish (PFMC 1998a), coastal pelagic species (PFMC 1998b), and Pacific salmon (PFMC 1999).

9.3 Proposed Actions

The proposed actions covered by this SBE include commonly done construction methods for capital improvement program (CIP) projects and operations and maintenance activities. These methods are divided into categories, based on the type of construction and are described in Section 3 (Description of the Proposed Action: Methods). The methods are for work only within the City of Seattle boundaries and include geographically defined action areas. The action areas are identified in Section 6 (Environmental Baseline). These action areas include habitats that have been designated as EFH for various life-history stages of 46 species of groundfish, 4 species of coastal pelagic species, and 3 species of Pacific salmon (Table 9-1).

Table 9-1
Fish species with designated Essential Fish Habitat in the Seattle action areas

Groundfish Species		
redstripe rockfish *S. proriger*	Dover sole *Microstomus pacificus*	spiny dogfish *Squalus acanthias*
rosethorn rockfish *S. helvomaculatus*	English sole *Parophrys vetulus*	big skate *Raja binoculata*
rosy rockfish *S. rosaceus*	flathead sole *Hippoglossoides elassodon*	California skate *Raja inornata*
rougheye rockfish *S. aleutianus*	petrale sole *Eopsetta jordani*	longnose skate *Raja rhina*
ratfish *Hydrolagus colliei*	sharpchin rockfish *S. zacentrus*	rex sole *Glyptocephalus zachirus*
Pacific cod *Gadus macrocephalus*	splitnose rockfish *S. diploproa*	rock sole *Lepidopsetta bilineata*
Pacific whiting (hake) *Merluccius productus*	striptail rockfish *S. saxicola*	sand sole *Psettichthys melanostictus*
black rockfish *Sebastes melanops*	tiger rockfish *S. nigrocinctus*	starry flounder *Platichthys stellatus*
bocaccio *S. paucispinis*	bermilion rockfish *S. miniatus*	arrowtooth flounder *Atheresthes stomias*
yelloweye rockfish *S. ruberrimus*	brown rockfish *S. auriculatus*	yellowtail rockfish *S. flavidus*
canary rockfish *S. pinniger*	shortspine thornyhead *Sebastolobus alascanus*	China rockfish *S. nebulosus*
cabezon *Scorpaenichthys marmoratus*	copper rockfish *S. caurinus*	Lingcod *Ophiodon elongates*
darkblotch rockfish *S. crameri*	kelp greenling *Hexagrammos decagrammus*	greenstriped rockfish *S. elongates*
sablefish *Anoplopoma fimbria*	Pacific ocean perch *S. alutus*	Pacific sanddab *Citharichthys sordidus*
quillback rockfish *S. maliger*	butter sole *Isopsetta isolepis*	redbanded rockfish *S. babcocki*
curlfin sole *Pleuronichthys decurrens*		
Coastal Pelagic Species		
anchovy *Engraulis mordax*	Pacific sardine *Sardinops sagax*	Pacific mackerel *Scomber japonicas*
market squid *Loligo opalescens*		
Pacific Salmon Species		
Chinook salmon *Oncorhynchus tshawytscha*	coho salmon *O. kisutch*	Puget Sound pink salmon *O. gorbuscha*

9.4 Effects of Proposed Actions

As described in detail in **Section 7, Effects of the Action**, the proposed actions (construction methods with conservation measures) may result in the following detrimental short and long-term effects on a variety of habitat parameters:

- Fish mortality, injury and/or behavioral changes resulting from pile driving activities.
- Changes in saltwater and freshwater shallow-water habitat associated with shoreline hardening. This can result in permanent loss of habitat; reduced availability and extent of foraging, spawning, and refuge areas; loss of complex habitat; and altered hydrology.
- Temporary impacts associated with increased turbidity and suspended solid concentrations associated with construction activities. Increased turbidity and suspended solids can result in decreased feeding efficiency, reduced growth, increased predation, and decreased habitat availability.
- Injury and mortality associated with capture and handling of fish during stream dewatering activities, including electrofishing.
- Sharp underwater light contrasts during the day and night as a result of overwater structures and artificial lighting surrounding piers and overwater structures, affecting predator-prey relationships, behaviors, migration, spawning, rearing, and refugia.
- Temporary suspension and a long-term increase in creosote-contaminated sediments due to the removal of creosote-treated timber piles, resulting in reduced reproductive success and reduced survival.

9.5 Essential Fish Habitat Conservation Measures

The activities addressed in this SBE will apply conservation measures that feature best management practices for the following:

- Approved work/timing restrictions for ESA-listed species
- Stormwater pollution prevention
- Work area isolation
- Fish handling
- Overwater structure size
- Piling installation and noise abatement
- Shoreline and aquatic habitat protection
- Pesticides.

The conservation measures are to minimize direct and indirect impacts to ESA-listed species and their habitats. These measures will also minimize impacts to EFH. The conservation measures are detailed separately in **Section 4, Conservation Measures**. The methods are identified in **Section 3, Description of Proposed Action: Construction Methods**, where they are linked to specific conservation measures.

Table 9-2, below, is a quick reference guide to where EFH is found within the Seattle action areas.

Table 9-2
Quick reference for Essential Fish Habitat species within the Seattle action areas and selected watersheds

Action area	**Species**		
	Groundfish	**Coastal pelagic**	**Pacific salmon**
Elliott Bay	X	X	X
Ship Canal			(Chinook & Coho only)*
Lower Green/Duwamish			(Chinook & Coho only)*
North Seattle/Puget Sound	X	X	X
North Lake Washington Thornton Creek			(Chinook & Coho only)*
South Lake Washington			(Chinook & Coho only)*
South Seattle/Puget Sound	X	X	X
Source: NMFS			

*Of the 3 Pacific salmon species covered under EFH, only Chinook and coho salmon are found within these action areas and need to be analyzed.

Section 10

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Specific Project Information Form (SPIF)
Cover Page

Project Title: _____

Project CIP Number: __

Project Manager: _____ Department: __

Phone Number: _____

Corps Reference #: __ Corps Project Manager: _____

Filled-in by Corps

Phone Number: _____

USFWS/NMFS Representative Signature: ______________________________________

Signature required prior to submittal to the Corps

The City of Seattle project manager should fill out this form with help from the City's US Fish and Wildlife Service (USFWS)/National Marine Fisheries Service representative[1] (jointly the "Services") or have that representative fill out the form for them. Prior to submitting this SPIF to the Corps of Engineers, with the other SPIFs (in Appendix A) and the Joint Aquatic Resources Permit Application (JARPA), it must be reviewed and approved as accurate and complete by the representative, and then signed above.

If the project will have No Effect to listed species and designated critical habitat, no SPIFS need to be filled out and submitted, including this SPIF Cover Page. As such, only the no effect template (in Appendix B) needs to be filled out and submitted to the Corps. If the Corps does not agree with the no effect determination, then this SPIF Cover Page and individual SPIFs must be filled out and submitted.

I BACKGROUND

This form replaces the submission of a biological evaluation. To answer the following sections you must be familiar with Sections 3 and 4 of the Seattle Biological Evaluation (SBE). You may also have to gather additional information, such as what Endangered Species Act (ESA)-listed fish, birds, or marine mammals occur in your project area. Information is available from the appropriate agency (Washington Department of Fish and Wildlife or the Services) and departments within the City of Seattle.

1. The following documents must be included with this form:
   - A. Joint Aquatic Resources Permit Application (JARPA)
   - B. Vicinity Map
   - C. Project drawings
   - D. Map showing location of sensitive areas that will be protected [*see SBE section 3.1, Method 1 for a definition of "Sensitive Areas"*]
   - E. Hydraulic Project Approval (issued by Washington State Dept. of Fish and Wildlife)

[1] Under an Agreement between the City of Seattle, the US Fish and Wildlife Service and the National Oceanic and Atmospheric Administration (NOAA) Fisheries, Jim Muck (206-526-4740, Jim.Muck@NOAA.gov) provides ESA services to City of Seattle staff.

2. Define the size of the Action Area for the project and the rationale behind how the boundary was determined. The action area 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. For example, if a project will work in a stream, the action area may be defined as the extent downstream (200 ft.) of the project at which turbidity levels reach background levels. For impact or vibratory pile driving, the action area will be determined by the distance increased sound levels will attenuate to background levels. _____

3. Project schedule or timing (Please be a specific as possible):

   A. Total construction period for all activities: _____

   B. Work timing windows (specify dates):

      i. Fresh waters - work waterward of ordinary high water (OHW): _____

      ii. Marine waters – work waterward of mean higher high water (MHHW): _____

II SPECIES INFORMATION

1. Endangered Species Act (ESA). From the list below, identify all threatened, endangered, and proposed species and designated and proposed critical habitat that occur in the project's action area. If no listed species or designated critical habitats are present in the action area, justification is needed by the Corps that the project will not impact listed species or designated critical habitat. The next few sections provide the justification to the Corps for their ESA responsibilities.

2. Reference Tables 5-1 and 5-3 in SBE Section 5. To find out which species are in your project's action area, consult with your in-house scientist or consultant, as appropriate.

<u>NMFS Species</u>

☐ Puget Sound Chinook salmon - ☐ PS Chinook critical habitat

☐ Puget Sound steelhead - ☐ Propose PS steelhead critical habitat

☐ Southern Resident killer whale - ☐ SR killer whale critical habitat

☐ Steller sea lion

☐ Humpback whale

☐ Eulachon

☐ Bocaccio - ☐ Bocaccio critical habitat

☐ Canary rockfish - ☐ Canary rockfish critical habitat

☐ Yelloweye rockfish - ☐ Yelloweye rockfish critical habitat

<u>FWS Species</u>

☐ Coastal-Puget Sound bull trout - ☐ CPS bull trout critical habitat

☐ Marbled murrelet

☐ Bald eagles – bald eagles are no longer listed under the ESA, but are protected under the Bald and Golden Eagle Act. Please check if your project will impact bald eagles and contact the USFWS/NMFS representative for the City of Seattle (Jim Muck).

3. Essential Fish Habitat (EFH). Identify all EFH that occurs in the project's action area. See SBE Section 9. To find out if your project area contains EFH, consult with your in-house scientist or consultant, as appropriate.
4. Check below the EFH species and their habitat that could be affected by the project or maintenance activity.

☐ Chinook salmon ☐ Pink salmon ☐ Coho salmon

☐ Groundfish

☐ Coastal-pelagic species

III CONSTRUCTION METHODS AND CONSERVATION MEASURES

1. From the list below, identify all methods that will be required to construct the project. *See SBE Section 3 for a description of each method.*

☐ Method 1: Delineation of Work Areas and Project Startup

☐ Method 2: Clearing, Grubbing, Grading, and Placement of Temporary Fill

Method 3: Work Area Isolation and Fish Removal in Streams, Large Waterbodies and for Pipe Bypass

☐ No isolation will be used for this project.

Describe why none is needed: _____

☐ 3A1: Temporary Bypass for Stream Flow: Partial Channel

☐ 3A2: Temporary Bypass for Stream Flow: Full Channel

☐ 3A3: Isolating Work Areas in Large Waterbodies

☐ 3B: Isolation/Bypassing of Piped Infrastructure

☐ Method 4: Pipe and Culvert Installation and Replacement

Method 5: Vactoring, Jetting, and Excavating Accumulated Sediments; Debris, Sediment Test Boring; and Pipe, Culvert, and Bridge Maintenance

☐ 5A: Vactoring and Jetting

☐ 5B: In-water Excavating

☐ 5C: Sediment Test Boring

Method 6: Bank Stabilization

☐ 6A: Demolish Bulkheads, Revetments, Groins

☐ 6B: Construct Sheet Piling Bulkhead

☐ 6C: Construct Cast-in-place Concrete Bulkhead

☐ 6D: Construct Log or Rock Toe

☐ 6E: Biotechnical Stabilization

☐ 6F: Repair Bulkheads

Method 7: Habitat Addition or Maintenance

☐ 7A: Large Woody Material

☐ 7B: Boulders and Boulder Clusters

☐ 7C: Weirs and Groins

Method 8: Beach Nourishment and Substrate Addition

☐ 8A: Beach Nourishment

☐ 8B: Substrate Addition

Method 9: Boat Launch Improvement, Repair and Maintenance

☐ 8A: Fill Prop Wash Holes

☐ 9B: Replace Ballast, Edge Armoring and Concrete Panels; Repair Concrete Panels

☐ 9C: Pressure Washing Boat Ramps

Method 10: In-water and Overwater Structure Repair and Replacement*

☐ 10A: Piling

☐ 10B: Anchor and Chain Systems

☐ 10C: Superstructure, Decking and Utilities on Fixed Structures

☐ 10D: Floats and Gangways

☐ 10E: Floating Log Boom

☐ 10F: Buoys

☐ 10G: Fixed Breakwaters

☐ 10H: Highway or Road Bridge Foundation or Footing Repair

☐ 10I: Removal of Plants and Animals from Pilings for Inspection or Repair

☐ Method 11: Seawall Repair and Maintenance

☐ Method 12: Site Restoration

☐ Method 13: Landscaping and Planting

*NOTE: Methods 12A through 12G *each* require a different set of conservation measures. All other methods use a specific group of conservation measures for that method.

2. For each method checked above, use the SPIF forms starting on page 6 to provide information <u>specific</u> to your project. If the project does not include a method, do not fill out a form. Fill out each question on each form submitted. Put N/A for questions not applicable to your project.

3. **Conservation Measure (CM)**. For each construction method, there are conservation measures assigned to avoid, reduce or minimize impacts to the environment. On the SPIFs for each construction method there is a table at the end that identifies all the CMs that pertain to that method. Please check, with an X in the box titled "Included in Project?" for each conservation measure you will use. *If a conservation measure is not applicable, or you will not use it, state the reason the CM will not be used. Additional conservation measures may be used. Describe these at the end.* **The use of a CM is important to minimize project impacts to the environment, please do not just check all the CMs thinking they will be used. Consider applicability of each CM and only check those that will be followed.**

IV INTERRELATED AND INTERDEPENDENT ACTIVITIES:

Identify and describe any interrelated and/or interdependent activities that have not already been described in section III (Methods and Conservation Measures) above.

Interrelated actions are those actions that are part of a larger action and depend on the larger action for their justification.

Interdependent actions are actions having no independent utility apart from the proposed action.

V ESA DETERMINATION OF EFFECT:

The Corps requires all applicants to determine if there will be any effect on ESA-listed species or on their critical habitat. Do not use this form if the project will have no effect on all listed species and designated critical habitat; instead use the Appendix B no effect template.

1. Fill out the table below
2. For each species and critical habitat that may occur in the project's action area (identified above in section II Species Information), provide a determination of effect and the rationale for the determination. If you need help in making this determination, please consult your in-house scientist or consultant, as appropriate. Make sure the rational for the effects determination is based on species or critical habitat within the action area and not just the project area.

Species	**Effect Determination**
PS Chinook	☐ No effect ☐ NLAA[2] ☐ LAA[3]
Rationale for Determination – please attach separate sheet if necessary.	
PS Chinook critical habitat	☐ No effect ☐ NLAA ☐ LAA
Rationale for Determination – please attach separate sheet if necessary.	
PS steelhead	☐ No effect ☐ NLAA ☐ LAA
Rationale for Determination – please attach separate sheet if necessary.	
PS steelhead critical habitat	☐ No effect ☐ No jeopardy[4] ☐ Jeopardy[5]
Rationale for Determination – please attach separate sheet if necessary.	

[2] NLAA - "may affect, not likely to adversely affect"
[3] LAA - "may affect, likely to adversely affect"
[4] No jeopardy – "is not likely to jeopardize the continued existence of the species"
[5] Jeopardy – "is likely to jeopardize the continued existence of the species"

SR killer whale	☐ No effect ☐ NLAA ☐ LAA

Rationale for Determination – please attach separate sheet if necessary.

SR killer whale critical habitat	☐ No effect ☐ NLAA ☐ LAA

Rationale for Determination – please attach separate sheet if necessary.

Humpback whale	☐ No effect ☐ NLAA ☐ LAA

Rationale for Determination – please attach separate sheet if necessary.

Eulachon	☐ No effect ☐ NLAA ☐ LAA

Rationale for Determination – please attach separate sheet if necessary.

Bocaccio	☐ No effect ☐ NLAA ☐ LAA

Rationale for Determination – please attach separate sheet if necessary.

Bocaccio critical habitat	☐ No effect ☐ NLAA ☐ LAA

Rationale for Determination – please attach separate sheet if necessary.

Canary rockfish	☐ No effect ☐ NLAA ☐ LAA

Rationale for Determination – please attach separate sheet if necessary.

Canary rockfish critical habitat	☐ No effect ☐ NLAA ☐ LAA	

Rationale for Determination – please attach separate sheet if necessary.

Yelloweye rockfish	☐ No effect ☐ NLAA ☐ LAA	

Rationale for Determination – please attach separate sheet if necessary.

Yelloweye rockfish critical habitat	☐ No effect ☐ NLAA ☐ LAA	

Rationale for Determination – please attach separate sheet if necessary.

CPS bull trout	☐ No effect ☐ NLAA ☐ LAA	

Rationale for Determination – please attach separate sheet if necessary.

CPS bull trout critical habitat	☐ No effect ☐ NLAA ☐ LAA	

Rationale for Determination – please attach separate sheet if necessary.

Marbled murrelet	☐ No effect ☐ NLAA ☐ LAA	

Rationale for Determination – please attach separate sheet if necessary.

VI EFH DETERMINATION OF EFFECT:

For each guild or species and its designated essential fish habitat that may occur in the action area, provide a determination of effect and the rationale for the determination. Please make sure to provide a habitat-based rationale

Guild	**Effect Determination**
Pacific salmon	☐ None in action area ☐ WNAA[6] ☐ WAA[7]
Rationale for Determination – please attach separate sheet if necessary.	
Groundfish	☐ None in action area ☐ WNAA ☐ WAA
Rationale for Determination – please attach separate sheet if necessary.	
Coastal-pelagic	☐ None in action area ☐ WNAA ☐ WAA
Rationale for Determination – please attach separate sheet if necessary.	

ATTACH THE SPIF FORMS SPECIFIC TO EACH METHOD

Attach the Specific Project Information Forms for every method you have selected above.

[6] WNAA is 'will not adversely affect'
[7] WAA is 'will adversely affect'

Method 1: Delineation of Work Areas and Project Startup

Project Title: _____
Project CIP Number: _____

See Section 3 of the SBE, Method 1 for a description of the activity and conservation measures for this method. You need this information to fill out this form.

Has a site visit been made to the project area? ☐ **Yes** ☐ **No**

Who made the site visit? _____

Sensitive areas: Environmentally sensitive areas include marine shorelines, lakes, streams, riparian corridors or wetlands and their buffers.

1. Have all sensitive areas within the project area been identified on a site map?

   ☐ Yes ☐ No

   If no, explain why not, or provide further information: _____
2. Will all sensitive areas be flagged or fenced off? ☐ Yes ☐ No

   If no, explain why not, or provide further information: _____
3. Which sensitive areas will be protected?

   ☐ Marine shoreline
   ☐ Streams
   ☐ Lakes
   ☐ Riparian corridors
   ☐ Wetlands
   ☐ Other (describe) or provide further information: _____
4. How will sensitive areas be protected?

   ☐ Flagging
   ☐ Silt or construction fencing
   ☐ Mulch
   ☐ Wood pallets
   ☐ Other (describe), or provide any further information: _____

Work areas: staging areas

1. Have staging areas been identified? ☐ Yes ☐ No

   If no, explain why not, or provide further information: _____
2. Are staging areas at least 150 ft away from all environmentally sensitive areas?

   ☐ Yes ☐ No

   If no, explain how you will minimize impacts to sensitive areas, or provide further information: _____

Stormwater Pollution Prevention: Temporary Erosion and Sediment Control (TESC) Plan or Construction Stormwater Erosion Control Plan (CSECP)

1. Has a TESC Plan or CSECP been developed for the project? ☐ Yes ☐ No
2. Do you agree to submit a copy of the TESC Plan or CSECP upon request by the Corps or Services?

   ☐ Yes ☐ No

Note: To minimize construction-related sediment input into sensitive areas, especially lakes, streams, and wetlands, sediment control best management practices should be installed between all disturbed areas and sensitive areas. Once construction begins, a review of sensitive area protection may be needed to verify that best management practices are installed properly and all sensitive areas are protected.

Conservation Measures

The following table contains the conservation measures identified for Method 1. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the "Provide additional information" section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
2	Onsite TESC Plan or CSECP	
3	Onsite Spill Prevention and Control Plan	
4	Maintain a spill kit onsite	
5	Confine construction impacts to the minimum area necessary, delineate impacts on project plans and onsite.	
6	Establish staging and site access areas along existing roadways or other disturbed areas	
8	Divert run-off from entering the project area	
9	Implement BMPs to prevent erosion of excavated material	
22	Locate equipment wash areas where washwater, sediment, and pollutants cannot enter waterbodies	
23	Do not track sediment onto paved streets or roadways	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 2: Clearing, Grubbing, Grading, and Placement of Temporary Fill

Project Title: _____
Project CIP Number: _____

See Section 3 of the SBE, Method 2 for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.

What activities will be conducted under this method? Complete those sections below related to the following activities:

☐ Clearing

☐ Grading

☐ Grubbing

☐ Temporary fill

Will any of these activities occur within buffer zones around sensitive areas (e.g. within 50 ft of stream or lake)? ☐ Yes ☐ No

If yes, please describe impact to buffer zone (a map showing impact area may be useful): _____

Is the impact area the minimum size necessary to conduct work? ☐ Yes ☐ No

Has a plan been developed to restore native vegetation (see Method 13)? ☐ Yes ☐ No

Clearing: removal (or pruning) of vegetation

1. Clearing will remove how much vegetation? _____ ft^2
2. Describe the vegetated habitat that will be cleared (e.g., riparian shrub; riparian shrub and herbaceous; riparian shrubs with 2 conifers (~ 15 years old); etc.): _____

Grubbing: root and organic debris removal

1. Grubbing will remove how much vegetation? _____ ft^2
2. Describe the vegetated habitat that will be grubbed (e.g., *English Ivy, Himalayan blackberry, Japanese knotweed, Scot's broom, clematis vitalba, English holly, morning glory, etc.*): _____

Grading: moving earth generally to establish access or staging areas or to prepare sites for foundation installation

1. Grading will remove how much vegetation? _____ ft^2
2. Describe the habitat that will be graded (e.g., *riparian shrub; riparian shrub and herbaceous; riparian shrubs with 2 conifers (~ 15 years old); etc.*) _____
3. What will the final slope of the graded area be (e.g., *2%; 2H:1V, etc.*): _____
4, Is graded area sloping towards a sensitive area? ☐ Yes ☐ No

   If yes, are measures being used to minimize erosion and sediment input into the sensitive area? ☐ Yes ☐ No

Temporary fill

1. Explain why temporary fill will be used? _____
2. Will any fill be placed in waters or wetlands? _____
3. Provide necessary information in table:

Yes	No	Use of Temporary Fill	Amount of Fill Fill Type (e.g., gravel, sand, etc.)	Fill Placed in Water or Wetlands
☐	☐	Stockpiling	yd^3 Type:	☐ No ☐ Yes
☐	☐	Access roads	yd^3 Type:	☐ No ☐ Yes
☐	☐	Work pads	yd^3 Type:	☐ No ☐ Yes
☐	☐	Other:	yd^3 Type:	☐ No ☐ Yes
☐	☐	Other:	yd^3 Type:	☐ No ☐ Yes

4. What methods will be used to protect sensitive areas from the placement of temporary fill?

☐ Timber mats ☐ Other biodegradable material*
☐ Pallets ☐ Hay*
☐ Metal sheeting ☐ Hog fuel (wood waste)*
☐ Other (describe): _____

*complete removal of these materials is not required

5. Will a geotextile separator be used under the temporary fill? ☐ Yes ☐ No
6. Will all imported soil and rock be removed and the surface area be regraded and replanted to equal or better condition? ☐ Yes ☐ No
7. Will area be graded or regraded to equal or better condition? ☐ Yes ☐ No
8. Provide additional information (if needed) on this construction method.

_____

Conservation Measures

The following table contains the conservation measures identified for Method 2. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the “Provide additional information” section below. Provide any additional conservation measures that may be implemented but are

not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work window	
7	Limit clearing and grubbing areas to minimum required, retain vegetation to maximum extent	
9	Implement BMPs to prevent erosion of excavated material	
12	Use sediment barriers to prevent erosion and sediment from entering waterbodies	
13	Keep erosion control materials onsite to respond to emergencies	
14	Use curb inlet sediment traps and geotextile filters to capture sediment before it leaves the site	
19	Operate machinery from existing roads and paved areas	
20	Use temporary materials to stabilize haul and access routes, staging areas, and stockpile areas	
23	Do not track sediment onto paved streets or roadways	
75	Apply pesticides under direct supervision of a licensed applicator	
77	Use herbicide products containing glyphosate or other Ecology-approved herbicide	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 3: Work Area Isolation and Fish Removal in Streams, Large Waterbodies and for Pipe Bypass

3A1: Temporary Bypass for Stream Flow: Partial Channel

Project Title: _____
Project CIP Number: _____

See Section 3 of the SBE, Method 3 for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.

Isolation of In-water Work Area – Temporary Bypass for Stream Flow: Partial Channel

1. How will water be diverted in the channel?

   ☐ Sandbags

   ☐ Portable bladders

   ☐ Other (describe): _____

2. Size of stream area that will be diverted: _____ Length _____ Width.

   Total size of stream: _____ Length _____ Width.

3. Approximate duration in which stream will be bypassed: _____

4. Will any pumping of stream flow be conducted? ☐ No ☐ Yes

5. If pumps are used, what methods will be used to minimize erosion at the discharge site?

   ☐ Ecology block "box" filled with gravel and riprap

   ☐ Porous geotextile bags

   ☐ Flow spreaders

   ☐ Visqueen sheets or geotextile fabric

   ☐ 90-degree elbow at pipe end

   ☐ Other (describe): _____

6. Are any bank protection methods being used to protect channel erosion? ☐ No ☐ Yes

   If yes, explain: _____

7. Has project design for temporary bypass of a partial channel taken into consideration high-flow stormwater runoff that may occur during project construction? ☐ No ☐ Yes

   Provide details: _____

Fish Removal and Handling

1. Will fish be removed from the whole stream where the bypass will occur?

   ☐ No ☐ Yes (fish removal within the whole channel is recommended prior to installation of bypass structure to minimize injury or mortality of fish during construction of bypass structure).

2. What method will be used to capture fish (see Table 4-6, page 4-11 of the SBE)?

   ☐ Minnow traps

   ☐ Seining

   ☐ Dip nets

   ☐ Electrofishing

3. Will all methods in Tables 4-5 and 4-7 on pages 4-10 through 4-12 of the SBE (fish transfer, storage, and release method) be followed?

   ☐ Yes ☐ No

   If no, explain: _____

3. Will all methods in Table 3-1, page 3-13 of the SBE, (stream flow diversion technique) be followed?

   ☐ Yes ☐ No

   If no, explain: _____

4. Will the intake structure of the pump have appropriately sized fish screening per NMFS' Juvenile Fish Screen Criteria and Pump Intake Screen Guidelines? ☐ Yes ☐ No

   If no, explain: _____

5. Has special consideration been made to facilitate fish removal in any pools left after water is diverted? ☐ Yes ☐ No Please explain: _____

Rewatering Work Area

1. Will rewatering of work area occur slowly and stepwise fashion to minimize sediment impacts downstream? ☐ Yes ☐ No

   If no, explain how the water will be reintroduced into the work area: _____

Conservation Measures

The following table contains the conservation measures identified for Method 3A1. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the "Provide additional information" section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
31	Follow proper work area isolation measures	
32	Follow proper fish capture and handling measures	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 3: Work Area Isolation and Fish Removal in Streams, Large Waterbodies and for Pipe Bypass

3A2: *Temporary Bypass for Stream Flow: Full Channel*

Project Title: _____
Project CIP Number: _____

See Section 3 of the SBE, Method 3 for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.

Temporary Bypass for Stream Flow: Full Channel

1. How will water be diverted in the channel?
   - ☐ Sandbags
   - ☐ Portable bladders
   - ☐ Other (describe): _____
2. Size of stream area that will be diverted: _____ Length _____ Width.
3. Approximate duration in which stream will be bypassed: _____
4. What methods will be used to minimize erosion at the discharge site?
   - ☐ Ecology block "box" filled with gravel and riprap
   - ☐ Porous geotextile bags
   - ☐ Flow spreaders
   - ☐ Visqueen sheets or geotextile fabric
   - ☐ 90-degree elbow at pipe end
   - ☐ Other (describe): _____
5. Will any bank protection methods be used to protect channel erosion? ☐ No ☐ Yes

   If yes, explain: _____
6. Has project design for temporary bypass of a full channel taken into consideration high-flow stormwater runoff that may occur during project construction? ☐ No ☐ Yes

   Provide details: _____

Fish Removal and Handling

1. What method will be used to capture fish (see Table 4-6, page 4-11 of the SBE)?
   - ☐ Minnow traps
   - ☐ Seining
   - ☐ Dip nets
   - ☐ Electrofishing

2. Will all methods in Tables 4-5 and 4-7, pages 4-10 through 4-12 of the SBE, (fish transfer, storage, and release method) be followed?

   ☐ Yes ☐ No

   If no, explain: _____

3. Will all methods in Table 3-1, page 3-13 of the SBE, (stream flow diversion technique) be followed?

   ☐ Yes ☐ No

   If no, explain: _____

4. Will the intake structure of the pump have appropriately sized fish screening per NMFS' Juvenile Fish Screen Criteria and Pump Intake Screen Guidelines? ☐ Yes ☐ No

   If no, explain: _____

5. Has special consideration been made to facilitate fish removal in any pools left after water is diverted? ☐ Yes ☐ No Please explain: _____

Rewatering Work Area

1. Will rewatering of work area occur slowly and stepwise fashion to minimize sediment impacts downstream? ☐ Yes ☐ No

   If no, explain how the water will be reintroduced into the work area: _____

Conservation Measures

The following table contains the conservation measures identified for Method 3A2. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the "Provide additional information" section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
31	Follow proper work area isolation measures	
32	Follow proper fish capture and handling measures	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 3: Work Area Isolation and Fish Removal in Streams, Large Waterbodies and for Pipe Bypass

3A3*: Isolating Work Areas in Large Waterbodies*

Project Title: _____
Project CIP Number: _____

See Section 3 of the SBE, Method 3 for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.

Isolating Work Areas in Large Waterbodies

1. What methods will be used to isolate the waterbody?
   - ☐ Silt curtain, sediment curtain, or filter fabric
   - ☐ Sand or gravel bags
   - ☐ Sheet piles
   - ☐ Ecology blocks
   - ☐ K-frames or steel support frames
   - ☐ Other (describe): _____
2. Will the area be dewatered?
   ☐ No ☐ Yes
   ☐ Other (describe): _____
3. Will pumping be necessary? ☐ No ☐ Yes
   If yes, what method will be used to treat water prior to discharge? _____
4. If area is not dewatered, will divers be used to verify that the area is totally isolated from the rest of the waterbody? ☐ No ☐ Yes If not, identify how the verification of complete isolation will occur? _____
5. Is the area to be isolated the minimum amount of area needed to construct the project?
   ☐ No ☐ Yes
6. Provide additional information (if any) on this construction method: _____

Fish Removal and Handling

1. Will fish be removed out of the isolated area? ☐ No ☐ Yes
   What method will be used to capture fish (see Table 4-6, page 4-11 of the SBE)?
   - ☐ Minnow traps
   - ☐ Seining
   - ☐ Dip nets
   - ☐ Electrofishing
2. What is the maximum depth within the isolated area? _____

3. Will the fish removal method collect fish throughout the water column within the isolated area? ☐ No ☐ Yes

   If not, how will it be determined that all fish are removed from inside the isolated area? _____

4. Will the method used to isolate the area be installed in a manner that avoids or minimizes fish being isolated within the work area? ☐ No ☐ Yes

   If yes, explain procedure: _____

5. Will applicable ~~all~~ methods in Tables 4-5, 4-6, and 4-7 of the SBE, (fish transfer, storage, and release method) be followed?

   ☐ Yes ☐ No

   If no, explain: _____

6. Will all methods in Table 3-1, page 3-13 of the SBE, (stream flow diversion technique) be followed?

   ☐ Yes ☐ No

   If no, explain: _____

7. Will the intake structure have appropriately sized fish screening per NMFS' Juvenile Fish Screen Criteria and Pump Intake Screen Guidelines? ☐ Yes ☐ No

   If no, explain: _____

Rewatering Work Area (Do not fill out if work area will not be dewatered)

1. Will rewatering of work area occur slowly and stepwise fashion to minimize sediment impacts downstream? ☐ Yes ☐ No

   If no, explain how the water will be reintroduced into the work area: _____

Conservation Measures

The following table contains the conservation measures identified for Method 3A3. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the "Provide additional information" section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
31	Follow proper work area isolation measures	
32	Follow proper fish capture and handling measures	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 3: Work Area Isolation and Fish Removal in Streams, Large Waterbodies and for Pipe Bypass

3B: *Isolation/Bypassing of Piped Infrastructure*

Project Title: _____
Project CIP Number: _____

See Section 4 of the SBE, Method 3 for a complete description of the activity and a list of the conservation measures for this method. You need this information to fill out this form.

Isolation/Bypassing of Pipe Infrastructure

1. Will work be conducted within 0.25 mile of a discharge point to a creek or other waterbody? ☐ No ☐ Yes. Provide additional information _____
2. Identify methods that will be used:
   - ☐ Backwater from pumped flows will not impact the work area. Flows will be pumped to the nearest downstream maintenance hole.
   - ☐ Backwater is an issue. Pump capacity and diameter of bypass hoses will be increased, or parallel bypasses will be installed.
   - ☐ No maintenance hole is available. Flows will be pumped directly to stream and water quality standards will be met.
   - ☐ Treatment is necessary. Flow may be pumped to a tank for settling and then dispersed onsite and infiltrated into the soil or reintroduced back into the stream. Water quality standards will be met.
   - ☐ Discharge exceeds the capacity of a nearby stream. Flows may be pumped to a tank for offsite disposal.
3. Provide additional information (if any) on this construction method _____

Conservation Measures

The following table contains the conservation measures identified for Method 3B. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the “Provide additional information” section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
31	Follow proper work area isolation measures	
32	Follow proper fish capture and handling measures	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 4: Pipe, Culvert, and Outfall Installation, Removal and Replacement

Project Title: _____
Project CIP Number: _____

See Section 3 of the SBE, Method 4 for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.

Pipe, Culvert, and Outfall Installation, Removal and Replacement

1. Identify methods that will be used:

   Pipe ☐ Installation ☐ Removal ☐ Removal and replacement
   Culvert ☐ Installation ☐ Removal ☐ Removal and replacement
   Outfall ☐ Installation ☐ Removal ☐ Removal and replacement

   ☐ Slip line pipe
   ☐ Directional drill
   ☐ Protection of underground pipe or casing protect pipe
   ☐ Extension of pipe or outfall

2. Identify work, if any, that will occur below the OHW or MHHW line: _____
3. Identify which document was used to assist in design of culvert to facilitate fish passage:

   ☐ NMFS' Anadromous Salmonid Passage Facility Design document.
   ☐ WDFW's manual Design of Road Culverts for Fish Passage.
   ☐ Other: _____

4, Will any bed or fill material be used during installation of culvert or pipe (for pipe to rest on, or to cover pipe)? ☐ No ☐ Yes

   If yes, provide the amount of fill: _____ yd^3

5. Will habitat mix be used to fill any interstitial spaces resulting from installation of bed or fill material ☐ No ☐ Yes

   If yes, provide the amount of fill: _____ yd^3

6. If working in a tidal area, will all work be conducted at low tide ☐ No ☐ Yes
7. Can work be finished within one tidal cycle ☐ No ☐ Yes

   If not, will work be phased so work is complete during each low tide cycle
   ☐ No ☐ Yes

8. Provide additional information (if any) on this construction method _____

Conservation Measures

The following table contains the conservation measures identified for Method 4. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the "Provide additional information" section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
2	Onsite Temporary Erosion and Sediment Control Plan	
3	Onsite Spill Prevention and Control Plan	
4	Maintain a spill kit onsite	
12	Use sediment barriers to prevent erosion and sediment from entering waterbodies	
13	Keep erosion control materials onsite to respond to emergencies	
14	Use curb inlet sediment traps and geotextile filters to capture sediment before it leaves the site	
15	Clean equipment that will work below the OHW or MHHW lines or in riparian or shoreline areas	
16	Fuel equipment in staging areas	
17	Onsite oil absorbing floating booms	
18	Use vegetable-based hydraulic fluid when equipment operates in sensitive areas	
30	Develop a TDP for any dewater lasting more than 1 day	
78	Other chemicals will be subject to Tier 1 chemical applications exemptions and will require approval from the Seattle Parks and Recreation IPM coordinator and the Office of Sustainability and Environment	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 5: Vactoring, Jetting, and Excavating Accumulated Sediments; Debris, Sediment Test Boring; and Pipe, Culvert and Bridge Maintenance

5A: Vactoring and Jetting

Project Title: _____
Project CIP Number: _____

See Section 3 of the SBE, Method 5 for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.

Vactoring and Jetting

1. Will vactoring be used to remove accumulated sediments? ☐ Yes ☐ No
   a. For each site where vactoring will be used, identify the site location (e.g., *Alpha Creek at 1st and Main Street*), the amount of sediment that will be removed, and the disposal location (e.g., *sump, catch basin, vactor disposal area, etc.*) of the sediments.

Site Location	Amount Sediment Removal	Sediment Removed To
	yd^3	
	yd^3	
	yd^3	

2. Will jetting (flushing) be used to flush accumulated sediments? ☐ Yes ☐ No
   a. Will accumulated sediment be removed after jetting? ☐ Yes ☐ No
   b. For each site where flushing will be used, identify the site location (e.g., *Alpha Creek at 1st and Main Street*), the amount of sediment that will be flushed and removed (if any), and the disposal location (e.g., *sump, catch basin, etc.*) of the sediments.

Site Location	Amount Sediment Flushed and/or Removed	Sediment Removed To
	yd^3	
	yd^3	
	yd^3	

3. Provide additional information (if any) on this construction method: _____

Conservation Measures

The following table contains the conservation measures identified for Method 5A. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the “Provide additional information” section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
2	Onsite Temporary Erosion and Sediment Control Plan	
3	Onsite Spill Prevention and Control Plan	
4	Maintain a spill kit onsite	
15	Clean equipment that will work below the OHW or MHHW lines or in riparian or shoreline areas	
16	Fuel equipment in staging areas	
17	Onsite oil absorbing floating booms	
18	Use vegetable-based hydraulic fluid when equipment operates in sensitive areas	
21	Stockpile native streambed or substrate material	
25	Minimize stream and riparian crossings	
26	Manage stream crossings to minimize erosion	
27	Place erosion and water quality control devices prior to beginning of work	
28	If mechanized equipment is used within the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters)	
29	Confine use of equipment operating below OHW or MHHW to designated access corridors	
57	Perform all work in the dry when possible	
58	Conduct work during minus tides or low water levels	
60	Slope or fill excavated trenches in open water between tidal cycles	
61	Equipment and materials are mobilized to and from the site via upland access or construction barge	
62	Do not ground or rest construction barge on substrate or on vegetation	
65	Retrieve and remove debris that enters waterbody	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 5: Vactoring, Jetting, and Excavating Accumulated Sediments; Debris, Sediment Test Boring; and Pipe, Culvert and Bridge Maintenance

5B: In-water Excavating

Project Title: _____
Project CIP Number: _____

See Section 3 of the SBE, Method 5 for a complete description of this activity and conservation measures for this method. You need this information to fill out this form.

Excavating: In-Water

1. Will excavating be used to remove accumulated sediments from below the OHW or MHHW? ☐ Yes ☐ No

   Provide additional information (if any) _____

2. Will excavating be conducted during low tides? ☐ Yes ☐ No

   Provide additional information (if any) _____

3. Will work be done by ☐ hand or ☐ mechanized equipment?

   If mechanized equipment will be used will work be conducted from ☐ shore or ☐ barge?

   a. For each site where excavating will occur below the OHW or MHHW, identify the waterbody (e.g., *Lake Washington, Elliott Bay*), indicate how much sediment will be removed, and describe whether the sediment will be removed from within the wetted perimeter (i.e., within flowing water), from outside the wetted perimeter (i.e., in-the-dry), or from a wetland.

Name Waterbody	Excavation Type and Amount Sediment Removed	
	☐ In wetted perimeter	yd^3
	☐ In the dry	yd^3
	☐ In wetland	yd^3
	☐ In wetted perimeter	yd^3
	☐ In the dry	yd^3
	☐ In wetland	yd^3
	☐ In wetted perimeter	yd^3
	☐ In the dry	yd^3
	☐ In wetland	yd^3

4. Provide additional information (if any) on this construction method: _____

Conservation Measures

The following table contains the conservation measures identified for Method 5B. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the "Provide additional information" section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
2	Onsite Temporary Erosion and Sediment Control Plan	
3	Onsite Spill Prevention and Control Plan	
4	Maintain a spill kit onsite	
15	Clean equipment that will work below the OHW or MHHW lines or in riparian or shoreline areas	
16	Fuel equipment in staging areas	
17	Onsite oil absorbing floating booms	
18	Use vegetable-based hydraulic fluid when equipment operates in sensitive areas	
21	Stockpile native streambed or substrate material	
25	Minimize stream and riparian crossings	
26	Manage stream crossings to minimize erosion	
27	Place erosion and water quality control devices prior to beginning of work	
28	If mechanized equipment is used within the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters)	
29	Confine use of equipment operating below OHW or MHHW to designated access corridors	
57	Perform all work in the dry when possible	
58	Conduct work during minus tides or low water levels	
60	Slope or fill excavated trenches in open water between tidal cycles	
61	Equipment and materials are mobilized to and from the site via upland access or construction barge	
62	Do not ground or rest construction barge on substrate or on vegetation	
65	Retrieve and remove debris that enters waterbody	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 5: Vactoring, Jetting, and Excavating Accumulated Sediments; Debris, Sediment Test Boring; and Pipe, Culvert and Bridge Maintenance

5C: Sediment Test Boring

Project Title: _____
Project CIP Number: _____

See Section 3 of the SBE, Method 5 for a complete description of this activity and conservation measures for this method. You need this information to fill out this form.

Sediment Test Boring

1. Is sediment test boring being conducted below the OHW or MHHW? ☐ Yes ☐ No
2. Number of test bore samples that will be taken? _____
3. Will sediment boring be enclosed in a casing to minimize sediment input into the water column? ☐ Yes ☐ No
4. Provide additional information (if any) on this construction method: _____

Conservation Measures

The following table contains the conservation measures identified for Method 5C. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the “Provide additional information” section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
2	Onsite Temporary Erosion and Sediment Control Plan	
3	Onsite Spill Prevention and Control Plan	
4	Maintain a spill kit onsite	
15	Clean equipment that will work below the OHW or MHHW lines or in riparian or shoreline areas	
16	Fuel equipment in staging areas	
17	Onsite oil absorbing floating booms	
18	Use vegetable-based hydraulic fluid when equipment operates in sensitive areas	

Conservation Measures	Description	Included in Project?
21	Stockpile native streambed or substrate material	
25	Minimize stream and riparian crossings	
26	Manage stream crossings to minimize erosion	
27	Place erosion and water quality control devices prior to beginning of work	
28	If mechanized equipment is used within the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters)	
29	Confine use of equipment operating below OHW or MHHW to designated access corridors	
57	Perform all work in the dry when possible	
58	Conduct work during minus tides or low water levels	
60	Slope or fill excavated trenches in open water between tidal cycles	
61	Equipment and materials are mobilized to and from the site via upland access or construction barge	
62	Do not ground or rest construction barge on substrate or on vegetation	
65	Retrieve and remove debris that enters waterbody	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 5: Vactoring, Jetting, and Excavating Accumulated Sediments; Debris, Sediment Test Boring; and Pipe, Culvert and Bridge Maintenance

5D: Pipe, Culvert and Bridge Maintenance

Project Title: _____

Project CIP Number: _____

See Section 3 of the SBE, Method 5 for a complete description of this activity and conservation measures for this method. You need this information to fill out this form.

Pipe, Culvert, and Bridge Maintenance

1. Identify methods that will be used:

   Pipe ☐ Repair of structural deficiency ☐ Removal of non-embedded material

   Culvert ☐ Repair of structural deficiency ☐ Removal of non-embedded material

   Bridge ☐ Repair of structural deficiency ☐ Removal of non-embedded material

2. Will the non-embedded material (LWD) be removed and placed downstream of the pipe, culvert, or bridge? ☐ Yes ☐ No

3. Provide additional information (if any) on this construction method: _____

Conservation Measures

The following table contains the conservation measures identified for Method 5D. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the “Provide additional information” section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
2	Onsite Temporary Erosion and Sediment Control Plan	
3	Onsite Spill Prevention and Control Plan	
4	Maintain a spill kit onsite	
15	Clean equipment that will work below the OHW or MHHW lines or in riparian or shoreline areas	
16	Fuel equipment in staging areas	
17	Onsite oil absorbing floating booms	

Conservation Measures	Description	Included in Project?
18	Use vegetable-based hydraulic fluid when equipment operates in sensitive areas	
21	Stockpile native streambed or substrate material	
25	Minimize stream and riparian crossings	
26	Manage stream crossings to minimize erosion	
27	Place erosion and water quality control devices prior to beginning of work	
28	If mechanized equipment is used within the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters)	
29	Confine use of equipment operating below OHW or MHHW to designated access corridors	
57	Perform all work in the dry when possible	
58	Conduct work during minus tides or low water levels	
60	Slope or fill excavated trenches in open water between tidal cycles	
61	Equipment and materials are mobilized to and from the site via upland access or construction barge	
62	Do not ground or rest construction barge on substrate or on vegetation	
65	Retrieve and remove debris that enters waterbody	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 6: Bank Stabilization

6A: *Demolish Bulkheads, Revetments, Groins*

Project Title: _____
Project CIP Number: _____

See Section 3 of the SBE, Method 6 for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.

Demolish Bulkheads, Revetments, or Groins

1. Identify the type and length of stabilization structure to be demolished.

Yes	No	Demolish Type Structure	Length Demolished
☐	☐	Concrete bulkhead	linear feet
☐	☐	Sheetpile bulkhead	linear feet
☐	☐	Revetment	linear feet
☐	☐	Groin	linear feet
☐	☐	Other:	linear feet
☐	☐	Other:	linear feet

2. Will shoreline be graded? ☐ No ☐ Yes (if yes, fill out form for **Method 2**).
3. Are there any utilities that will need to be avoided or relocated? ☐ No ☐ Yes If yes, explain what will occur with the utility: _____
4. If sheet piles cannot be fully extracted, will they be cut at or 2 feet below the mudline?
   ☐ Yes ☐ No If no, explain or provide additional information: _____
5. Are riparian plantings going to be added to the project? ☐ No ☐ Yes (if yes, fill out form for **Method 13**)
6. Provide additional information (if any) on this construction method: _____

Conservation Measures

The following table contains the conservation measures identified for Method 6A. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the “Provide additional information” section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
2	Onsite Temporary Erosion and Sediment Control Plan	
3	Onsite Spill Prevention and Control Plan	
4	Maintain a spill kit onsite	
9	Implement BMPs to prevent erosion of excavated material	
15	Clean equipment that will work below the OHW or MHHW lines or in riparian or shoreline areas	
16	Fuel equipment in staging areas	
17	Onsite oil absorbing floating booms	
18	Use vegetable-based hydraulic fluid when equipment operates in sensitive areas	
27	Place erosion and water quality control devices prior to beginning of work	
28	If mechanized equipment is used within the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters)	
29	Confine use of equipment operating below OHW or MHHW to designated access corridors	
45	Use plastic, cement or timber piles over steel piles	
46	Use containment boom	
47	Cap holes from pulling or cutting treated pilings	
48	Do not use piling treated with creosote, pentachloraphenol, or coal tar.	
49	Do not use hydraulic water jets to remove or place piling	
50	Replace piling in same general location (see CM# 34)	
51	All treated wood removed will be contained on land or barge to preclude sediments and contaminated materials from entering water.	
52	Use vibratory driver for installing piles	
53	Use bubble curtain or other noise attenuation method	
54	Conduct hydroacoustic monitoring during installation of large piles	
55	Reduce noise from work operation	
57	Perform all work in the dry when possible	
58	Conduct work during minus tides or low water levels	
59	Use clean, washed material	
62	Do not ground or rest construction barge on substrate or on vegetation	
63	Take care to prevent spread of invasive plant species during their removal	
64	Plant with native vegetation	

Conservation Measures	Description	Included in Project?
65	Retrieve and remove debris that enters waterbody	
67	Use clean grave (less than 3% fines)	
69	No wet concrete or epoxy shall come in contact with water	
70	Move bulkhead above the OHW or MHHW	
71	Construct bulkhead to contain habitat complexity (i.e. coves)	
72	Plant bulkhead with native riparian vegetation	
73	Include rootwads and LWD with riprap	
74	Cover riprap with habitat mix to fill voids	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 6: Bank Stabilization

6B: *Construct Sheet Pile Bulkhead*

Project Title: _____
Project CIP Number: _____

See Section 3 of the SBE, Method 6 for a complete description of this activity and conservation measures for this method. You need this information to fill out this form.

Construct Sheet Pile Bulkhead

1. Will shoreline be graded? ☐ No ☐ Yes (if yes, fill out form for **Method 2**).
2. How many linear feet of sheet pile bulkhead will be constructed? _____
3. Is the new bulkhead landward of the previous bulkhead (if there was one)? ☐ No ☐ Yes
4. Will auger cast pilings be installed? ☐ No ☐ Yes
5. Describe tie-backs or deadman anchors that will be used: _____
6. Will aggregate backfill be installed behind the bulkhead. ☐ No ☐ Yes If yes, identify size _____ ft^2 and quantity _____ yd^3
7. Will drainage piping be installed? ☐ Yes ☐ No

   Where will drainage piping drain to? _____
8. Will armoring be installed at the toe? ☐ No ☐ Yes (if yes, fill out **Method 7D**)
9. Describe the amount of clean gravel (habitat mix) that will be placed at the toe:

   _____ yd^3; _____ inches in depth
10. Are riparian plantings going to be added to the project? ☐ No ☐ Yes (if yes, fill out form for **Method 13**)
11. Provide additional information (if any) on this construction method: _____

Conservation Measures

The following table contains the conservation measures identified for Method 6B. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the “Provide additional information” section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
2	Onsite Temporary Erosion and Sediment Control Plan	
3	Onsite Spill Prevention and Control Plan	
4	Maintain a spill kit onsite	
9	Implement BMPs to prevent erosion of excavated material	
15	Clean equipment that will work below the OHW or MHHW lines or in riparian or shoreline areas	
16	Fuel equipment in staging areas	
17	Onsite oil absorbing floating booms	
18	Use vegetable-based hydraulic fluid when equipment operates in sensitive areas	
27	Place erosion and water quality control devices prior to beginning of work	
28	If mechanized equipment is used within the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters)	
29	Confine use of equipment operating below OHW or MHHW to designated access corridors	
45	Use plastic, cement or timber piles over steel piles	
46	Use containment boom	
47	Cap holes from pulling or cutting treated pilings	
48	Do not use piling treated with creosote, pentachloraphenol, or coal tar.	
49	Do not use hydraulic water jets to remove or place piling	
50	Replace piling in same general location (see CM# 34)	
51	All treated wood removed will be contained on land or barge to preclude sediments and contaminated material from entering water.	
52	Use vibratory driver for installing piles	
53	Use bubble curtain or other noise attenuation method	
54	Conduct hydroacoustic monitoring during installation of large piles	
55	Reduce noise from work operation	
57	Perform all work in the dry when possible	
58	Conduct work during minus tides or low water levels	
59	Use clean, washed material	
62	Do not ground or rest construction barge on substrate or on vegetation	
63	Take care to prevent spread of invasive plant species during their removal	
64	Plant with native vegetation	
65	Retrieve and remove debris that enters waterbody	
67	Use clean grave (less than 3% fines)	
69	No wet concrete or epoxy shall come in contact with water	
70	Move bulkhead above the OHW or MHHW	

Conservation Measures	Description	Included in Project?
71	Construct bulkhead to contain habitat complexity (i.e. coves)	
72	Plant bulkhead with native riparian vegetation	
73	Include rootwads and LWD with riprap	
74	Cover riprap with habitat mix to fill voids	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 6: Bank Stabilization

6C: *Construct Cast-in-place Concrete Bulkhead*

Project Title: _____
Project CIP Number: _____

See Section 3 of the SBE, Method 6 for a description of the activity and conservation measures for this method. You need this information to fill out this form.

Construct Cast-in-place Concrete Bulkhead

1. Will shoreline be graded? ☐ No ☐ Yes (if yes, fill out form for **Method 2**).
2. How many linear feet of cast-in-place concrete bulkhead will be constructed? _____
3. Is the new bulkhead landward of the previous bulkhead (if there was one)?
   ☐ No ☐ Yes
4. In tidal waters, will concrete be poured into forms when tide is out?
   ☐ Yes ☐ No If no, explain: _____
5. Are measures in place to make sure wet concrete does not come in contact with marine or fresh water? ☐ No ☐ Yes
6. Will aggregate backfill be installed behind bulkhead. ☐ No ☐ Yes If yes, identify size _____ ft^2 and quantity _____ yd^3
7. Will drainage piping be installed? ☐ Yes ☐ No
   Where will drainage piping drain to? _____
8. Will armoring be installed at the toe? ☐ No ☐ Yes (if yes, fill out **Method 7D**).
9. Describe the amount of clean gravel (habitat mix) that will be placed at the toe:
   _____ yd^3; _____ inches in depth
10. Are riparian plantings going to be added to the project? ☐ No ☐ Yes (if yes, fill out form for **Method 13**)
11. Provide additional information (if any) on this construction method: _____

Conservation Measures

The following table contains the conservation measures identified for Method 6C. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the “Provide additional information” section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
2	Onsite Temporary Erosion and Sediment Control Plan	
3	Onsite Spill Prevention and Control Plan	
4	Maintain a spill kit onsite	
9	Implement BMPs to prevent erosion of excavated material	
15	Clean equipment that will work below the OHW or MHHW lines or in riparian or shoreline areas	
16	Fuel equipment in staging areas	
17	Onsite oil absorbing floating booms	
18	Use vegetable-based hydraulic fluid when equipment operates in sensitive areas	
27	Place erosion and water quality control devices prior to beginning of work	
28	If mechanized equipment is used within the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters)	
29	Confine use of equipment operating below OHW or MHHW to designated access corridors	
45	Use plastic, cement or timber piles over steel piles	
46	Use containment boom	
47	Cap holes from pulling or cutting treated pilings	
48	Do not use piling treated with creosote, pentachloraphenol, or coal tar.	
49	Do not use hydraulic water jets to remove or place piling	
50	Replace piling in same general location (see CM# 34)	
51	All treated wood removed will be contained on land or barge to preclude sediments and contaminated material from entering water.	
52	Use vibratory driver for installing piles	
53	Use bubble curtain or other noise attenuation method	
54	Conduct hydroacoustic monitoring during installation of large piles	
55	Reduce noise from work operation	
57	Perform all work in the dry when possible	
58	Conduct work during minus tides or low water levels	
59	Use clean, washed material	
62	Do not ground or rest construction barge on substrate or on vegetation	
63	Take care to prevent spread of invasive plant species during their removal	
64	Plant with native vegetation	

Conservation Measures	Description	Included in Project?
65	Retrieve and remove debris that enters waterbody	
67	Use clean grave (less than 3% fines)	
69	No wet concrete or epoxy shall come in contact with water	
70	Move bulkhead above the OHW or MHHW	
71	Construct bulkhead to contain habitat complexity (i.e. coves)	
72	Plant bulkhead with native riparian vegetation	
73	Include rootwads and LWD with riprap	
74	Cover riprap with habitat mix to fill voids	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 6: Bank Stabilization

6D: *Construct Log or Rock Toe*

Project Title: _____
Project CIP Number: _____

See Section 3 of the SBE, Method 6 for a complete description of this activity and conservation measures for this method. You need this information to fill out this form.

Construct Log or Rock Toe

1. Will shoreline be graded? ☐ No ☐ Yes (if yes, fill out form for **Method 2**).
2. How many linear feet of log toe will be constructed? _____
3. How many linear feet of rock toe will be constructed? _____
4. Describe the size (_____ ft^2) and amount (_____ yd^3) of rock that will be placed to make the log or rock toe?
5. Describe the amount of clean gravel (habitat mix) that will be placed to fill any voids: _____ yd^3
6. Are any of the following being installed?
   - ☐ Root wads How many _____
   - ☐ Large wood debris How many _____
   - ☐ Live stakes How many _____
7. Are riparian plantings going to be added to the project? ☐ No ☐ Yes (if yes, fill out form for **Method 13**)
8. Provide additional information (if any) on this construction method: _____

Conservation Measures

The following table contains the conservation measures identified for Method 6D. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the “Provide additional information” section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
2	Onsite Temporary Erosion and Sediment Control Plan	
3	Onsite Spill Prevention and Control Plan	
4	Maintain a spill kit onsite	
9	Implement BMPs to prevent erosion of excavated material	
15	Clean equipment that will work below the OHW or MHHW lines or in riparian or shoreline areas	
16	Fuel equipment in staging areas	
17	Onsite oil absorbing floating booms	
18	Use vegetable-based hydraulic fluid when equipment operates in sensitive areas	
27	Place erosion and water quality control devices prior to beginning of work	
28	If mechanized equipment is used within the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters)	
29	Confine use of equipment operating below OHW or MHHW to designated access corridors	
45	Use plastic, cement or timber piles over steel piles	
46	Use containment boom	
47	Cap holes from pulling or cutting treated pilings	
48	Do not use piling treated with creosote, pentachloraphenol, or coal tar.	
49	Do not use hydraulic water jets to remove or place piling	
50	Replace piling in same general location (see CM# 34)	
51	All treated wood removed will be contained on land or barge to preclude sediments and contaminated material from entering water.	
52	Use vibratory driver for installing piles	
53	Use bubble curtain or other noise attenuation method	
54	Conduct hydroacoustic monitoring during installation of large piles	
55	Reduce noise from work operation	
57	Perform all work in the dry when possible	
58	Conduct work during minus tides or low water levels	
59	Use clean, washed material	
62	Do not ground or rest construction barge on substrate or on vegetation	
63	Take care to prevent spread of invasive plant species during their removal	
64	Plant with native vegetation	
65	Retrieve and remove debris that enters waterbody	
67	Use clean gravel (less than 3% fines)	
69	No wet concrete or epoxy shall come in contact with water	
70	Move bulkhead above the OHW or MHHW	

Conservation Measures	Description	Included in Project?
71	Construct bulkhead to contain habitat complexity (i.e. coves)	
72	Plant bulkhead with native riparian vegetation	
73	Include rootwads and LWD with riprap	
74	Cover riprap with habitat mix to fill voids	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 6: Bank Stabilization

6E: *Biotechnical Stabilization*

Project Title: _____
Project CIP Number: _____

See Section 3 of the SBE, Method 6 for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.

Biotechnical Stabilization

1. Will shoreline be graded? ☐ No ☐ Yes (if yes, fill out form for **Method 2**).
2. Which of the following permanent stabilization methods will be installed or implemented?
   - ☐ Brush layering
   - ☐ Brush matting
   - ☐ Fascines
   - ☐ Geotextile fabric
   - ☐ Coir blankets
   - ☐ Coir logs
   - ☐ Soil wraps
   - ☐ Reinforced soil lifts
   - ☐ Root wads
   - ☐ Mulching around native vegetation
   - ☐ Herbaceous cover type: _____
   - ☐ Native woody vegetation type: _____
   - ☐ Other (describe): _____
3. How many linear feet of biotechnical stabilization will be constructed? _____
4. Provide additional information (if needed) on this construction method: _____

Conservation Measures

The following table contains the conservation measures identified for Method 6E. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the "Provide additional information" section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
2	Onsite Temporary Erosion and Sediment Control Plan	
3	Onsite Spill Prevention and Control Plan	
4	Maintain a spill kit onsite	

Conservation Measures	Description	Included in Project?
9	Implement BMPs to prevent erosion of excavated material	
15	Clean equipment that will work below the OHW or MHHW lines or in riparian or shoreline areas	
16	Fuel equipment in staging areas	
17	Onsite oil absorbing floating booms	
18	Use vegetable-based hydraulic fluid when equipment operates in sensitive areas	
27	Place erosion and water quality control devices prior to beginning of work	
28	If mechanized equipment is used within the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters)	
29	Confine use of equipment operating below OHW or MHHW to designated access corridors	
45	Use plastic, cement or timber piles over steel piles	
46	Use containment boom	
47	Cap holes from pulling or cutting treated pilings	
48	Do not use piling treated with creosote, pentachloraphenol, or coal tar.	
49	Do not use hydraulic water jets to remove or place piling	
50	Replace piling in same general location (see CM# 34)	
51	All treated wood removed will be contained on land or barge to preclude sediments and contaminated material from entering water.	
52	Use vibratory driver for installing piles	
53	Use bubble curtain or other noise attenuation method	
54	Conduct hydroacoustic monitoring during installation of large piles	
55	Reduce noise from work operation	
57	Perform all work in the dry when possible	
58	Conduct work during minus tides or low water levels	
59	Use clean, washed material	
62	Do not ground or rest construction barge on substrate or on vegetation	
63	Take care to prevent spread of invasive plant species during their removal	
64	Plant with native vegetation	
65	Retrieve and remove debris that enters waterbody	
67	Use clean grave (less than 3% fines)	
69	No wet concrete or epoxy shall come in contact with water	
70	Move bulkhead above the OHW or MHHW	
71	Construct bulkhead to contain habitat complexity (i.e. coves)	
72	Plant bulkhead with native riparian vegetation	
73	Include rootwads and LWD with riprap	
74	Cover riprap with habitat mix to fill voids	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 6: Bank Stabilization

6F: *Repair Bulkheads*

Project Title: _____
Project CIP Number: _____

See Section 3 of the SBE, Method 6 for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.

Repair Bulkheads

1. Will the footprint of the repaired or replaced bulkhead be larger, smaller or the same size as the existing bulkhead?

Larger	Smaller	Same Size	Type Replacement or Repair	Amt. Smaller or Larger
☐	☐	☐	Replace eroded substrate	ft^2
☐	☐	☐	Face bulkhead with riprap	ft^2
☐	☐	☐	Reset/replace rock, riprap, spalls	ft^2
☐	☐	☐	Replace section broken bulkhead	ft^2
☐	☐	☐	Repair cantilever soldier piles	ft^2
☐	☐	☐	Other:	ft^2
☐	☐	☐	Other:	ft^2

2. Describe the size (_____ ft^2) and amount of rock (_____ yd^3) that will replace the eroded substrate?
3. Describe the amount of clean gravel (habitat mix) that will be placed to fill any voids: _____ yd^3
4. If concrete is going to be used, are measures in place to make sure wet concrete does not come in contact with marine or fresh water? ☐ No ☐ Yes
5. Provide additional information (if any) on this method: _____

Conservation Measures

The following table contains the conservation measures identified for Method 6F. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the “Provide additional information” section below. Provide any additional conservation measures that may be implemented but are

not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
2	Onsite Temporary Erosion and Sediment Control Plan	
3	Onsite Spill Prevention and Control Plan	
4	Maintain a spill kit onsite	
9	Implement BMPs to prevent erosion of excavated material	
15	Clean equipment that will work below the OHW or MHHW lines or in riparian or shoreline areas	
16	Fuel equipment in staging areas	
17	Onsite oil absorbing floating booms	
18	Use vegetable-based hydraulic fluid when equipment operates in sensitive areas	
27	Place erosion and water quality control devices prior to beginning of work	
28	If mechanized equipment is used within the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters)	
29	Confine use of equipment operating below OHW or MHHW to designated access corridors	
45	Use plastic, cement or timber piles over steel piles	
46	Use containment boom	
47	Cap holes from pulling or cutting treated pilings	
48	Do not use piling treated with creosote, pentachloraphenol, or coal tar.	
49	Do not use hydraulic water jets to remove or place piling	
50	Replace piling in same general location (see CM# 34)	
51	All treated wood removed will be contained on land or barge to preclude sediments and contaminated material from entering water.	
52	Use vibratory driver for installing piles	
53	Use bubble curtain or other noise attenuation method	
54	Conduct hydroacoustic monitoring during installation of large piles	
55	Reduce noise from work operation	
57	Perform all work in the dry when possible	
58	Conduct work during minus tides or low water levels	
59	Use clean, washed material	
62	Do not ground or rest construction barge on substrate or on vegetation	
63	Take care to prevent spread of invasive plant species during their removal	

Conservation Measures	Description	Included in Project?
64	Plant with native vegetation	
65	Retrieve and remove debris that enters waterbody	
67	Use clean grave (less than 3% fines)	
69	No wet concrete or epoxy shall come in contact with water	
70	Move bulkhead above the OHW or MHHW	
71	Construct bulkhead to contain habitat complexity (i.e. coves)	
72	Plant bulkhead with native riparian vegetation	
73	Include rootwads and LWD with riprap	
74	Cover riprap with habitat mix to fill voids	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 7: Habitat Addition and Maintenance

7A: *Large Woody Material*

Project Title: _____
Project CIP Number: _____

See Section 3 of the SBE, Method 7 for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.

Large Woody Material

1. Describe the number of large woody material elements that will be installed

Yes	No	Type of Woody Material	Number
☐	☐	Whole trees with root wads and limbs	
☐	☐	Tree pieces with/without roots and limbs	
☐	☐	Cut logs	
☐	☐	Rootwads with roots attached.	
☐	☐	Other:	

2. What is the length of the work along the waterbody? _____

3. Will rootwads (large woody debris) be installed so they do not rest on stream or lake bottom, but provide area under the rootwad for cover? ☐ Yes ☐ No

4. Will rootwads (large woody debris) be installed so they are in the water and provide fish habitat at all times? ☐ Yes ☐ No

5. Will design comply with guidance provided in *WDFW Stream Habitat Restoration Guidelines* (2004)? ☐ Yes ☐ No

   Explain rationale for design selected if WDFW guidelines will not be complied with, or provide additional information: _____

   Other (specify): _____

6. Describe anchoring method (e.g., *bole burial and ballasting, pinned with rebar, etc*.): _____

7. Describe installation method (e.g., *by hand, type of machines, etc*.): _____

8. Provide additional information (if any) on this construction method: _____

Conservation Measures

The following table contains the conservation measures identified for Method 7A. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the "Provide additional information" section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
2	Onsite Temporary Erosion and Sediment Control Plan	
3	Onsite Spill Prevention and Control Plan	
4	Maintain a spill kit onsite	
5	Confine construction impacts to the minimum area necessary, delineate impacts on project plans and onsite	
6	Establish staging and site access areas along existing roadways or other disturbed areas	
7	Limit clearing and grubbing areas to minimum required, retain vegetation to maximum extent	
9	Implement BMPs to prevent erosion of excavated material	
10	Stockpile large wood, vegetation, and soils for establishment of staging area and site restoration	
11	Salvage debris to use for habitat or mulch	
12	Use sediment barriers to prevent erosion and sediment from entering waterbodies	
13	Keep erosion control materials onsite to respond to emergencies	
14	Use curb inlet sediment traps and geotextile filters to capture sediment before it leaves the site	
15	Clean equipment that will work below the OHW or MHHW lines or in riparian or shoreline areas	
16	Fuel equipment in staging areas	
17	Onsite oil absorbing floating booms	
18	Use vegetable-based hydraulic fluid when equipment operates in sensitive areas	
19	Operate machinery from existing roads and paved areas	
20	Use temporary materials to stabilize haul and access routes, staging areas, and stockpile areas	
21	Stockpile native streambed or substrate material	
22	Locate equipment wash areas where washwater, sediment, and pollutants cannot enter waterbodies	
25	Minimize stream and riparian crossings	
26	Manage stream crossings to minimize erosion	

Conservation Measures	Description	Included in Project?
27	Place erosion and water quality control devices prior to beginning of work	
28	If mechanized equipment is used within the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters)	
29	Confine use of equipment operating below OHW or MHHW to designated access corridors	
30	Develop a TDP for any dewater lasting more than 1 day	
57	Perform all work in the dry when possible	
58	Conduct work during minus tides or low water levels	
59	Use clean, washed material	
60	Slope or fill excavated trenches in open water between tidal cycles	
61	Equipment and materials are mobilized to and from the site via upland access or construction barge	
62	Do not ground or rest construction barge on substrate or on vegetation	
63	Take care to prevent spread of invasive plant species during their removal	
64	Plant with native vegetation	
65	Retrieve and remove debris that enters waterbody	
68	Use habitat mix	
69	No wet concrete or epoxy shall come in contact with water	
75	Apply pesticides under direct supervision of a licensed applicator	
76	Use pesticides only to control weeds listed on King County Noxious Week list	
77	Use herbicide products containing glyphosate or other Ecology-approved herbicide	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 7: Habitat Addition and Maintenance

7B: *Boulders and Boulder Clusters*

Project Title: _____
Project CIP Number: _____

See Section 3 of the SBE, Method 7 for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.

Boulders or Boulder Clusters

1. Describe the number of boulders and boulder clusters that will be installed.

Yes	No	Type of Rock Material	Number
☐	☐	Single boulders	
☐	☐	Boulder clusters	
☐	☐	Other:	
☐	☐	Other:	

2. What is the length of the work along the waterbody? _____

3. Will design comply with guidance provided in *WDFW Stream Habitat Restoration Guidelines* (2004)? ☐ Yes ☐ No

   Explain rationale for design selected if WDFW guidelines will not be complied with, or provide additional information: _____

4. Describe installation method (e.g., *by hand, type of machines, etc*.): _____

5 Provide additional information (if any) on this construction method: _____

Conservation Measures

The following table contains the conservation measures identified for Method 7B. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the “Provide additional information” section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
2	Onsite Temporary Erosion and Sediment Control Plan	
3	Onsite Spill Prevention and Control Plan	
4	Maintain a spill kit onsite	
5	Confine construction impacts to the minimum area necessary, delineate impacts on project plans and onsite	
6	Establish staging and site access areas along existing roadways or other disturbed areas	
7	Limit clearing and grubbing areas to minimum required, retain vegetation to maximum extent	
9	Implement BMPs to prevent erosion of excavated material	
10	Stockpile large wood, vegetation, and soils for establishment of staging area and site restoration	
11	Salvage debris to use for habitat or mulch	
12	Use sediment barriers to prevent erosion and sediment from entering waterbodies	
13	Keep erosion control materials onsite to respond to emergencies	
14	Use curb inlet sediment traps and geotextile filters to capture sediment before it leaves the site	
15	Clean equipment that will work below the OHW or MHHW lines or in riparian or shoreline areas	
16	Fuel equipment in staging areas	
17	Onsite oil absorbing floating booms	
18	Use vegetable-based hydraulic fluid when equipment operates in sensitive areas	
19	Operate machinery from existing roads and paved areas	
20	Use temporary materials to stabilize haul and access routes, staging areas, and stockpile areas	
21	Stockpile native streambed or substrate material	
22	Locate equipment wash areas where washwater, sediment, and pollutants cannot enter waterbodies	
25	Minimize stream and riparian crossings	
26	Manage stream crossings to minimize erosion	

Conservation Measures	Description	Included in Project?
27	Place erosion and water quality control devices prior to beginning of work	
28	If mechanized equipment is used within the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters)	
29	Confine use of equipment operating below OHW or MHHW to designated access corridors	
30	Develop a TDP for any dewater lasting more than 1 day	
57	Perform all work in the dry when possible	
58	Conduct work during minus tides or low water levels	
59	Use clean, washed material	
60	Slope or fill excavated trenches in open water between tidal cycles	
61	Equipment and materials are mobilized to and from the site via upland access or construction barge	
62	Do not ground or rest construction barge on substrate or on vegetation	
63	Take care to prevent spread of invasive plant species during their removal	
64	Plant with native vegetation	
65	Retrieve and remove debris that enters waterbody	
68	Use habitat mix	
69	No wet concrete or epoxy shall come in contact with water	
75	Apply pesticides under direct supervision of a licensed applicator	
76	Use pesticides only to control weeds listed on King County Noxious Week list	
77	Use herbicide products containing glyphosate or other Ecology-approved herbicide	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 7: Habitat Addition and Maintenance

7C: *Weirs or Groins*

Project Title: _____
Project CIP Number: _____

See Section 3 of the SBE, Method 7 for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.

Weirs or Groins

1. Describe whether weirs that fully span or partially span the width of the waterbody will be installed, the number of each type of weir that will be installed, and the material (e.g., *log, rock*) that will be used to construct the weirs.

Yes	No	Type of Weir	Number	Type Construction Material
☐	☐	Partial span weirs		
☐	☐	Full span weirs		
☐	☐	Other:		
☐	☐	Other:		

2. Describe the type of groins that will be installed,(e.g., *log, rock, etc.*) the number of each type that will be installed, and the orientation of the groin relative to stream flow (e.g., *downstream at 15 degree angle from bank*).

Yes	No	Type of Groin	Number	Orientation
☐	☐	Log		
☐	☐	Rock		
☐	☐	Other:		
☐	☐	Other:		

3. What is the length of the work along the waterbody? _____

4. Will design comply with guidance provided for weirs and groins in *WDFW Integrated Stream Protection Guidelines* (2003)? ☐ Yes ☐ No

   Explain rationale for design selected if WDFW guidelines will not be complied with or provide additional information: _____

5. Provide additional information (if any) on this construction method: _____

Conservation Measures

The following table contains the conservation measures identified for Method 7C. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the "Provide additional information" section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
2	Onsite Temporary Erosion and Sediment Control Plan	
3	Onsite Spill Prevention and Control Plan	
4	Maintain a spill kit onsite	
5	Confine construction impacts to the minimum area necessary, delineate impacts on project plans and onsite	
6	Establish staging and site access areas along existing roadways or other disturbed areas	
7	Limit clearing and grubbing areas to minimum required, retain vegetation to maximum extent	
9	Implement BMPs to prevent erosion of excavated material	
10	Stockpile large wood, vegetation, and soils for establishment of staging area and site restoration	
11	Salvage debris to use for habitat or mulch	
12	Use sediment barriers to prevent erosion and sediment from entering waterbodies	
13	Keep erosion control materials onsite to respond to emergencies	
14	Use curb inlet sediment traps and geotextile filters to capture sediment before it leaves the site	
15	Clean equipment that will work below the OHW or MHHW lines or in riparian or shoreline areas	
16	Fuel equipment in staging areas	
17	Onsite oil absorbing floating booms	
18	Use vegetable-based hydraulic fluid when equipment operates in sensitive areas	
19	Operate machinery from existing roads and paved areas	
20	Use temporary materials to stabilize haul and access routes, staging areas, and stockpile areas	
21	Stockpile native streambed or substrate material	
22	Locate equipment wash areas where washwater, sediment, and pollutants cannot enter waterbodies	
25	Minimize stream and riparian crossings	

Conservation Measures	Description	Included in Project?
26	Manage stream crossings to minimize erosion	
27	Place erosion and water quality control devices prior to beginning of work	
28	If mechanized equipment is used within the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters)	
29	Confine use of equipment operating below OHW or MHHW to designated access corridors	
30	Develop a TDP for any dewater lasting more than 1 day	
57	Perform all work in the dry when possible	
58	Conduct work during minus tides or low water levels	
59	Use clean, washed material	
60	Slope or fill excavated trenches in open water between tidal cycles	
61	Equipment and materials are mobilized to and from the site via upland access or construction barge	
62	Do not ground or rest construction barge on substrate or on vegetation	
63	Take care to prevent spread of invasive plant species during their removal	
64	Plant with native vegetation	
65	Retrieve and remove debris that enters waterbody	
68	Use habitat mix	
69	No wet concrete or epoxy shall come in contact with water	
75	Apply pesticides under direct supervision of a licensed applicator	
76	Use pesticides only to control weeds listed on King County Noxious Week list	
77	Use herbicide products containing glyphosate or other Ecology-approved herbicide	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 8: Beach Nourishment and Substrate Addition

8A: *Beach Nourishment*

Project Title: _____
Project CIP Number: _____

See Section 3 of the SBE, Method 8 for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.

Beach Nourishment

1. Indicate the type of material, the quantity of material, and the slope of the beach onto which the material will be placed.

Yes	No	Type of Material	Quantity of Material	Footprint of Material	Slope of Beach
☐	☐	Sand	yd^3	Length Width	%
☐	☐	Gravel	yd^3	Length Width	%
☐	☐	Clean cobble	yd^3	Length Width	%
☐	☐	Other:	yd^3	Length Width	%

2. Will any material be placed directly into the water? ☐ No ☐ Yes If yes, provide further information on amount and how material will be distributed. _____
3. How will the material be spread on the beach?
   - ☐ Trucked in and placed by front-end loader, tractor or backhoe
   - ☐ Trucked in and placed on beach and allowed to distribute by wave action
   - ☐ Barged in and placed on beach by conveyor system
   - ☐ Other: _____
4. Will material be placed on beach during low tide, or when lake level is at its lowest level?
   ☐ No ☐ Yes
5. Will beach be graded? ☐ No ☐ Yes (if yes, fill out form for **Method 2**)
6. Provide additional information (if any) on this construction method: _____

Conservation Measures

The following table contains the conservation measures identified for Method 8A. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the "Provide additional information" section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
4	Maintain a spill kit onsite	
15	Clean equipment that will work below the OHW or MHHW lines or in riparian or shoreline areas	
16	Fuel equipment in staging areas	
18	Use vegetable-based hydraulic fluid when equipment operates in sensitive areas	
27	Place erosion and water quality control devices prior to beginning of work	
28	<u>If mechanized equipment is used within the OHW or MHHW,</u> only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters). This prevents material from entering the water during construction. It is recommended that a tarp be placed on the substrate of the work area. All debris removed shall be disposed of offsite in an approved upland disposal area.	
29	Confine use of equipment operating below OHW or MHHW to designated access corridors	
57	Perform all work in the dry when possible	
58	Conduct work during minus tides or low water levels	
59	Use clean, washed material	
62	Do not ground or rest construction barge on substrate or on vegetation	
66	Use clean, washed beach material	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 8: Beach Nourishment and Substrate Addition
8B: Substrate Addition

Project Title: _____
Project CIP Number: _____

See Section 3 of the SBE, Method 8 for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.

Substrate Addition

1. Indicate the type, quantity and footprint of material and the gradient of the streambed onto which the material will be placed.

Yes	No	Type of Material	Quantity of Material	Footprint of Material	Stream Gradient
☐	☐	Clean gravel	yd^3	Length Width	%
☐	☐	Clean cobble	yd^3	Length Width	%
☐	☐	Other:	yd^3	Length Width	%

2. Describe purpose of substrate addition (e.g., *stream bed material, spawning gravel, etc.*): _____
3. Provide additional information (if any) on this construction method: _____

Conservation Measures

The following table contains the conservation measures identified for Method 8B. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the "Provide additional information" section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
4	Maintain a spill kit onsite	

Conservation Measures	Description	Included in Project?
15	Clean equipment that will work below the OHW or MHHW lines or in riparian or shoreline areas	
16	Fuel equipment in staging areas	
18	Use vegetable-based hydraulic fluid when equipment operates in sensitive areas	
27	Place erosion and water quality control devices prior to beginning of work	
28	If mechanized equipment is used within the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters)	
29	Confine use of equipment operating below OHW or MHHW to designated access corridors	
57	Perform all work in the dry when possible	
58	Conduct work during minus tides or low water levels	
59	Use clean, washed material	
62	Do not ground or rest construction barge on substrate or on vegetation	
66	Use clean, washed beach material	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 9: Boat Launch Improvement, Repair and Maintenance

9A: *Fill Prop Wash Holes*

Project Title: _____
Project CIP Number: _____

See Section 3 of the SBE, Method 9 for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.

Fill Prop Wash Holes

1. Method used to return or replace substrate to hole created by prop wash:
   - ☐ Gravel return
   - ☐ Gravel replacement
2. Area of hole that will be filled: _____ ft^2
3. Type of material that will be used to fill hole: _____
4. Will work occur within the wetted perimeter? ☐ Yes ☐ No
5. Will work be conducted by hand? ☐ Yes ☐ No
6. Provide additional information (if any) on this construction method: _____

Conservation Measures

The following table contains the conservation measures identified for Method 9A. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the "Provide additional information" section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
2	Onsite Temporary Erosion and Sediment Control Plan	
3	Onsite Spill Prevention and Control Plan	
15	Clean equipment that will work below the OHW or MHHW lines or in riparian or shoreline areas	
16	Fuel equipment in staging areas	
18	Use vegetable-based hydraulic fluid when equipment operates in sensitive areas	

Conservation Measures	Description	Included in Project?
27	Place erosion and water quality control devices prior to beginning of work	
28	If mechanized equipment is used within the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters)	
29	Confine use of equipment operating below OHW or MHHW to designated access corridors	
57	Perform all work in the dry when possible	
58	Conduct work during minus tides or low water levels	
59	Use clean, washed material	
63	Take care to prevent spread of invasive plant species during their removal	
69	No wet concrete or epoxy shall come in contact with water	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 9: Boat Launch Improvement, Repair and Maintenance

9B: *Replace Ballast, Edge Armoring and Concrete Panels; Repair Concrete Panels*

Project Title: _____
Project CIP Number: _____

See Section 3 of the SBE, Method 9 for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.

Replace Ballast, Edge Armoring and Concrete Panels; Repair Concrete Panels

1. Identify what work will be done and whether the footprint of the repaired or replaced boat launch will be larger, smaller or the same size as the existing boat launch?

Work conducted	Larger	Smaller	Same Size	Boat Launch Element	Amt. Smaller or Larger
☐ Yes ☐ No	☐	☐	☐	Ballast	yd^3
☐ Yes ☐ No	☐	☐	☐	Edge armoring	ft^2
☐ Yes ☐ No	☐	☐	☐	Pre-cast concrete panels	ft^2
☐ Yes ☐ No	☐	☐	☐	Cast-in-place concrete panels	ft^2
☐ Yes ☐ No	☐	☐	☐	Repair concrete panels	ft^2
☐ Yes ☐ No	☐	☐	☐	Other:	ft^2
☐ Yes ☐ No	☐	☐	☐	Other:	ft^2

2. Will all work be conducted by hand? ☐ Yes ☐ No
3. Will all work be conducted in the dry? ☐ Yes ☐ No
4. If fresh concrete will be poured, what measures will be implemented to avoid or reduce exposure of wet concrete to water? _____
5. Provide additional information (if any) on this construction method: _____

Conservation Measures

The following table contains the conservation measures identified for Method 9B. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the "Provide additional information" section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
2	Onsite Temporary Erosion and Sediment Control Plan	
3	Onsite Spill Prevention and Control Plan	
15	Clean equipment that will work below the OHW or MHHW lines or in riparian or shoreline areas	
16	Fuel equipment in staging areas	
18	Use vegetable-based hydraulic fluid when equipment operates in sensitive areas	
27	Place erosion and water quality control devices prior to beginning of work	
28	If mechanized equipment is used within the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters)	
29	Confine use of equipment operating below OHW or MHHW to designated access corridors	
57	Perform all work in the dry when possible	
58	Conduct work during minus tides or low water levels	
59	Use clean, washed material	
63	Take care to prevent spread of invasive plant species during their removal	
69	No wet concrete or epoxy shall come in contact with water	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 9: Boat Launch Improvement, Repair and Maintenance

9C: Pressure Washing Boat Ramps

Project Title: _____
Project CIP Number: _____

See Section 3 of the SBE, Method 9 for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.

Pressure Washing Boat Ramps

1. From condition of boat ramp, does it appear only algae will be removed by pressure washing, or is there a buildup of sediment that also needs to be removed?
   - ☐ Algae
   - ☐ Sediment: Quantity _____ yd^3

2, Will all work be conducted by hand? ☐ Yes ☐ No

3. Will all work be conducted in the dry? ☐ Yes ☐ No

4. Provide additional information (if any) on this construction method: _____

Conservation Measures

The following table contains the conservation measures identified for Method 9C. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the “Provide additional information” section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
57	Perform all work in the dry when possible	
58	Conduct work during minus tides or low water levels	
61	Equipment and materials are mobilized to and from the site via upland access or construction barge	
63	Take care to prevent spread of invasive plant species during their removal	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 10: In-Water and Overwater Structure Repair and Replacement

10A: *Piling*

Project Title: _____
Project CIP Number: _____

See Section 3 of the SBE, Method ***10A*** *for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.*

Piling

1. Identify activity that will be conducted
   - ☐ Full extraction of existing piles
   - ☐ Cutting off existing piles a piles
     - ☐ Below the mudline: How far below? _____ ft
     - ☐ At the mudline
     - ☐ Above the mudline: How far above? _____ ft
   - ☐ Cutting off damaged section of pile and splicing in a new section.
   - ☐ Installation of new piles
2. Number, composition, and diameter of piling that will be extracted or cut off (e.g., *14 12" creosote treated piling and 3 10" steel piling*): _____
3. Method of piling extraction:

   ☐ Choker chain ☐ Vibratory pile driver

   ☐ Other (describe): _____
4. Explain how the hole left from the extracted pile will be filled (e.g., clean sand will be backfilled into the hole; hole will be filled with similar material to match surrounding area): _____
5. If piles will be cut, what equipment will be used: ☐ pneumatic knife ☐ pneumatic saw
6. Will any excavation occur around the piles to facilitate cutting, if so, explain how excavation will occur, how much material will be removed, and where material will be stored: ☐ No ☐ Yes Explanation: _____
7. For treated piles that are being cut off, what type of cap or cover will be used to minimize or reduce to prevent leaching of contaminants into the water: ☐ None ☐ plastic cap ☐ metal cap Other: _____
8. Number, composition, and diameter of piling where the damaged section will be removed and new section spliced onto the pile: (e.g., *14 12" creosote treated piling and 3 10" steel piling*): _____
9. How large of sections will be removed from the piles: _____

10. Explain how section of pile will be replaced? (e.g., will dock or superstructure be removed first and then pile cut and replaced, or will temporary structure be installed to bear weight of structure when section of pile is removed and replaced): _____
11. Number, composition, and diameter of piling that will be installed (e.g., *5 10" diameter steel piling and 3 untreated 12" diameter timber piling*): _____
12. Method of piling installation:

    ☐ Impact hammer ☐ Vibratory with proofing ☐ Vibratory without proofing

    ☐ Other (describe): _____
13. Sound attenuation method you'll use for impact driving or proofing steel piling:

    ☐ Bubble curtain ☐ Wood block ☐ Nylon block

    ☐ Other (describe): _____
14. Substrate material into which piling will be installed: _____
15. Provide additional information (if any) on this construction method: _____

Conservation Measures

The following table contains the conservation measures identified for Method 10A. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the "Provide additional information" section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
34	Minimize number of piles and increase spacing between piles to reduce shading	
45	Use plastic, cement or timber piles over steel piles	
46	Use containment boom	
47	Cap holes from pulling or cutting treated pilings	
48	Do not use piling treated with creosote, pentachloraphenol, or coal tar	
49	Do not use hydraulic water jets to remove or place piling	
50	Replace piling in same general location (see CM# 34)	
51	All treated wood removed will be contained on land or barge to preclude sediments and contaminated material from entering water	
52	Use vibratory driver for installing piles	
53	Use bubble curtain or other noise attenuation method	
54	Conduct hydroacoustic monitoring during installation of large piles	
55	Reduce noise from work operation	

Conservation Measures	Description	Included in Project?
56	Deploy sound attenuation devices with use of impact hammers in marine/estuarine waters. An onsite observer must be available to scan for marine mammals	
62	Do not ground or rest construction barge on substrate or on vegetation	
65	Retrieve and remove debris that enters waterbody	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 10: In-Water and Overwater Structure Repair and Replacement

10B: *Anchor and Chain Systems*

Project Title: _____

Project CIP Number: _____

See Section 3 of the SBE, Method ***10B*** *for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.*

Anchor and Chain Systems

1. Will you place any anchors in aquatic vegetation? ☐ Yes ☐ No
2. List the species of aquatic vegetation and the density of the vegetation into which any anchors will be placed (e.g., *Ulva fenestrata 5% and Fucus sp 5%*).

   _____
3. If anchors are not placed in aquatic vegetation, what is the distance from the anchor to the nearest aquatic vegetation? _____ ft
4. Identify type of anchor used:

   ☐ Concrete ☐ Metal
5. Will a midline float be attached to prevent the chain from dragging on the substrate?

   ☐ Yes ☐ No
6. Provide additional information (if any) on this construction method: _____

Conservation Measures

The following table contains the conservation measures identified for Method 10B. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the “Provide additional information” section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
15	Clean equipment that will work below the OHW or MHHW lines or in riparian or shoreline areas	
16	Fuel equipment in staging areas	
29	Confine use of equipment operating below OHW or MHHW to	

Conservation Measures	Description	Included in Project?
	designated access corridors	
43	Ensure anchor lines do not drag on the substrate or in aquatic vegetation	
44	Use mechanical anchors instead of concrete anchors	
62	Do not ground or rest construction barge on substrate or on vegetation	
65	Retrieve and remove debris that enters waterbody	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 10: In-Water and Overwater Structure Repair and Replacement

10C: *Superstructure, Decking and Utilities on Fixed Structures*

Project Title: _____
Project CIP Number: _____

*See Section 3 of the SBE, Method **10C** for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.*

Superstructure, Decking and Utilities on Fixed Structures

1. Will the footprint of the repaired or replaced structure be larger, smaller or the same size as the existing structure?

Larger	Smaller	Same Size	Fixed Structure Element	Amt. Smaller or Larger
☐	☐	☐	Fixed pier	ft^2
☐	☐	☐	Viewing platforms	ft^2
☐	☐	☐	Pedestrian bridges	ft^2
☐	☐	☐	Abutments	ft^2
☐	☐	☐	Footings	ft^2
☐	☐	☐	Other:	ft^2
☐	☐	☐	Other:	ft^2

2. Will the repaired or replaced structure have more, less or the same amount of light transmitting material as the existing structure? List the type of light transmitting material that will be placed in each structure: grating, glass block, glass prisms, glass floors, etc.

More	Less	Same Size	Fixed Structure Element	Amt. More or Less	Type Light Transmitting Material
☐	☐	☐	Fixed pier	ft^2	
☐	☐	☐	Viewing platforms	ft^2	
☐	☐	☐	Pedestrian bridges	ft^2	
☐	☐	☐	Abutments	ft^2	
☐	☐	☐	Footings	ft^2	
☐	☐	☐	Other:	ft^2	
☐	☐	☐	Other:	ft^2	

3. If only maintenance will be occurring on the superstructure(s), identify activities that will be conducted:

   ☐ Replace deck planks – type of material, number and size: _____

   ☐ Replace hand rails – number and size: _____

   ☐ Replace stringers and rails – numbers and size: _____

   ☐ Lateral, cam timbers, or walers – numbers and size: _____

   ☐ Other: _____

4. Will a pneumatic or jack hammer be used to install or replace any micro or pin pilings
   ☐ No ☐ Yes If yes, will the pneumatic or jack hammer be operated in water?
   ☐ No ☐ Yes

5. Will any bridge base structure be repaired or replaced. ☐ No ☐ Yes

   If yes, identify type and size:

   ☐ Shot rock - Size _____

   ☐ Rubble - Size _____

   ☐ Pile with lagging - Size _____

   ☐ Concrete - Size _____

   ☐ Other - Size _____

7. Will any work be conducted below the OHW or MHHW. ☐ No ☐ Yes If yes, please identify type of work. _____

8. Provide additional information (if any) on this method: _____

Conservation Measures

The following table contains the conservation measures identified for Method 10C. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the "Provide additional information" section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
3	Onsite Spill Prevention and Control Plan	
4	Maintain a spill kit onsite	
7	Limit clearing and grubbing areas to minimum required, retain vegetation to maximum extent	
12	Use sediment barriers to prevent erosion and sediment from	

Conservation Measures	Description	Included in Project?
	entering waterbodies	
15	Clean equipment that will work below the OHW or MHHW lines or in riparian or shoreline areas	
16	Fuel equipment in staging areas	
18	Use vegetable-based hydraulic fluid when equipment operates in sensitive areas	
19	Operate machinery from existing roads and paved areas	
25	Minimize stream and riparian crossings	
26	Manage stream crossings to minimize erosion	
27	Place erosion and water quality control devices prior to beginning of work	
28	If mechanized equipment is used within the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters)	
29	Confine use of equipment operating below OHW or MHHW to designated access corridors	
33	Minimize overwater structure size to reduce shading impacts	
35	Use grating on fixed structures over water	
37	Replacement floats shall be at least 4 feet above marine vegetation	
38	Floatation material shall not block any grating or other surface light treatment through the overwater structure	
39	Place new and replacement piers at least 2 feet above OHW or MHHW	
40	New or replacement skirting will not be installed	
45	Use plastic, cement or timber piles over steel piles	
46	Use containment boom	
48	Do not use piling treated with creosote, pentachloraphenol, or coal tar	
55	Reduce noise from work operation	
57	Perform all work in the dry when possible	
58	Conduct work during minus tides or low water levels	
59	Use clean, washed material	
62	Do not ground or rest construction barge on substrate or on vegetation	
63	Take care to prevent spread of invasive plant species during their removal	
64	Plant with native vegetation	
65	Retrieve and remove debris that enters waterbody	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 10: In-Water and Overwater Structure Repair and Replacement

10D: *Floats and Gangways*

Project Title: _____
Project CIP Number: _____

*See Section 3 of the SBE, Method **10D** for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.*

Floats and Gangways

1. Will the footprint of the repaired or replaced structures be larger, smaller or the same size as the existing structure?

Larger	Smaller	Same Size	Structure	Amt. Smaller or Larger
☐	☐	☐	Floats	ft^2
☐	☐	☐	Gangways	ft^2
☐	☐	☐	Other:	ft^2
☐	☐	☐	Other:	ft^2

2. Will the repaired or replaced structure have more, less or the same amount of light transmitting material as the existing structure? List the type of light transmitting material that will be placed in each structure: grating, glass block, glass prisms, glass floors, etc.

More	Less	Same Size	Structure	Amt. More or Less	Type of Light Transmitting Material
☐	☐	☐	Floats	ft^2	
☐	☐	☐	Gangways	ft^2	
☐	☐	☐	Other:	ft^2	
	☐	☐	Other:	ft^2	

3. Identify the type of in-water lateral support that will be used:

☐ Piles

☐ Anchor and Chains

Provide additional information (if any) on this construction method: _____

Conservation Measures

The following table contains the conservation measures identified for Method 10D. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the “Provide additional information” section below. Provide any additional conservation measures that may be implemented but are not listed below. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
2	Onsite Temporary Erosion and Sediment Control Plan	
3	Onsite Spill Prevention and Control Plan	
4	Maintain a spill kit onsite	
6	Establish staging and site access areas along existing roadways or other disturbed areas	
7	Limit clearing and grubbing areas to minimum required, retain vegetation to maximum extent	
9	Implement BMPs to prevent erosion of excavated material	
12	Use sediment barriers to prevent erosion and sediment from entering waterbodies	
13	Keep erosion control materials onsite to respond to emergencies	
14	Use curb inlet sediment traps and geotextile filters to capture sediment before it leaves the site	
15	Clean equipment that will work below the OHW or MHHW lines or in riparian or shoreline areas	
16	Fuel equipment in staging areas	
17	Onsite oil absorbing floating booms	
18	Use vegetable-based hydraulic fluid when equipment operates in sensitive areas	
19	Operate machinery from existing roads and paved areas	
25	Minimize stream and riparian crossings	
26	Manage stream crossings to minimize erosion	
27	Place erosion and water quality control devices prior to beginning of work	
28	If mechanized equipment is used within the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters)	
29	Confine use of equipment operating below OHW or MHHW to designated access corridors	
33	Minimize overwater structure size to reduce shading impacts	
35	Use grating on fixed structures over water	
36	Contain flotation for floats in a durable protective casing to prevent breakup of the flotation material	
37	Replacement floats shall be at least 4 feet above marine vegetation	
38	Floatation material shall not block any grating or other surface light treatment through the overwater structure	

Conservation Measures	Description	Included in Project?
63	Take care to prevent spread of invasive plant species during their removal	
64	Plant with native vegetation	
65	Retrieve and remove debris that enters waterbody	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 10: In-Water and Overwater Structure Repair and Replacement

10E: *Floating Log Boom*

Project Title: _____
Project CIP Number: _____

*See Section 3 of the SBE, Method **10E** for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.*

Floating Log Boom

1. Will the length of repaired or replaced log booms be larger, smaller or the same size as the existing log booms?

Larger	Smaller	Same Size	Structure	Amt. Longer or Shorter
☐	☐	☐	Log booms	ft
☐	☐	☐	Other:	ft
☐	☐	☐	Other:	ft

2. Identify the type of in-water lateral support that will be used:

☐ Piles

☐ Anchor and Chains

☐ Other _____

3. Provide additional information (if any) on this construction method: _____

Conservation Measures

The following table contains the conservation measures identified for Method 10E. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the “Provide additional information” section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
41	Limit size of breakwaters for wave attenuation and public safety	
43	Ensure anchor lines do not drag on the substrate or in aquatic vegetation	
44	Use mechanical anchors instead of concrete anchors	
62	Do not ground or rest construction barge on substrate or on vegetation	
65	Retrieve and remove debris that enters waterbody	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 10: In-Water and Overwater Structure Repair and Replacement

10G: *Fixed Breakwaters*

Project Title: _____
Project CIP Number: _____

*See Section 3 of the SBE, Method **10G** for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.*

Fixed Breakwaters

1. Will the length of the repaired or replaced structures be larger, smaller or the same size as the existing structure?

Larger	Smaller	Same Size	Fixed Breakwater Type	Amt. Larger or Smaller
☐	☐	☐	Pile with lagging	ft
☐	☐	☐	Rock revetment	ft
☐	☐	☐	Other:	ft
☐	☐	☐	Other:	ft

2. Identify work that will be conducted:
   - ☐ Repair and replace piles. Number of piles to be repaired or replaced: _____
   - ☐ Repair and replace lagging timbers. Number (_____) and length (_____) of lagging timbers.
   - ☐ Replace revetment rock. Quantity of rock: _____ yd^3
   - ☐ Other _____
3. Will work be conducted by hand or mechanized equipment?
   ☐ Hand ☐ Mechanized equipment
4. Will be work be done by shore or from barge/work boat? ☐ Shore ☐ barge/work boat
4. Provide additional information: _____

Conservation Measures

The following table contains the conservation measures identified for Method 10G. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the "Provide additional information" section below. Provide any additional conservation measures that may be implemented but are

not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
2	Onsite Temporary Erosion and Sediment Control Plan	
3	Onsite Spill Prevention and Control Plan	
4	Maintain a spill kit onsite	
6	Establish staging and site access areas along existing roadways or other disturbed areas	
12	Use sediment barriers to prevent erosion and sediment from entering waterbodies	
13	Keep erosion control materials onsite to respond to emergencies	
14	Use curb inlet sediment traps and geotextile filters to capture sediment before it leaves the site	
15	Clean equipment that will work below the OHW or MHHW lines or in riparian or shoreline areas	
16	Fuel equipment in staging areas	
17	Onsite oil absorbing floating booms	
18	Use vegetable-based hydraulic fluid when equipment operates in sensitive areas	
19	Operate machinery from existing roads and paved areas	
20	Use temporary materials to stabilize haul and access routes, staging areas, and stockpile areas	
27	Place erosion and water quality control devices prior to beginning of work	
28	If mechanized equipment is used within the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters)	
42	Logs shall be clean and without bark	
57	Perform all work in the dry when possible	
58	Conduct work during minus tides or low water levels	
59	Use clean, washed material	
62	Do not ground or rest construction barge on substrate or on vegetation	
63	Take care to prevent spread of invasive plant species during their removal	
64	Plant with native vegetation	
65	Retrieve and remove debris that enters waterbody	
67	Use clean grave (less than 3% fines)	
73	Include rootwads and LWD with riprap	
74	Cover riprap with habitat mix to fill voids	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 10: In-Water and Overwater Structure Repair and Replacement

10H: *Highway or Road Bridge Foundation or Footing Repair*

Project Title: _____
Project CIP Number: _____

See Section 3 of the SBE, Method ***10H*** *for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.*

1. Indentify the work that will be conducted
   - ☐ Repair foundation
   - ☐ Repair footings
   - ☐ Repair abutments
2. Identify what activities will occur
   - ☐ Loose and deteriorating concrete will be removed
   - ☐ Rebar or steel bracing added or replaced
   - ☐ Concrete installed to repair damaged areas
   - ☐ Riprap installed or replaced around foundation, footings, or abutments

   Quantity: _____
3. Provide additional information: _____

Conservation Measures

The following table contains the conservation measures identified for Method 10H. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the "Provide additional information" section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
15	Clean equipment that will work below the OHW or MHHW lines or in riparian or shoreline areas	
16	Fuel equipment in staging areas	
17	Onsite oil absorbing floating booms	
18	Use vegetable-based hydraulic fluid when equipment operates in sensitive areas	

Conservation Measures	Description	Included in Project?
57	Perform all work in the dry when possible	
58	Conduct work during minus tides or low water levels	
59	Use clean, washed material	
61	Equipment and materials are mobilized to and from the site via upland access or construction barge	
62	Do not ground or rest construction barge on substrate or on vegetation	
65	Retrieve and remove debris that enters waterbody	
74	Cover riprap with habitat mix to fill voids	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 10: In-Water and Overwater Structure Repair and Replacement

10I: *Removal of Plants and Animals from Pilings for Inspection or Repair*

Project Title: _____
Project CIP Number: _____

*See Section 3 of the SBE, Method **10I** for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.*

1. Identify number of piles from which plants and animals will be removed: _____
2. Identify the size of the seawall from which plants and animals will be removed: _____
3. How will plants and animals be removed:
   - ☐ Scraping
   - ☐ Pressure washing
   - ☐ Hand removal
4. Provide additional information: _____

Conservation Measures

The following table contains the conservation measures identified for Method 10I. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the "Provide additional information" section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
57	Perform all work in the dry when possible	
58	Conduct work during minus tides or low water levels	
61	Equipment and materials are mobilized to and from the site via upland access or construction barge	
62	Do not ground or rest construction barge on substrate or on vegetation	
63	Take care to prevent spread of invasive plant species during their removal	
65	Retrieve and remove debris that enters waterbody	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 11: Seawall Repair and Maintenance

Project Title: _____
Project CIP Number: _____

*See Section 3 of the SBE, Method **11A** and **11B** for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.*

A, Remove and replace damaged concrete, wood, or steel

1. Identify the type of seawall where maintenance will occur:
   - ☐ Pre-cast concrete face panels resting on steel piles driven into underlying sediment
   - ☐ Pre-cast concrete face panels resting on steel sheet piles that extend up through the intertidal water column.
   - ☐ Timber-pile-supported unreinforced concrete gravity wall.
   - ☐ Concrete-pile-supported reinforced concrete sidewalk frame wall.
   - ☐ Concrete face panels and support columns
2. What type of facing will be repaired?
   - ☐ Concrete
   - ☐ Steel
   - ☐ Wood
3. Size of seawall to be repaired? _____
4. Will damaged concrete be removed: ☐ No ☐ Yes, if yes, how will it be removed?
   - ☐ Jack-hammer
   - ☐ Air driven chipping gun
   - ☐ Other: _____
5. Will wooden panels be removed from the seawall? ☐ No ☐ Yes
6. Type of wood:
   - ☐ Ekki
   - ☐ Other: _____
7. Upon removing any panels or portions of the seawall, will any fill behind the seawall fall into marine waters? ☐ No ☐ Yes If so, how much? _____
8. Provide additional information: _____

B. Backfilling of voids in seawall

1. Will backfilling of voids be needed during maintenance of the seawall? ☐ No ☐ Yes
2. Quantity of fill needed? _____
3. Provide additional information: _____

C. Cathodic protection and electronic monitoring system maintenance

1. Identify the work that will be conducted:

   ☐ Replacement of anode(s)

   ☐ Replacement of conduits

2. Provide additional information: _____

D. Riprap repair

1. Will riprap be replaced along the seawall? ☐ No ☐ Yes, if yes, fill out SPIF for Method 7F.

Conservation Measures

The following table contains the conservation measures identified for Method 11A and 11B. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the "Provide additional information" section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
3	Onsite Spill Prevention and Control Plan	
4	Maintain a spill kit onsite	
15	Clean equipment that will work below the OHW or MHHW lines or in riparian or shoreline areas	
16	Fuel equipment in staging areas	
17	Onsite oil absorbing floating booms	
18	Use vegetable-based hydraulic fluid when equipment operates in sensitive areas	
27	Place erosion and water quality control devices prior to beginning of work	
28	If mechanized equipment is used within the OHW or MHHW, only an extension arm with bucket or similar attachment shall enter the water. Conduct debris removal and work below OHW or MHHW during low water levels (fresh waters) or at low tide (marine waters)	
29	Confine use of equipment operating below OHW or MHHW to designated access corridors	
57	Perform all work in the dry when possible	
58	Conduct work during minus tides or low water levels	
59	Use clean, washed material	
61	Equipment and materials are mobilized to and from the site via upland access or construction barge	

Conservation Measures	Description	Included in Project?
62	Do not ground or rest construction barge on substrate or on vegetation	
65	Retrieve and remove debris that enters waterbody	
74	Cover riprap with habitat mix to fill voids	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 12: Site Restoration

Project Title: _____
Project CIP Number: _____

See Section 3 of the SBE, Method 12 for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.

Site Restoration

1. Provide additional information (if any) on this construction method: _____

Conservation Measures

The following table contains the conservation measures identified for Method 12. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the "Provide additional information" section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
4	Maintain a spill kit onsite	
11	Salvage debris to use for habitat or mulch	
12	Use sediment barriers to prevent erosion and sediment from entering waterbodies	
15	Clean equipment that will work below the OHW or MHHW lines or in riparian or shoreline areas	
16	Fuel equipment in staging areas	
18	Use vegetable-based hydraulic fluid when equipment operates in sensitive areas	
19	Operate machinery from existing roads and paved areas	
24	Remove equipment and excess supplies, clean work storage areas, and remove temporary erosion control materials and temporary fill after construction and when soils have stabilized	
57	Perform all work in the dry when possible	
58	Conduct work during minus tides or low water levels	
65	Retrieve and remove debris that enters waterbody	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Method 13: Landscaping and Planting

Project Title: _____
Project CIP Number: _____

See Section 3 of the SBE, Method 13 for a complete description of the activity and conservation measures for this method. You need this information to fill out this form.

1. Provide with this form the *landscaping and planting plan* for areas that will be disturbed during project construction. The plan must include:
   - ☐ a drawing or drawings showing the location of the areas to be landscaped/planted
   - ☐ the types of species and number of each species to be planted in each area, identify whether the species used are native or not.
   - ☐ performance standards (e.g., *100% survival of all planted trees and shrubs during the first year after planting; 30% cover of native trees and shrubs by the second year after planting; 50% cover of native trees and shrubs by the fifth year after planting*).
   - ☐ monitoring and maintenance program and schedule.
2. When will planting occur?
   - ☐ End of project
   - ☐ Late fall to ensure greater success
3. Will any fertilizers or pesticides (see definition in SBE) be used ☐ No ☐ Yes, if yes, identify type? _____
4. Provide additional information (if any) on this construction method: _____

Conservation Measures

The following table contains the conservation measures identified for Method 13. The table only provides a brief summary of the conservation measures. Please see Section 4 of the SBE for a complete description of each conservation measure. To get programmatic coverage by the Corps and Services for projects using this method, all conservation measures identified below must be included with the project (see Section 10 of the SBE). If, for some reason, a conservation measure is not applicable, or will not be used, you MUST provide a reason the conservation measure is not applicable or will not be used in the “Provide additional information” section below. Provide any additional conservation measures that may be implemented but are not listed. These may be found in Section 4: Conservation Measures of the SBE or in the City Standard Specifications.

Conservation Measures	Description	Included in Project?
1	Approved work windows	
2	Onsite Temporary Erosion and Sediment Control Plan	
3	Onsite Spill Prevention and Control Plan	
4	Maintain a spill kit onsite	
5	Confine construction impacts to the minimum area necessary, delineate impacts on project plans and onsite	

Conservation Measures	Description	Included in Project?
6	Establish staging and site access areas along existing roadways or other disturbed areas	
7	Limit clearing and grubbing areas to minimum required, retain vegetation to maximum extent	
9	Implement BMPs to prevent erosion of excavated material	
10	Stockpile large wood, vegetation, and soils for establishment of staging area and site restoration	
11	Salvage debris to use for habitat or mulch	
12	Use sediment barriers to prevent erosion and sediment from entering waterbodies	
13	Keep erosion control materials onsite to respond to emergencies	
14	Use curb inlet sediment traps and geotextile filters to capture sediment before it leaves the site	
15	Clean equipment that will work below the OHW or MHHW lines or in riparian or shoreline areas	
16	Fuel equipment in staging areas	
18	Use vegetable-based hydraulic fluid when equipment operates in sensitive areas	
19	Operate machinery from existing roads and paved areas	
20	Use temporary materials to stabilize haul and access routes, staging areas, and stockpile areas	
22	Locate equipment wash areas where washwater, sediment, and pollutants cannot enter waterbodies	
25	Minimize stream and riparian crossings	
26	Manage stream crossings to minimize erosion	
57	Perform all work in the dry when possible	
63	Take care to prevent spread of invasive plant species during their removal	
64	Plant with native vegetation	
65	Retrieve and remove debris that enters waterbody	
67	Use clean gravel (less than 3% fines)	
72	Plant bulkhead with native riparian vegetation	
73	Include rootwads and LWD with riprap	
74	Cover riprap with habitat mix to fill voids	
75	Apply pesticides under direct supervision of a licensed applicator	
76	Use pesticides only to control weeds listed on King County Noxious Week list	
78	Other chemicals will be subject to Tier 1 chemical applications exemptions and will require approval from the Seattle Parks and Recreation IPM coordinator and the Office of Sustainability and Environment	

Please provide any additional information on Conservation Measures used or not used for this Method: _____

Appendix B. Effects Templates

The Endangered Species Act (ESA) requires a determination be made of the effects, or impacts, to both the ESA-listed species and to their federally-designated critical habitat. Note that only some of the ESA-listed species have federally-designated critical habitats.

Essential fish habitat (EFH) is regulated under the Magnuson-Stevens Fishery Conservation Management Act and requires an assessment of impacts to EFH. This assessment is usually done in conjunction with the ESA impacts analysis. However, depending on where a project is located (i.e. Piper's Creek, Fauntleroy Creek), there may not be ESA listed species, but EFH species may be present and therefore, only an EFH consultation is required.

This SBE Appendix B provides two effects templates for these effects determinations. Either template can also be used as a reference document to provide necessary information in the effects determination section of the SPIF Cover Page. The two template forms are:

- No Effect (NE) to ESA species and critical habitat, and Will Not Adversely Affect (NAA) Determination for EFH
- Not Likely to Adversely Affect (NLAA) or Likely to Adversely Affect (LAA) Determination for ESA species and critical habitat and either Will Not Likely Adversely Affect (NLAA) or Will Likely Adversely Affect (LAA) determination for EFH.

Directions for Filling out the Templates:

The City of Seattle representative from the US Fish and Wildlife Service and National Oceanic and Atmospheric Administration (NOAA) Fisheries[1] can help fill out these templates. In fact, the representative can take a lead in filling out the forms with the City of Seattle project manager. In such collaboration, the project manager should at least provide the project name, description and location information. After the forms are completed, they should be packaged with the SBE SPIFs and submitted with the Joint Aquatic Resources Permit Application (JARPA) to the Corps of Engineers.

[1]Under an Agreement between the City of Seattle, the US Fish and Wildlife Service and the National Oceanic and Atmospheric Administration (NOAA) Fisheries, Jim Muck (206-526-4740, Jim.Muck@NOAA.gov) provides ESA services to City of Seattle staff.

Appendix B. NE and NAA Template

- **No Effect (NE) Analysis/Determinations for ESA Species and Critical Habitat**
- **Will Not Adversely Affect (NAA) Determination for Essential Fish Habitat**

Use this form when analysis of a project shows that there are no effects to:

- ESA-listed species,
- Critical habitat of ESA-listed species and
- Essential fish habitat.

The Endangered Species Act (ESA) requires a determination be made of the effects, or impacts, to both the ESA-listed species and to their federally-designated critical habitat. Note that only some of the ESA-listed species have federally-designated critical habitats.

Essential fish habitat (EFH) is regulated under the Magnuson-Stevens Fishery Conservation Management Act and requires an assessment of impacts to EFH. This assessment is usually done in conjunction with the ESA impacts analysis. However, depending on where a project is located (i.e. Piper's Creek, Fauntleroy Creek), there may not be ESA listed species, but EFH species may be present and therefore, only an EFH consultation is required.

This SBE Appendix B provides an effects template for the effects determination for No Effect (NE) to ESA species and critical habitat, and Will Not Adversely Affect (NAA) determination for EFH. Use the SPIF Cover Page and not this template for determinations that are Not Likely to Adversely Affect (NLAA) or Likely to Adversely Affect (LAA) determination for ESA species and critical habitat and either Will Not Likely Adversely Affect (NLAA) or Will Likely Adversely Affect (LAA) determination for EFH.

Directions for Filling out the Templates:

Fill out the form by replacing the red Italics wording with project-specific information. The City of Seattle representative from the US Fish and Wildlife Service and National Oceanic and Atmospheric Administration (NOAA) Fisheries[1] can help with the template. In fact, the representative can take a lead in filling it out with the City of Seattle project manager. In such collaboration, the project manager should at least provide the project name, description and location information. After the form is completed, it should be packaged with the JARPA and submitted with the Joint Aquatic Resources Permit Application (JARPA) to the Corps of Engineers.

PROJECT NAME

Type in the actual and proper project name.

[1]Under an Agreement between the City of Seattle, the US Fish and Wildlife Service and the National Oceanic and Atmospheric Administration (NOAA) Fisheries, Jim Muck (206-526-4740, Jim.Muck@NOAA.gov) provides ESA services to City of Seattle staff.

LOCATION

If this information is presented in the JARPA or other submitted documentation, it need not be repeated. Instead, please state where the project location information can be found.

PROJECT DESCRIPTION

If this information is presented in the JARPA or other submitted documentation, it need not be repeated. Instead, please state where the project description information can be found.

ALLOWABLE WORK WINDOW

Identify the work timing window for the water body in which work is being conducted. If the project is not complying with the work timing window, please give complete justification as to why it is not being followed.

ACTION AREA

Identify the action area for the project. The action area is defined by all areas to be affected directly or indirectly by the project and not merely the immediate area involved in the action. For example, if a project will work in a stream, the action area may be defined as the extent downstream of the project at which turbidity levels reach background levels.

CONSERVATION MEASURES (CMS)

Using this SBE, either list individual CMs or state which construction methods and their associated CMs will be used.

ESA SPECIES AND CRITICAL HABITAT: ANALYSIS AND DETERMINATION OF EFFECT

For each species and designated critical habitat in the project action area identified in Section II of the SPIF Cover Page, please provide a rationale, justification, or analysis of why the project will have No Effect on the listed species or critical habitat within the action area, not just the project area. Remember that a "No Effect" determination means "no effect. It does not mean a small effect or an effect that is unlikely to occur.

For species analysis, the following could be included in this analysis:

- *Species is not located within the watershed*
- *Fish barrier is some distance downstream (describe the barrier and the state the distance)*
- *Project has no overland connection to a stream or other waterbody*
- *Work is being conducted below the ordinary high water (OHW) or mean higher high water (MHHW) lines, but work is being conducted in the dry, such as at a low enough tide or when Lake Washington is drawn down.*
- *Describe how any potential effects will be avoided (silt curtains, etc.)*

For critical habitat, a similar analysis is needed on how the project will not affect the primary constituent elements (PCEs) of the designated critical habitat. The bulleted items listed above may also be used for this analysis.

ESSENTIAL FISH HABITAT (EFH)

Please provide an analysis of the project as to why the project will not adversely affect EFH. EFH means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. Adverse effect under EFH means any impact that reduces quality and/or quantity of EFH, and may include direct, indirect, site-specific or habitat-wide impacts, including individual, cumulative or synergistic consequences of actions. The bulleted items listed above may be used for this analysis. In addition, the following bullets could be addressed:

- *Project will not impact the physical, chemical and biological properties of the water.*
- *Project will not impact the sediment or substrate underlying the waters, and associated biological communities.*

Date | Name of Analysis Preparer

Appendix C. Bald and Golden Eagle Protection Act

The bald eagle was removed from the federal list of endangered and threatened species on August 9, 2007 (72 FR 37346). While not listed under the ESA, the bald eagle is still protected under the Bald and Golden Eagle Protection Act (Eagle Act). As such, for project manager's convenience, this appendix provides information on the protection of bald eagles under the Eagle Act.

C.1 Listing, Critical Habitat Designation, and Delisting

The bald eagle (*Haliaeetus leucocephalus*) is currently a Species of Concern for the U.S. Fish and Wildlife Service (USFWS) and a sensitive species within the State of Washington by the Washington Department of Fish and Wildlife. The bald eagle was federally listed in 1978 as an endangered species in all states except Michigan, Minnesota, Wisconsin, Washington, and Oregon, where it was designated as threatened (USDI 1978). The listing was a result of a decline in the bald eagle population throughout the lower 48 states. The decline was largely attributed to the widespread use of dichloro-diphenyl-trichloro-ethane (DDT) and other organochlorine compounds, in addition to habitat loss, harassment and disturbance, shooting, electrocution from power lines, poisoning, and a decline in the food base.

The bald eagle was reclassified in 1995 from endangered to threatened as a result of a significant increase in numbers of nesting pairs, increased productivity and expanded distribution (USDI 1994). Since 1989, the bald eagle nesting population increased at an average rate of about 8% per year (USDI 1999b). The national average for fledglings per occupied breeding area is greater than 1. Because of the increase in the number of breeding pairs, the bald eagle was removed from the list of threatened and endangered species list on August 9, 2007.

Of the 7 states covered in the Pacific Recovery Area, Washington State supports the largest breeding and wintering populations (USDI 1986). In 2001, 684 nest territories were occupied in Washington (WDFW 2003, unpub. data). Most nesting territories in Washington are located on the San Juan Islands, along the coastline of the Olympic Peninsula, and along the Strait of Juan de Fuca, Puget Sound, Hood Canal, and the Columbia River. Wintering concentration areas in Washington are along salmon spawning streams and waterfowl wintering areas (Stinson et al. 2001).

C.2 Species Information

Life History

The bald eagle is a bird of aquatic ecosystems. It frequents estuaries, large lakes, reservoirs, major rivers, and some seacoast habitats. Fish is the major component of its diet, but it also eats waterfowl, seagulls, and carrion. The species may also use prairies if adequate food is available. Bald eagle habitats encompass both public and private lands.

Bald eagles usually nest in trees near water, but are known to nest on cliffs and (rarely) on the ground. Nest sites are usually in large trees along shorelines in relatively remote areas that are free of disturbance. The trees must be sturdy and open to support a nest that is often 5 feet (1.5 m) wide and 3 feet (0.9 m) deep. Adults tend to use the same breeding areas year after year, and often the same nest, though a breeding area may include 1 or more alternate nests. In winter, bald eagles often congregate at specific wintering sites that are generally close to open water and offer good perch trees and night roosts.

It is presumed that once they mate, the bond is long-term, though documentation is limited. Variations in pair bonding are known to occur. If one mate dies or disappears, the other will accept a new partner. The female bald eagle usually weighs 10 to 14 pounds (4.5 to 6.4 kg) and is larger than the male, which weighs 8 to 10 pounds (3.6 to 4.5kg). Bald eagle wings span 6 to 7 feet (1.8 to 2.1 m).

Bald eagle pairs begin courtship about a month before egg-laying. In the south, courtship occurs as early as September, and in the north, as late as May. The nesting season lasts about 6 months. Incubation lasts about 35 days and fledging takes place at 11 to 12 weeks of age. Parental care may extend 4 to 11 weeks after fledging (Wood et al. 1998). The fledgling bald eagle is generally dark brown except for the underwing linings, which are primarily white. Between fledging and adulthood, the bald eagle's appearance changes with feather replacement each summer. Young dark bald eagles may be confused with the golden eagle, *Aquila chrysaetos*. The bald eagle's distinctive white head and tail are not apparent until the bird fully matures, at 4 to 5 years.

As they leave their breeding areas, some bald eagles stay in the general vicinity while most migrate for several months and hundreds of miles to their wintering grounds. Young eagles may wander randomly for years before returning to nest in natal areas.

Wintering bald eagles often roost at communal sites that give shelter during inclement weather. Bald eagles may roost communally in single trees or large forest stands of uneven ages. Bald eagles may remain at their daytime perches throughout the night as well, but bald eagles typically gather at large communal roosts in the evening.

Communal night roosting sites are traditionally used year after year and are characterized by favorable microclimatic conditions. Roost trees are usually the largest and have the most open structure (Keister and Anthony 1983, Watson and Pierce 1998). They are often located in areas that provide a more favorable microclimate during inclement weather (Knight et al. 1983, Keister et al. 1985, Watson and Pierce 1998). Prey sources may be available in the general vicinity, but for roosting, close proximity to food is not as critical as the need for shelter.

C.3 Species Occurrence in Action Areas

Bald eagles occur as year-round residents in Washington. Resident and wintering populations of bald eagles are known to occur in the action areas identified in this SBE. Bald eagles use the area throughout the year, including the breeding and wintering seasons.

Bald eagle foraging habitat, both summer and winter, occurs throughout western Washington. The action areas contain ample active eagle foraging habitat (perch site along shorelines and accessibility to fish) and can support the species in both winter and summer (Stinson et al. 2001).

North Seattle/Puget Sound

No bald eagle nests are known to be located in this action area.

Elliott Bay

Six bald eagle nests are located in the Elliott Bay action area. Five are located within Discovery Park and one located along Magnolia Bluff. Two of these nests have been regularly surveyed and have been active with young being produced. All the nests have been surveyed and have been found active (WDFW 2010b).

Lake Washington Ship Canal

Two bald eagle nests are located in the Ship Canal action area. Both are located near Green Lake and the Woodland Park Zoo. Both nests have been active over the past 10 years (WDFW 2010b).

Lower Green/Duwamish

One active bald eagle nest is located in the Lower Green Duwamish action area, along Marginal Way (WDFW 2010b).

North Lake Washington

Three bald eagle nests are located in the North Lake Washington action area. Two nests are near Wolf Bay. The third nest is near the University Village. Two of these nests were constructed since 1997. No survey has been conducted to see if young have been produced. No information is available on the third nest and whether it is active.

South Seattle/Puget Sound

Two bald eagle nests are located in the South Seattle/Puget Sound action area. One bald eagle nest is located near Lincoln Park. The other nest is located near Seacrest Marina Park. Both nests are still active (WDFW 2010b).

South Lake Washington

Seven bald eagle nests are located in the South Lake Washington action area. One is located in Deadhorse Canyon and may be located within Lakeridge. Three nests are located within Seward Park. All nests are active. Three nests are located near the Broadmoor Golf Course and the University of Washington Arboretum. Two of these nests have been found active and one inactive (WDFW 2010b).

C.4 Effects of the Action on Bald Eagles

Effects on Nesting Eagles

Disturbance

Nesting territories within an action area are subject to disturbance from construction and potential long-term project use. Any potentially disturbing activity in excess or under the right conditions can alter a bald eagle's normal behavior or induce nesting failure (Grubb and King 1991). The response of nesting eagles to human activity can range from behavioral, such as flushing or reduced nest attendance, to nest failure (Fraser et al. 1985, McGarigal et al. 1991, Grubb and King 1991, Grubb et al. 1992, Anthony et al. 1995, Steidl and Anthony 1996, Watson and Pierce 1998). The magnitude of the response varies inversely with distance and increases with disturbance duration, the number of vehicles or pedestrians per event, visibility, sound, and position relative to affected eagle (Grubb and King 1991).

Bald eagles vary in their sensitivity to disturbance, but generally nest away from human disturbance (Stinson et al. 2001). Watson and Pierce (1998) found that vegetative screening and distance were the 2 most important factors determining the impact of disturbances. Heavy vegetative screening can dramatically reduce eagle response to human activity. Human activities that are distant, of short duration, out of sight, few in number, below the nest, and quiet have the least impact (Grubb and King 1991). Parson (1994) reported that successful nests had lower densities of human residences within about 295 feet (90 m) than unsuccessful nests. Larger set-back distances for buildings have been correlated with greater eagle use. Hodges et al. (1984) reports that in coastal British Columbia, adult eagles and active nests were found in higher than expected numbers in undisturbed habitat, and that disturbed habitat with no remnant old-growth contained far fewer adult birds and no active nests. Grubb et al. (1992) reported the threshold for alert response was about 1,800 feet (549 m) [and for flight response was about 650 feet (195 m)] for breeding bald eagles in Michigan and Arizona, with vehicles and pedestrians eliciting the highest response frequencies.

Bald eagle tolerance of disturbance may depend in part on prior experience and the level of the nesting population relative to carrying capacity. Disturbance experiments conducted by Steidl and Anthony (2000) suggested that bald eagles habituated somewhat over 24 hours to camping about 330 feet (100 m) from nests, but the tendency was not cumulative, with each disturbance being essentially independent of the last. Bald eagles exhibit strong year-to-year fidelity to a nest territory and have been shown to be reluctant to abandon a territory despite increased disturbance and habitat alteration (Stinson et al. 2001). A small but apparently growing number of bald eagles in Washington have been exhibiting an unexpected tolerance to human presence and activities, and nesting successfully in close proximity to homes (Watson et al. 1999). However, this may be the result, in part, from a local shortage of nesting habitat. Nest site fidelity may be stronger when the population is at carrying capacity and no vacant suitable sites are available (Stinson et al. 2001).

Bald eagles may be deterred from nesting, perching, foraging, or wintering within 0.25-mile (0.4 km) of project sites if there will be increases in pedestrian and vehicular traffic. An increase in traffic is not anticipated within Seattle because most areas within the City are already highly urbanized. However, an increase in activity due to future projects less than 0.25-mile (0.4 km) from bald eagle nests can affect bald eagle behavior indirectly through the associated increase in pedestrian activity (Watson and Pierce 1998). Studies have shown pedestrian traffic is more disturbing than auto traffic or aircraft (Fraser et al. 1985, Grubb and King 1991, Grubb et al. 1992).

Pile driving generates the highest noise level of all common construction activities (Bolt et al. 1971). Noise measurements of impact driving of steel piles taken by Washington State Ferries at the Anacortes terminal recorded Lmax readings (peak sound emitted from a source) that averaged between 105 to115 dB at 50 feet (15.3 m) (Visconty 2000). Heavy equipment operation for road construction generates noise levels of 77 to 96 dB at 50 feet (15.3 m). A general equation of noise propagation for pulsed sound in air is that there is a 7.5 dB loss for each doubling of distance in areas of soft (forested) ground cover. Noise begins to disturb most birds at 80 to 85 dB, and the sound level threshold for the flight response is around 95 dB (Awbrey and Bowles 1990).

Bottorff et al. (1987) observed bald eagle behavior in response to wood or steel pile driving and determined that impact driving of steel piles may have flushed bald eagles at 4,000 feet (1,219 m). Stanford et al. (1997) determined density and distribution of bald eagles during construction of a dam on the Ohio River and documented a significant reduction in bald eagle numbers within 1 mile (1.6 km) of the construction site. The mean distribution of bald eagles also shifted from a point 0.5-mile (0.8 km) upstream from the dam construction site to a point 1.5 miles (2.4 km) upstream. Pile driving was identified as the most notable disturbance during construction of the dam. Impact driving of steel piles could result in a flight response for any bald eagles within a 1-mile (1.6 km) radius of a project site.

Adequate incubation time and adult perch time near the nest were the best predictors of bald eagle nest success in Washington (Watson and Pierce 1998). Incubation time for bald eagles must be above certain minimum levels and without excessive exposure of eggs in order for embryos to grow and hatch. Exposed eggs weaken the embryos and reduce hatchability (Watson and Pierce 1998). Human or natural events that increase egg exposure by flushing incubating bald eagles for extended periods can cause embryos to die and nests to fail (Watson and Pierce 1998). Disturbance reduces the time bald eagles spend incubating, and decreased incubation time reduces nesting success. Pile driving within 1 mile (1.6 km) and any activity within 656 feet (200 m) of the nest during incubation could cause a flush response, which would reduce incubation time and may affect nest success.

After eggs hatch, Watson (1993) suggested that regular disruption by aircraft or other human activities could result in reduced attentiveness and nest failure due to reduced brooding and feeding of young. In Alaska, humans camping about 330 feet (101 m) from nests for 24 hours caused clear and consistent changes to behavior, including a reduction of 29% in the amount of prey fed to nestlings (Steidl and Anthony 2000). Pile driving within 1 mile (1.6 km) and any human activity that occurs within 656 feet (200 m) of the nest during the nestling period could result in reduced brooding and feeding of young, which could result in nest failure.

Habitat

Assuming the presence of an adequate food supply, the single most critical habitat factor associated with bald eagle nest locations and success is the presence of large super-dominant trees (Watson and Pierce 1998). The average life expectancy of nests is 5 to 20 years. Therefore, bald eagles need trees of similar stature located nearby to serve as replacement nest trees if a nesting territory is to persist (Stinson et al. 2001). Anthony and Isaacs (1989) recommended a 0.25-mile (0.4 km) primary buffer zone around nests to minimize the vulnerability of the nest area to blowdown from wind, fire, disease, and insect infestation. They also recommended against road building, hiking trails, and boat launches less than 0.25 mile (0.4 km) from bald eagle nests, based on their finding that such alterations or the associated human activities were correlated with reduced nest success. Habitat alteration that removes large trees and prevents their replacement could prevent bald eagles from nesting within 0.25-mile (0.4 km) of a project site.

Projects that result in permanent facilities or increased activity will result in increases in both noise and visual disturbance of bald eagles in any adjacent suitable habitat. Fraser et al. (1985) concluded that "Chronic disturbance results in disuse of areas of human activity . . . thus, human activities that chronically exceed the limits of eagle tolerances, may be considered a form of habitat destruction." Passive displacement may impact habitat that otherwise is undegraded. Passive displacement occurs when human use prevents eagles from using a site (Stinson et al. 2001). Passive displacement has not been widely investigated, but may be more prevalent and important than active disturbance that briefly affects birds (McGarigal et al. 1991, Anthony et al. 1995).

Loss of vegetation around the nests could have long-term negative impacts to the nests themselves by reducing protective screening. Watson and Pierce (1998) found that the presence of vegetation that concealed nests dramatically affected disturbance response. Removal of screening vegetation could expose nestlings and increase noise and visual disturbance of adults and juveniles.

Effects on Wintering Eagles

Disturbance

Wintering bald eagles use all of the Seattle action areas. Disturbances that cause wintering eagles to flush can result in reduced food intake, increased energy expenditure during critical winter periods, and forced use of marginal habitat (Stalmaster and Kaiser 1997).

Habitat

Bald eagles commonly use all Seattle action areas for foraging and nest in all areas except Elliott Bay and North Seattle/Puget Sound action areas. Nesting bald eagles exhibit consistent daily foraging patterns and use of the same perches as they do during the winter (Stalmaster 1987). Perch trees provide bald eagles with some security (Stalmaster and Kaiser 1998). Bald eagles most often forage close to shoreline perch trees (Buehler 2000).

The removal of perch trees from within 250 feet (76 m) of foraging habitat would reduce security and disrupt bald eagle foraging patterns during winter. The result would be reduced feeding and increased energy consumption for both adult and juveniles, which could lead to lower body weights and reduced survival (Hansen and Hodges 1985, Stalmaster and Kaiser 1998).

C.5 Permitting Process for Take of Bald Eagles

The Eagle Act prohibits the "taking" of bald eagles, including their parts, nests, or eggs. Take under the Eagle Act is defined as pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb. Disturb has further been defined as to agitate or bother an eagle to a degree that causes, or is likely to cause, based on the best scientific information available, (1) injury to an eagle, (2) a decrease in its productivity by substantially interfering with normal breeding, feeding, or sheltering behavior, or (3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior (72 FR 31132).

The USFWS has developed a permitting process to improve management of bald eagles under the Eagle Act. Two types of permits are available to protect public safety and manage activities or projects that may disturb or otherwise incidentally "take" bald eagles or their nests, while maintaining stable or increasing populations. Permits will only be granted when they are compatible with this goal.

When the bald eagle was listed under the ESA, a permit was available to take eagles incidental to an otherwise lawful activity. But when the eagle was removed from ESA protection in 2007, there were no provisions for issuing permits under the Eagle Act for activities that could disturb or otherwise incidentally take bald eagles. The growing population of bald eagles could significantly curtail legal human activities if such permits were not available.

The first permit type may be issued only where the "take" – in this case referring to the disturbing, or harming of eagles – is associated with, but not the purpose of an activity, such as commercial or residential real estate development. The second permit type governs removal of bald eagle nests under limited circumstances, including removal of nests that create safety concerns on or near airports. Deliberate killing of eagles will not be allowed under either permit types.

Any person or entity carrying out activities that may result in take as defined in the Bald and Golden Eagle Act will need to obtain a permit through the USFWS. The permitting process will occur directly between the City of Seattle and the USFWS.

C.6 Permit Process

If your project will involve construction near a bald eagle nest or roosting tree, a permit may be needed if the project will disturb eagles. The following are general guidelines for determining whether a project may disturb bald eagles.

1. No known bald eagle nest trees, perch trees, or roost trees will be felled or modified.
2. Suitable bald eagle habitat will not be removed within 0.25 miles (approximately 400 meters) of nest or roost sites.
3. Potential eagle perches (large snags, dead top trees or other suitable sites) within 0.5 mile (800 meters) of nests or roosts will not be felled.
4. Work activities will not take place within 330 feet (approximately 100 meters) of active nests/roosts that are out of line of sight, or within 660 feet (approximately 200 meters) from nests/roosts that are in the line of sight during periods of eagle use, unless surveys demonstrate that the nest or roost is not being used. Critical nesting periods generally fall between January 1 and August 31. The wintering period is October 15 through March 15.
5. Pile driving, both impact and vibratory, will not occur within 0.5 mile (800 meters) during the active breeding season (January 1 through August 31) when active nests are in line of sight, and 1.0 mile (1.6 km) when nests are out of line of sight.

For projects that do not meet the above guidelines, a permit from the USFWS is needed. Applications for permits under the Eagle Act can be found at the USFWS's website at:

For permits regarding the disturbance of bald eagles: http://www.fws.gov/forms/3-200-71.pdf.

For permits regarding the removal of an eagle nest: http://www.fws.gov/forms/3-200-72.pdf.

Send application to the:
U.S. Fish and Wildlife Office
Migratory Bird Regional Permit Office
911 N.E. 11th Avenue
Portland, OR 97232-4181
Phone #: (503) 872-2715

C.7 Bald Eagle Work Windows

To minimize disturbance and harassment of bald eagles, the following work windows should be followed. Determine the distance from the nearest point of the project to the location of documented bald eagle nests, roosts and foraging habitat (Table 4-3).

Table 4-3
Approved work windows and activity distances for bald eagles in the Seattle action areas[1]

Location/Activity	Distance from location	Window
In line of sight	>=660 feet	Wintering period[2] October 15 – March 15
		Nesting period January 1 – August 31
Out of line of sight	>330 feet	Same as above
Pile driving (both impact and vibratory)	> 0.5 mile (800 m), out of line of sight > 1 mile (1.6 km), in line of sight	Jan 1 – Aug 31
Source: USFWS 2015		

[1]Action areas are described in Section 2 of this SBE.

[2]Work is scheduled during the wintering period (October 15 through March 15) and/or the nesting period (January 1 through August 31) or **is restricted to a very short period of time to minimize disturbance**. 'Important wintering areas' are defined as documented communal roost sites and concentration areas of waterfowl and/or fish that attract large numbers of bald eagles. Screening activities from view (with vegetation or topography) or maintaining 0.5 mile (800 m) distance can minimize potential disturbance.

Follow general conservation measures**:**

- If habitat removal is proposed, the quantity of habitat removed is limited to a very small amount (therefore insignificant and discountable).
- Noise and activity levels of a proposed activity are kept within ambient levels already present at a site. If bald eagles at a site are tolerant of levels of existing activities, disturbance may be insignificant.